

SCARBOROUGH BOROUGH COUNCIL

**Woodlands and Throxenby Flood
Alleviation Assessment**

Draft for Clients Comments

June 2004

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Glossary of terms

Term	Meaning / Definition
Agency	The Environment Agency
Atkins	Atkins Consultants Ltd.
BF	Base Flow (FEH term)
COW	Critical ordinary Watercourse
Defra	Department for Environment, Food and Rural Affairs (Formerly MAFF)
EA	The Environment Agency
FEH	Flood Estimation Handbook
ISIS	Mathematical modelling package
MCM	Multi Coloured Manual A manual published by the Flood Hazard Research Centre at Middlesex Polytechnic containing data and costs for flood damage to a variety of properties in different scenarios.
OS	Ordnance Survey
PV	Present Value (of Damage occurring regularly over 50 years for example)
PR	Percentage Runoff (FEH term)
RSPB	Royal Society for the Protection of Birds
SBC	Scarborough Borough Council
T _P	Time to peak flow (an FEH term)
URBEXT	Urban Extent (FEH term denoting degree of urbanisation)

EXECUTIVE SUMMARY

Atkins were commissioned to undertake a preliminary feasibility assessment of the mechanisms of flooding in the Woodland and Throxenby area. In addition, this feasibility report, was required to determine whether a scheme was feasible to proceed to a more detailed assessment and modelling stage.

Historically the area of Woodland and Throxenby has flooded frequently from the watercourse that flows through it via culverts and open channel sections. The main reason for flooding is the incapacity of the culverts that are required to take flows from a flashy, urbanised catchment.

Due to the relatively no historical flooding of properties from the Throxenby watercourse it has not been classified as a COW. Woodlands watercourse has flooded several properties and is classified as a COW.

For Woodlands Beck a 100 year flood envelope has been estimated from historical data and has found to encompass 55 properties with approximately 8 properties at risk for a 1 in 2 year event. The flood envelope also encompasses the hospital access and flooding of this part can therefore cause risk of lives (see table 2.1).

The flood envelope for Throxenby Beck is estimated to be 2 properties in a 100 year flood event.

Three options have been assessed for each watercourse to alleviate flooding problem.

Since there is no record of flooding of properties from **Throxenby Beck** only the do minimum scheme appears economically feasible. This scheme requires the replacement and regular maintenance of the trash screens and culverts. The benefit cost ratio for this scheme has been determined to be between 1.9 and 2.4, although it should be noted that this will only result in a protection standard of 1 in 10 year standard.

For **Woodlands Beck** the preferred and most feasible option is to construct a flood protection wall around the vulnerable properties near Hovingham Drive (Option C). This scheme would bring a 100 year standard of protection to the area and the hospital access. The preliminary benefit cost ratio for this option is between 7.1 and 13.2 and a DEFRA priority score of 18.5.

It is, therefore, recommended that the Woodlands scheme is progressed to the detailed modelling and assessment phase.

The risks associated with this assessment are mainly due to the estimated 100 year flood envelope, although as this is based upon historical data combined with the robust benefit cost ratio, it is felt that this risk is within manageable limits. A

detailed modelling exercise in the next phase would more accurately define the flood envelope and determine flood defence levels.

1 Introduction

1.1 Aims and objectives

WS Atkins (WSA) was commissioned by Scarborough Borough Council (SBC) to undertake a pre-feasibility study for a section of Woodlands Vale and Throxenby Watercourses. This assessment is designed to collate and analyse information such that a determination can be made whether a scheme is feasible to justify a detailed study and submission to DEFRA for grant funding.

1.2 Methodology

For this stage the following information was collected and analysed:

- ◆ A topographic survey of the critical areas for the study
- ◆ Site visits and a photographic survey
- ◆ A questionnaire sent to residents and relevant groups including the Woodlands Vale Residents Association.
- ◆ An initial consultation exercise to relevant environmental organisations

Using the above information, flood mechanism and the extent of potential flooding were assessed and preliminary engineering and economic appraisals undertaken.

1.3 Catchment Descriptions

The route of these watercourses and their key hydraulic / drainage features have been assessed from three main sources: the published OS data, a walkover inspection, and a limited topographic survey carried out on the watercourse. A location and study reach of the two watercourses are presented in Figure 1.1 (Woodland Beck) and Figure 1.2 (Throxenby Beck).

Throxenby Beck and Woodland Beck drain the same catchment. In high flows, flood waters have been reported to flow from Throxenby Beck down Scalby Road, and from Woodland Beck continuing at Woodland Drive meeting at the cross-road of Scalby Road and Woodland Ravine. Woodlands Drive is the primary route to access the Scarborough General Hospital.

Throxenby Beck

Throxenby Beck is a small watercourse flowing in an easterly direction, located in the west of Throxenby (a small village slightly to the north of Scarborough). The watercourse is entirely open channel, originating in Throxenby Mere and running for approximately 1200m in an easterly direction.

The upper reaches of Throxenby Beck run through rural landscape, while the lower reaches flow through a semi urban area until it drain into the towns sewer system.

Woodlands Beck

Woodland Beck flows north, with a slight arc to the East. It is located in the outskirts of Scarborough to the west of the town. Approximately one third of the way down the beck a small tributary drains run-off from the neighbouring cemetery, crematorium and surrounding hills into the beck. Woodland Beck flows in open channel through rural landscape, until the last 250m where it arcs back into the urban outskirts of Scarborough.

It is believed that Woodlands Beck drains into Peasholm Beck. Though this is subject to further investigation.

It should be noted that while 'Woodlands Beck' does not appear to have an official name, the proximity to Woodlands Drive has resulted in Woodlands Beck being utilised throughout this report.

2 Data collection & review

2.1 Data collected

No previous studies have been carried out on Woodlands Beck and Throxenby Beck and therefore data for this report has been obtained from site visits, information from residents and SBC.

2.2 Site Walkover

A site visit and walkover inspection was undertaken by experienced river engineers in October 2003. The main objectives of the watercourse walkovers were to:

- ◆ Assess the general characteristics of the catchment;
- ◆ Identify any hydraulic controls on the watercourse;
- ◆ Make an initial assessment of the likely limit of the floodplain and flood risk areas.
- ◆ Identify locations for which topographic survey data will be required.

Properties that were potentially at flood risk or were known to have flooded in the past were identified during the walkover survey, and a flooding questionnaire was delivered to the properties following approval from Scarborough Borough Council.

Photographs of key features of the watercourse/catchment were taken during the site visit and can be found in Appendix A

2.3 Topographic survey

A topographic survey for both the Woodland and Throxenby water courses was carried out by Survey Operations Ltd during November & December 2003.

This survey incorporated structure data for identified bridges and culverts which were identified to be potential hydraulic constrictions from the site walkover. In general all hydraulic structures were surveyed as follows :

- ◆ One cross-section immediately upstream of the structure;
- ◆ Details of the structure and of any flood relief arches across the floodplain: shape, width, height, length (dimensions and shape), soffit level, deck level, springing levels, shape of weir, width of the weir crest, internal diameter;

- ◆ Ancillary equipment such as trash screen: general shape and details of the screen (skew angle, diameter of bars, space between bars).

The survey of both watercourses also included property thresholds in specified areas. The threshold level is defined as the lowest point where water can flood the property (e.g. basement window, brick grill, and front/back doors). This data was required in order to assess the extent of flooding and the number of properties likely to be affected by internal flooding during a high flow event. The survey locations and results are presented in Figure 2.1 (Woodlands Beck) and Figure 2.2 (Throxenby Beck).

2.4 Planning and development issues

Scarborough Borough Council is currently assessing a proposal from Joseph Rowntree Housing Trust to develop 2.8 ha area west of Hovingham Drive as indicated on Figure 2.1. The proposed development consists of 40 apartments divided in among 5 blocks, 14 self contained bungalows and a central amenity area.

The area is currently undeveloped and Scarborough Borough Council has raised concern of the additional runoff this development will bring to Woodlands Vale and the increased risk of flooding of the downstream properties.

2.5 Consultations

A number of organisations were contacted to determine whether they had any interests regarding Woodlands Vale and Throxenby watercourse. The list of bodies contacted and their responses are reproduced in Appendix B and summarised in Table 2.1

Organisation	Response
Scarborough General Hospital	Dual carriage way in front of the college floods and prevents ambulances from coming out of the hospital
Scarborough Borough Council (Highways)	No response
Scarborough Borough Council (Planning)	The Scarborough Local Plan allocates housing and open space to the west of Woodlands Vale. 1.46 ha of land for 36 dwellings west of Woodland Vale is allocated along with two areas designated for open space.
Scalby & Newby Parish Council	No issues regarding this area
Woodlands Vale Residents Association	No response
Woodlands Crematorium	No flooding reported
Woodlands School	No flooding reported
Yorkshire Water	No response
The Countryside Agency	No comment to make at this stage, would welcome being kept informed as the study progresses and reaches completion.
RSPB	No comments to make
Yorkshire Wildlife Trust	No response
Environment Agency	No formal response received. The watercourse is not designated as a critical ordinary watercourse by the EA
English Nature	No comments to make at this stage
English Heritage	No response.
National Farmers Union	No response received.

Table 2.1 – Responses from Consultees

The major consultees such as English Nature, RSPB and EA felt that there was no need for further consultation until proposals for works on flood defence were at a more mature stage.

2.6 Responses from residents

Questionnaires were delivered to properties identified to be at possible risk of flooding as described above. A full list of questionnaire responses can be found in Appendix B and a summary of the key information obtained is presented below.

The response rate to delivered questionnaires was extremely good with much information being obtained. Flooding was reported at a number of locations for Woodlands Beck and Throxenby Beck, this is summarised by location below and presented in Figure 2.3 for both watercourses.

Throxenby Beck

14 questionnaires were received from residents of Lady Edith's Drive, all of the respondents reported flooding of the school grounds, college grounds and of the road. The flooding is reported to be due to under capacity of the channel and debris further reducing the channel cross-section and blocking culvert inlet screens. In heavy rain the beck water level rises and backs up flooding lower ground in Yorkshire Coast College grounds and Raincliffe School and then spills onto the road pooling at the junction of Lady Edith's Drive and Scalby Road. Flooding of the College grounds is reported as being frequent. Flooding of the road is reported to occur 3-4 times per year.

In more extreme events such as August 2002 and autumn 2001 flooding affected much of Scalby Road which is a primary route (A171) and inundated vehicle access to the hospital. The whole of Lady Edith's Road and surrounding area is affected. Flooding of the road is reported 0.25m-0.5m deep at its deepest, making the road impassable for cars.

No property flooding was reported as a result of the beck overtopping, however some garden flooding was believed to occur.

Woodlands Beck

Residents of Dalby Close reported no flooding of the close itself but did note flooding had occurred in winter 2002 and Spring 2003. This flooding affected the park area through which the beck flows after flowing under Hovingham Drive. The roads Hovingham Drive and Woodland Drive were flooded in the area close to Cherry Tree Avenue. The area behind The Duchess public house also flooded.

The occupant of 101 Hovingham Drive reported that several times the water level in the beck reached bank level and overtopped the bank. However the water level did not quite reach property level.

Several residents stated that the culverts going under the roads in the area and the culvert draining into the sewer system get blocked regularly.

Residents of Caburn Close reported flooding due to the watercourse backing up from the culvert entrance where the watercourse flows into culvert at the downstream end of the park area. The culvert screen became blinded by vegetation causing water to back up and overtop the banks. The water flowed into the park area and behind 1-19 Caburn Close to the entrance of Caburn Close. Water then flowed through the lower part of Caburn Close 2-18 affecting the ground floor flats. Six properties were reported to have been affected. Water then continued to the lower part of Hovingham Drive and Woodlands Drive. Vehicles were damaged and water levels in the car parking area were reported as being high.

Wrack marks were observed following the flood event showing high water levels had occurred. Much debris remained following the flood event and flood waters took one day to subside.

It was reported that the culvert entrance blocks regularly and this has resulted in flooding as described above several times.

Throxenby and Woodlands

The owner of 1b Stepney Drive was met on site by our engineers. In association with the occupier of 1 Hovingham Drive, they have experienced flooding due to water flowing from Woodlands Drive in their properties. In high flow events water reaches Woodlands Drive from Throxenby Watercourse via Scalby Road and from Woodlands which flows onto Woodlands Drive via Hovingham Drive. The flooding problems are reported to have started after development on Hovingham Drive in the early eighties and the drainage of this area is possibly under capacity. During conditions of severe rainfall, the water flowing from Throxenby Watercourse that is supposed to drain to the sewer system overtops the banks and runs over the field at the college. It then turns south and joins Woodland watercourse.

Residents have also raised concerns about the planned development of 5 residential units in Woodland Vale. SBC states that since the area was previously blocked paved the development of this area will reduce the impermeable area by 46% and consequently reduce the surface water runoff. Consultants appointed by the developer undertook a soil investigation which concluded that the soil was suitable for soakaways. The occupant of 1b Stepney Drive is not satisfied with the tests since they were carried out in hot and dry summers and so are in his opinion unrepresentative. The results would have been quite different with saturated ground and a high ground water table.

Table 2.2 summarises the problems in the area as reported by the questionnaire responses.

No.	Location	Properties affected by Flooding	Frequency	Cause of Flooding
Throxenby Beck				
1	Lady Edith Drive	Road and Gardens	3-4 times Annually	Blockage of culvert
Woodlands Beck				
2	Hovingham Drive	Road and garden.	Annually	Blockage of culvert
3	Caburn Drive	6 Properties and road	Annually	Blockage of culvert
4	1 Hovingham Drive	House and Garden	Residential flood happened once. Road and gardens 3-4 times annually	Channel incapacity
5	1b Stepney Drive	House and Garden	Annually	Channel Incapacity

Table 2.2 – Summary of Historical Flooding Information

A detailed analysis of the culvert capacities can be found in section 3.

2.7 Recent Flooding

As outlined in Section 2.6, local residents have reported problems with flooding numerous times over the past few years. The incident dates reported are summarised below.

- 2001, Lady Edith Drive and Scalby Road
- 2nd August 2002, Lady Edith Drive and Scalby Road
- 10th August 2002, Lower flats on Caburn Close, 1b Stepney Drive and 1 Hovingham Drive.
- Winter 2002 Hovingham Drive
- March 2003, Woodlands Drive, Hovingham Drive, Cherry Tree Avenue. Back of Duchess Pub

It is clear that flooding in these areas along both watercourses is frequent and that a fundamental weakness of the drainage system is culvert incapacity combined with blockages at culvert entrances.

3 Hydraulic and Hydrological Calculations

3.1 Culvert Capacity Calculations

To analyse the capacity of the culverts the Culvert design guide (CIRIA) was used. The method adopted was standard circular inlet controlled culverts which enabled a determination of flow for varies water levels upstream of the culverts.

3.2 Hydrology Assessment

Rainfall runoff models were been constructed using FEH boundary units within the ISIS hydraulic modelling software. The catchment area is determined using the catchment boundaries suggested by FEH-CDROM. The rainfall-runoff method estimates flows by explicitly examining the relationship between rainfall and the hydrological response of a catchment to a storm event. Three key parameters are used by the rainfall-runoff model to define the hydrological characteristics of a catchment. These are: Catchment response to rainfall (unit hydrograph time-to-peak, T_p); proportion of rainfall which directly contributes to river flow (percentage runoff, PR); quantity of flow in the watercourse prior to the storm event (base flow, BF).

Since there is no flow gauge in the catchment, the parameters are derived using digital FEH catchment descriptors. Rainfall is defined in terms of duration, depth and distribution (over time), and may relate to either a probabilistic design event, eg: 1 in 100 year return period, or an observed storm event (for calibration purposes).

Figures 3.1 and 3.2 outline the catchment boundaries and the contour lines for the Woodlands Vale and Throxenby catchments respectively. It is clear that the catchments are both steep and would have high runoffs associated with severe events.

The return period flows from FEH are presented in Table 5.1 below, although being an un-gauged catchment it should be noted that reliable figures are best gained from a long period of flow readings.

Return Period (yrs)	2	5	10	25	50	75	100
Flow Rate m ³ /s Woodland	0.4	0.6	0.8	1.0	1.3	1.5	1.6
Flow Rate m ³ /s – Throxenby	0.6	0.9	1.1	1.5	1.8	2.0	2.2

Table 5.1 – FEH Flows for varying return periods

3.3 Return Periods of Recent Storms

With the survey information held and without a hydrological model it is difficult to access the return period of the August 2002 storm. Though for the benefit cost assessment it is assumed to have a 1 in 5 year return period.

3.4 Capacities of Throxenby Watercourse

The following conclusions were made comparing the FEH run off estimation with the culvert capacities estimated.

The culvert draining Throxenby watercourse going under Scalby Road is estimated to have a capacity of approximately a 40 year return period event, with a bank-full estimated to be of the order of 1.3m³/s.. A graph showing the flow – Head relationship is presented in Figure 3.3. This indicates that the Q100 flow is approximately 1.5m³/s. The stage (level) presented in this graph indicates the level the water would attain assuming the banks were vertical (i.e. a glass-walled channel) and the flow is determined at the culvert entrance.

The channel appears to possess a reasonable conveyance capacity, but is sensitive to debris and the storm capacity of the culvert that takes it out of the area.

The sewer drawing at location where Throxenby watercourse drains into the sewer is shown in Appendix D. From this it can be seen that the sewer system at this point is critically under capacity with a diameter of 150 mm. This would have an unsurcharged capacity of approximately 0.01 m³/s and a 1m surcharged capacity of 0.05 m³/s.

3.5 Capacities of Woodlands Watercourse

The culvert draining Woodland watercourse going under Caburn Close has been estimated to have a capacity of approximately 1.25 m³/sec corresponding to a return period event of between 10 and 25 years. A graph showing the flow – Head relationship is presented in Figure 3.4. This indicates that the Q100 flow is

estimated to be approximately $2.2\text{m}^3/\text{s}$. Clearly, the culvert is of insufficient capacity to take a 100 year event and regular flooding would be expected.

3.6 Assumptions made in Capacity Calculations

It should be noted that the above calculations exclude channel blockages and restrictions which can be seen from recent events to significantly reduce these return period capacities.

4 Defining the problem

4.1 Historical flooding

A number of properties and numerous gardens and roads are regularly inundated as determined through historical accounts and presented in Figure 2.3.

4.2 The 100 year predictive flood outline

The catchments for Woodlands Vale and Throxenby watercourse are both relatively rural and steep and thus exhibit a rapid runoff regime.

The culverts in the area do not appear to be designed appropriately to accommodate the degree of flow experienced and are consequently severely surcharged. This, combined with the incapacity of the open channel sections provides the main reason for flooding. A predictive 100 year flood outline is also presented in Figure 4.1, combined with the areas of historical flooding, indicating that up to 53 properties in total could be at risk in this scenario for a 100 year return period event. This is likely to be an over-estimate but indicates the potential seriousness of the problem.

It should be noted that the flood outlines predicted have not been determined from mathematical modelling, but via the historical flood locations combined with a basic assessment of expected volumes of water expected during a 100 year return period event. This predictive flood outline would require to be confirmed via detailed modelling and flood routing assessments.

4.3 Detailed Assessment of Flooding Mechanisms

Throxenby Beck

Throxenby watercourse drains Throxenby Mere a pond located on high ground west of Scarborough (see Figure 3.2). This part of the catchment is rural with a steep slope down to Scarborough giving a rapid runoff. The culverts along this watercourse are estimated to have capacities of a between a 10 and 25 year return period event. The questionnaires indicate that flooding is a frequent problem in this area which can be due to blockage of the culverts and/or channel.

In severe events Throxenby watercourse overtops and Lady Edith's Drive floods. The Road acts as a parallel watercourse and the water flows down to Scalby Road where it drains into the main sewer system through an 800mm diameter culvert. While this culvert can be considered to be adequate in terms of its size, it is understood that flood water does not appear to drain during flood conditions. The reasons for this could be a possible blockage or simply the culvert being filled to capacity via other sources.

Figure 4.3 presents a long section of the Throxenby Beck watercourse. Clearly, the bed slope is variable, the channel contains numerous culverts and the bank heights are non-uniform. This, combined with the fact that the channel capacity is quite limited and susceptible to overflow via debris and blockages, results in the current scenario evident of localised, frequent and unpredictable flooding. However, it should be mentioned that the probability of internal flooding of properties is considered low.

The area that appears to be the main source of the problem is the junction of Lady Edith's Drive and Scalby Road. A solution to the flooding problems at this location will also benefit the properties south along Scalby Road which acts as a flow path directing flood water into the woodland catchment.

Woodlands Beck

Woodlands Beck watercourse drains a large area west of Scarborough. The area has a steep slope from the hills to the west down to Woodland giving a rapid runoff. North of the upper part of the watercourse is the location of Woodland cemetery. This cemetery has not reported any flooding problem due to its location on slightly higher ground. Woodland watercourse has a small tributary draining the cemetery which can be seen in Figure 1.1.

Further downstream Woodland watercourse goes under Hovingham Drive and Caburn close. While these culverts are not considered to be undersized and it is possible that the frequent flooding of Woodland Drive occurs because of the blockage of the trash screen or because of reduction of the capacity due to poor maintenance of the channels and their banks, leading to channel blockages in times of high flows. It should also be mentioned (from Section 3.4) that the natural channel capacity is of the order of 10 to 25 years return period.

Figure 4.2 presents a long section through the Woodlands Beck watercourse. The watercourse appears to be a constant slope with relatively uniform left and right bank levels.

4.4 Other Issues

Throxenby Beck

There are a number of safety issues along the watercourse as follows:

- ◆ Undermining of outfall structure along the watercourse at various locations
- ◆ Lack of hand-railing along stretches with steep slopes and dangerous drops into the watercourse alongside pedestrian routes.
- ◆ There is evidence of undermining of steep banks and slope failures at certain locations. Potential failure of banks would lead to channel blockage and damage to the slope and residential structures.

- ◆ Lack of trash screens at each culvert allowing access to the public so compromising safety.
- ◆ There is a lack of comprehensive maintenance along the watercourse, for example, while banks are trimmed of vegetation, the plants and grass are allowed to enter the watercourse and wash down to the culvert entrance which is badly 'silted' as a result.

With the watercourse in an urban area and with schools nearby the above safety issues require serious and urgent attention.

5 Proposed flood alleviation schemes

5.1 Throxenby Beck

It should be noted that it is not believed that Throxenby poses a serious threat to properties, although road flooding is to be expected. Three main options have been assessed to limit damage to the roads (and possibly the houses) by Throxenby Watercourse. The options are listed below and presented in Figure 5.2. Note that all the options below would require addressing the safety issues identified in section 4.4 and would require an enhanced maintenance regime along the watercourse:

- ◆ Option A – Do minimum. Replace/enhance trash screens at all the bridge culverts. (Note that this option will not provide protection for the 100 year protection standard).
- ◆ Option B – Enlarge 700m of Channel along Lady Edith's Drive to increase channel and storage capacity.
- ◆ Option C – Construct 800 m culvert from Throxenby watercourse to Peasholm Beck.

The limited capacity of the culvert under Scalby Road would still inhibit the water flowing away from Throxenby Beck at the junction with Scalby Road. This could result in regular flooding of Scalby Road and is considered a separate problem outside the scope of this report.

5.2 Woodlands Beck

Two main options have been assessed to limit damage to the houses and roads by Woodlands Vale. These are listed below and presented in figure 5.2.

- ◆ Option A - Do minimum – Construct trash screens at every culvert entrance and exit, dwarf flood walls and bunds to keep water away from properties and within the roads.
- ◆ Option B – Widen 370m of channel and replace culvert going under Hovingham Drive.
- ◆ Option C – Construct an embankment around the area west of Hovingham Drive and utilise as storage area to restrict flow into the culvert going under Hovingham Drive.
- ◆ Option D – replace culvert from Caburn Close to Peasholm Beck, a distance of appx. 600m, so removing the main construction to flow.

The area that requires protection is the area round where the Woodlands Vale goes under Hovingham Drive and the area around Caburn Close, Hovingham Drive and the hospital access that conveys flood flow in extreme events.

5.3 Throxenby Options – detailed descriptions

Option A: Enhanced Maintenance and Trash Screens (Do Minimum)

The flooding of Lady Edith Drive is partly due to a poor trash screen at the bottom of Lady Edith Drive and at the junction of Scalby Road. It is also as a result of an inadequate maintenance regime along the watercourse. Reconstruction of the trash screen numbers TH00200 and TH00000 (See Appendix B – Survey report) and de-siltation of the culverts will be necessary

It should be noted that construction of trash screens and de-siltation of the culverts will only bring the water course to a capacity of a minimum of a 1 in 10 year event.

Option B: Enlarge Channel

Widen Throxenby Water course to increase the capacity and decrease the risk of flooding of Lady Edith drive. This will also increase the storage capacity and will decrease the risk of flooding around Woodland watercourse. The picture in Appendix B - survey report, shows that this work can be done without affecting the road. There is also an opportunity to re-direct the watercourse in places where the adjacent, steep bank is at risk of being undermined and to construct stepped weirs along the route to increase storage and enhance the watercourse.

Option C: Construct 800m Culvert

Construction of a culvert connected to Peasholm Beck would decrease the impact on the existing sewer system and reduce the risk of flooding of properties and roads. This would require the construction of a new 800m culvert. The route of the new culvert would be under Scalby road, Woodland Grove and Woodland Ravine before discharging into Peasholm Beck.

5.4 Woodlands Options – detailed descriptions

Option A: Do Minimum

This option involves an enhanced channel maintenance regime combined with placing trash screens at all culvert entrances and exits. These measures would not increase the capacity of the channel significantly, but will reduce the risk of regular flooding as a result of blockages, so ensuring that maximum use can be made of the existing channel.

Option B: Enlarge Channel

In this proposal, we widen Woodlands Beck to increase the capacity and decrease the flood risk of the properties on Hovingham Drive, Cherry Tree Avenue, Woodlands Drive and Stepney Drive. This would require the enlargement of approximately 370 metres of channel and would increase the conveyance capacity to take an event of the order of approximately 50 years assuming no blockages. Currently, it is not envisaged that channel regarding is required.

Option C: Flood Protection Wall

This option proposes the construction of flood protection walls where woodland watercourse flows into the urban areas at Dalby Close and Cropton Road. The area of land available is approximately 7,500 m², although it is understood that a planning permission for future development is under evaluation by SBC on the adjacent field. The volume required to store the excess volume for a 1 in a 50 year event is of the order of 130 m³ and 1,300 m³ for 1 in a 100 year event. Including extra capacity required for climate change, factors of safety, sequential storms, it is not unreasonable to allow for a storage capacity of the order of 2,000 m³.

This option would include construction of a 330 metres flood protection wall and reconstruction of the culvert going under Hovingham Drive to ensure the storage controls will work effectively.

Construction of this flood protection wall will affect the proposed development in the area. The storage area will be located close or in the proposed development. A solution combining solving the flooding problems by Woodlands Vale and decreasing the runoff from the proposed development should be considered if this solution is selected. This should be considered at the next stage of work.

Option D: Replace culvert leading to Peasholme Beck

The incapacity of the culvert can be directly dealt with via a replacement option. This will require a 600m culvert to replace the existing via a new route through roads and along boundaries of land owned by residents.

5.5 Combined Options

It is technically feasible to construct a replacement culvert from both Throxenby Beck and Woodlands Beck, taking both watercourse into Peasholme Beck. However, there may be adverse effects on Peasholme Beck and considerable works required along the latter watercourse as a result. Nevertheless, this option has been taken forward for an economical assessment. In the event of other bodies taking part in potential schemes such as developers, Yorkshire Water and the Highways Agency, this option may be politically possible.

6 COST BENEFIT ASSESSMENT

Table 6.1 presents the Benefit Cost Ratios for the proposed schemes using the MCM manual. It should be noted that at this stage costs of flooding of roads are not included in the scheme costs for Woodlands Vale as well as the risk of cost of lives caused by flooding of Woodlands Drive making ambulances unable to reach the Hospital.

	Option		Damage Prevented	Scheme Summary	Scheme Costs - £k		Benefit Cost Ratios	
					Min	Max	Min	Max
Throxenby Beck	A	Do Minimum	Frequent flooding of Scalby Road and Lady Edith's Drive	Enhance last trash screen, place more trash screens at all culverts and enhance maintenance regime	28	43	1.9	2.4
	B	Enlarge 700m of channel	Frequent flooding of Scalby Road and Lady Edith's Drive	Enlarge channel along Lady Edith's Drive	463	913	0.2	0.3
	C	Construct new 800m culvert	Annual flooding of Scalby Road and Lady Edith's Drive	Connect Throxenby watercourse to Peasholm Beck with a culvert	5,025	7538	0.0	0.0
Woodlands Beck	A	Do Minimum	Frequent flooding of roads and properties	Enhance maintenance regime and construct new trash screens along the channel	No identifiable benefit so not calculated			
	B	Enlarge Channel	8 homes every 5 years and up to 53 properties in a 1:100 year event	Enlarge 370m of channel and reconstruct culvert under Hovingham Drive to act as a control	2,256	3,500	1.6	2.4
	C	Flood Storage and flood protection wall		Construct 330m of flood protection wall to increase storage capacity at the culvert entrance before Caburn Close	388	744	7.1	13.2
	D	Construct new 600m culvert		Convey Wodlands Beck into Peasholme Beck via new culvert	3,775	5,553	1.4	1.0
Combined		Construct new 800m combined culvert	Flooding of Scalby Road and all properties along Woodlands Beck	Pick up Throxenby Beck and Woodlands Beck into Peasholme Beck, enlarge and enhance Peasholme Beck	5,788	8,738	0.6	0.9

Table 6.1 Benefit Cost Assessment Summary

The costs have been determined as presented in Appendix C, with maintenance of £1,000 per year allowed for and a contingency of 25%. The average annual damage has been calculated for as £8k with a present value of total damage of £241 for Throxenby watercourse. For Woodlands Vale the average annual damage of £209k with a present value of total damage of £3.5k.

It is advisable that schemes with a benefit cost ratio greater than 2 are worth presenting for DEFRA for grant aid assistance. On this basis option A is worth presenting for Throxenby Watercourse (do minimum) and options B and C for Woodlands watercourse, namely enlarging the channel and constructing flood defences respectively.

7 Conclusions & Recommendations

7.1 Throxenby Beck

Option A for Throxenby watercourse (Do Minimum) has been shown to have a benefit cost ratio of 1.9 to 2.4. The relatively small damages and few properties at risk do not make the DEFRA prioritisation score appropriate. It is recommended that the do minimum option is undertaken, especially as it relates to areas of safety such as hand-railing and undermining of embankments. The construction of additional trash screens, enhanced maintenance and upgrading and clearance of the existing trash screen should be sufficient to provide protection against the frequent events.

7.2 Woodlands Beck

The schemes proposed have been shown to be robust with benefit cost ratios up to 13.2 for Woodlands Vale. The DEFRA scheme prioritisation score of 18.5 has been achieved for Option E (flood storage option).

It is, therefore, recommended that the schemes for Woodlands Vale are taken forward to the next more detailed assessment phase. This would involve detailed mathematical modelling to confirm the flood outlines and check the technical feasibility of the proposals. The following items should be noted in this regard.

- (i) The detailed assessment will require a mathematical modelling exercise, including additional topographic survey. The modelling would provide design information for storage options, channel widening/regarding and requirements for and levels for various flood defences (i.e. floodwalls) proposed.
- (ii) It should be noted that the 100 year flood envelope has been determined using historical flood information and without detailed mathematical modelling and may be subject to change.
- (iii) The consultation phase of this project could be lengthy depending upon the solution adopted. This is due to the character of the area, the local interest in use of the land plus the land ownership issues that would need to be resolved for some of the options.
- (iv) There may be some requirements for a habitat survey and consultations with EN and EA, although at this stage, the initial consultations have suggested that these key consultees would only like to be kept informed. It should be noted though that there is a general philosophy of de-culverting wherever possible.

FIGURES

Appendix A
Site Photographs

Appendix B

Questionnaire Responses

Appendix C

Cost benefit Assessment

Appendix D

Sewer Record

