ENVIRONMENT AGENCY
NORTH EAST REGION

SECTION 105 - C30/92 SURVEYS
CATCHMENT DRAINAGE STUDIES AND
FLOOD PLAIN IDENTIFICATION

COCKSHAW/HALGUT BURN AT HEXHAM

JUNE 1998

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THE ENVIRONMENT AGENCY, NORTH EAST REGION, NORTHUMBRIA AREA
SECTION 105, CIRCULAR 30/92 FLOOD PLAIN MAPS
SUMMARY
COCKSHAW BURN AND HALGUT BURN
June 1998

This summary is to be read in conjunction with map reference:

- C1395/FPM/01/050

Study Reach

The study includes a 2.7km reach of the Cockshaw Burn between the River Tyne at NGR NY938 648 and Bishopton Way at NGR NY922 634 and a 1.6km reach of Halgut Burn between Cockshaw Burn at NGR NY933 644 and High Shields at NGR933 630.

Existing and Predicted Problems

Locations that are predicted to flood and the areas at risk during a 100 year event are as follows:

• Highford Lane Bridge	Road flooding
• Maidens Croft Culvert	Flooding to residential property
• Cockshaw Road footpath	Road flooding
• Cockshaw Burn confluence culvert	Flooding to properties and road
• West Cumberland twin culverts	Flooding to properties and road
• Ridley Terrace culvert	Road flooding
• Priestlands Lane Culvert entrance	Road flooding
• The Priory	Flooding to public area
• Halgut Burn confluence culvert	Flooding to properties and road

The existing flooding problems on this reach are covered in the "Report on Survey of Flooding Problems Volume 1, March 1997" Posford Duvivier

CONTENTS

1.0 INTRODUCTION

1.1 Section 105 Surveys Circular 30/92

Section 105 – C30/92 surveys will be the Environment Agency's main input to the preparation of the Local Planning Authority (LPA) development plans. The surveys have been instigated by the Department of the Environment Circular 30/92 and are carried out by the Agency under the powers granted by section 105(2) of the Water Resources Act 1991.

Surveys within the Agency's North East Region encompass three elements:

- Indicative flood plain mapping
- Surveys of flooding problems
- Catchment drainage studies

1.2 Scope of this Study

The Section 105 - C30/92 Survey reported here covers watercourses in Hexham, namely the reaches of Cockshaw Burn between the River Tyne confluence and Bishopton Way and the tributary of Cockshaw Burn, Halgut Burn between its confluence with Cockshaw Burn and High Shields all as detailed in the brief. Associated catchment details are also included where there is an impact on the reach under investigation.

The study includes a 2.7 km reach of Cockshaw Burn and a 1.6km reach of Halgut Burn.

Cockshaw Burn was hydraulically modelled between the River Tyne confluence at NGR NY938 648 and the Bishopton Way at NGR NY 922 634. Halgut Burn was modelled between the Cockshaw/Halgut Burn junction, at NGR NY933 644 and High Shields, at NGR NY 933 630.

The catchment associated with Cockshaw Burn has a total area of 9.68km². The catchment area was derived from 1,25,000 scale OS plans using contours which are shown every 5m. The 2.7 km reach modelled has an average slope of 1 in 32. The catchment of one of its tributaries, Halgut Burn, has a total area of 3.02 km². The 1.6 km reach of Halgut Burn to be modelled has an average slope of 1 in 24.

Figure 1.1 shows the extent of the reach under consideration. *Figure 1.2* shows a larger scale plan of the confluence of the two Burns and the joint channel downstream of their confluence. The Cockshaw/Halgut Burn junction occurs where two culverts join. Halgut Burn enters a culvert at the west end of Tanners Yard and runs under Alexander Place to approximately the junction with Eilansgate. Cockshaw Burn enters a culvert at the end of Tanners Row and again runs to approximately the Alexander Place/Eilansgate junction. Downstream of this point, both culverts are connected at regular intervals, running almost parallel beneath Tyne

Green Road until discharging to a single channel at the east side of Tyne Green Road.

1.3 Purpose of this Report

This report describes the work carried out for the Flood Plain Mapping and Catchment Drainage Studies. It provides the details required by the Agency's Survey Brief. It should be read in conjunction with the Report on Survey of Flooding Problems Volume 1, March 1997 and the following 1:10,000 scale map:

- C1395/FPM/01/050

and 1:2,500 scale map:

- C1395/DM/01/050

2.0 DATA COLLECTION

2.1 Environment Agency Area Offices

Visits were made to the Newcastle office of the Agency to gain survey and flow data that would assist in the building of the model. The Agency's Liaison Officer, Mr David Bassett, gave guidance during the visit as to where useful data could be found.

Some photographs of recent localised flooding were available. The Hexham (South East) Drainage Study, December 1994, and Hexham Drainage Study Stage II June 1995, both produced by Ove Arup & Partners were collected. These reports provided the following information:

- Flow capacities of the channels and culverts in the reach
- Predicted flood flows
- The route of flooding for an event that took place in October 1993

The reports also gave details of the dimensions of the culverts in the lower part of the catchment near the confluence of the Cockshaw and Halgut Burns

2.2 Site Visits

During site visits to the catchment an assessment of the main hydraulic and hydrological features to be included in the required model of both reaches was made. Each of the hydraulically significant structures on the watercourse was visited and a series of photographs taken during the visit. The knowledge gained from these visits was used to determine the location of the appropriate cross-sections (node points) to be surveyed in detail in order to build the required hydraulic model.

2.3 Topographical Survey

In order to construct the required hydraulic model a topographical survey of suitable cross sections was undertaken by James Bank Surveys during December 1996. Survey was undertaken at a total of twenty two locations, fourteen along the Cockshaw Burn and eight along the Halgut Burn. Twelve of these locations were at bridges. At four of the bridges additional cross-sections were surveyed. One was taken just downstream of the structure, one just upstream and the third was taken of the upstream face of the bridge. At the other eighteen locations a cross-section of the channel and banks was surveyed. The survey was limited to the minimum number of cross-sections needed to produce results that were appropriate to the accuracy of the model and other parameters used. Although, detailed cross sections at 50m centres would give excellent topographical detail of the channel, it would have little effect on the final water level confidence.

3.0 INDICATIVE FLOOD PLAIN MAPPING (Brief 3.1)

3.1 Flow Estimation

Visits to the Agency Offices and discussions with Agency staff confirmed that no flow gauge data was available for the Cockshaw Burn or Halgut Burn. Therefore in order to construct a useable hydraulic model it was necessary to make an estimation of flows based on the best theoretical data set available. The lack of gauge data or any event data also meant that the modelling work cannot be calibrated and consequently has a significant impact on the results.

The flow at various locations throughout the catchment was estimated using the methods identified in the Flood Studies Report and the subsequent supplementary reports. The Flood Studies Report was published by the Natural Environment Research Council in 1975. The document provides methods of flood estimation for use in engineering design. FSR was recognised in the brief as being an acceptable method of flow estimation.

There are fundamentally two types of flood prediction technique recommended in the Flood Studies Report. These are statistical methods (eg. frequency analysis) and unit hydrograph methods. The purpose of the statistical analysis is to derive a relationship between flood magnitude and return period. The simplest form of frequency analysis is the annual maxima series where the largest flood event from each year is abstracted. In general the procedure for the unit hydrograph method is rather more complex than for the statistical methods. The unit hydrograph should be derived if possible from rainfall run off records but may be estimated from catchment characteristics if no records exist. The accuracy of each method depends on the amount and quality of data available. Estimates from gauged catchments are more accurate than those from ungauged catchments.

The method of flood estimation contained within the Flood Studies Report has been reviewed by D. Archer in "A Catchment Approach to Flood Estimation". Archer suggests the use of catchment and regional flood parameters to adjust estimates of flood discharge Archers method of estimation was considered for use during the Section 105 surveys. The Agency have chosen in this case not to prefer Archers method because of the signficantly different flows predicted compared to Flood Studies results. The Agency's brief approved the use of the Flood Studies Report method of estimation.

Micro-FSR is a computer programme produced by the Institute of Hydrology. Micro-FSR, enables the estimation of design flood hygrographs and flood peaks using the methods contained in the Flood Studies Report. It requires the catchment characteristics to be input.

To estimate the increase in flow along both reaches being investigated the catchment was divided into sub-catchments. The flows were estimated using the unit hydrograph method in Micro-FSR at the following four locations as shown in Table 3.1 and Figure 1.1.

Table 3.1

Location of Flow Estimates

Location	NGR/Description	Reach
1	NY 938 648: Confluence of Cockshaw Burn and River Tyne	Cockshaw Burn
2	NY 931 641: Confluence of Cockshaw Burn and Hellpool Lane Tributary	Cockshaw Burn
3	NY 923 637: Confluence of Cockshaw Burn and Highford Lane Tributary	Cockshaw Burn
4	NY 933 633: Confluence of Halgut Burn and Wydon Burn Reservoir Overflow	Halgut Burn

These locations which are spread along the study reaches are generally at the confluence of Cockshaw Burn or Halgut Burn and one of their tributaries. The flows have been estimated immediately upstream of the confluence. This has been done so that the predicted flow could then be included within the model in the reach upstream of the confluence.

The characteristics estimated for each sub-catchment which are necessary inputs into MicroFSR are shown in Table 3.2 below. A description of each characteristic has also been included.

Table 3.2

Catchment Characteristics

Characteristic/ Parameters	Location			
	1	2	3	4
Area	9.68km²	6.13km²	4.4km²	1.5km²
Urban Fraction	19.9%	13.3%	2.0%	12%
Main Stream Length MSL	5.73km	4.48km	3.35km	1.76km
Stream Slope (S1085)	37.9m/km	41.7m/km	47.8m/km	60.6m/km
Soil Index	0.45	0.45	0.45	0.45
Annual rainfall (SAAR)	720mm	730mm	760mm	730mm
M5 -2 Day Rainfall	49mm	50mm	50mm	50mm
Ratio M5-60 Min Rainfall/M5-2D Rainfall	33.5%	33.5%	33%	33.5%
Effective Mean SMD	6.5mm	6.5mm	6.5mm	6.5mm

Characteristic/Parameter Description

Area	-	The area draining to a site
Urban Fraction	-	An index of urban development
Main Stream Length	-	The longest stream length measured upstream of a station
Stream Slope	-	Mainstream Slope between the 10 and 85 percentiles of mainstream length
Soil Index	-	Determined from the fractions of five classes of soil which are based on their winter rain acceptance potential
Annual Rainfall (SAAR)	-	Standard average annual rainfall
M5-2 Day Rainfall	-	2 day rainfall of 5 year return period
Ratio M5-60 min/M5-2 day	-	The ratio of the 60 minute rainfall of 5 year return period to the 2 day rainfall of 5 year return period
Effective mean SMD	-	Effective mean soil moisture deficit

The Soil Index, Annual Rainfall, M5-2 Day Rainfall, ratio of M5-60min rainfall to M5-2 day rainfall and the Effective Mean Soil Moisture Deficit values for the catchment were determined using the maps included in Volume V of the Flood Studies Report. The Soil Index is derived from the fractions of the catchment occupied by various soil classes. Five classes of soil, based on their winter rain acceptance potential, are shown on the map. The soil index for a catchment is derived by measuring the fractions of the catchment within each soil class, and adopting a weighted mean of these soil fractions. The surface area of Wydon Burn Reservoir is less than 1% of the area contributing to it so has been ignored.

The remaining values were derived from maps showing contours of each characteristic. Catchment average values are required and these were obtained by weighted areas.

The rainfall run-off method within Micro-FSR was used. This produces a flow peak for a flood of a particular return period and also has the option of producing flood hydrographs. The revised estimation equations summarised in Flood Studies Supplementary Report number 16 (FSSR16). were used.

All four of the locations where flow estimates were made have a catchment area of less than $10km^2$. This classes them as a small catchment. Institute of Hydrology Report No. 24, flood estimation for small catchments suggests an alternative method to FSSR16 for calculating the time-to-peak of the instantaneous unit hydrograph for catchments with an area less than $25km^2$. The result of this is that the flows estimated using the Institute of Hydrology method are approximately 7% lower than those using FSSR16. This small difference has not been considered in the modelling and therefore the worst case has been used.

Table 3.3 shows the estimated flows that were input into the model using the Micro-FSR output for flood events with return periods of 5, 10, 20, 50 and 100 years. The critical storm duration for the study reach was determined to be 4.5 hours.

Table 3.3

Flows estimated from MicroFSR Output

Return Period Year	U/S of River Tyne Confluence to Halgut/Cockshaw junction (m^3/s)	Between Junction to Hellpool Lane Tributary Confluence (m^3/s)	U/S of Hellpool Lane Tributary Confluence (m^3/s)	U/S of Highford Lane Tributary Confluence (m^3/s)	Between Junction to Halgut/Wydon Burn Reservoir Confluence (m^3/s)	U/S of Halgut/Wydon Burn Confluence (m^3/s)
5	7.88	4.99	4.23	3.47	2.75	1.57
10	9.45	5.98	5.06	4.14	3.31	1.89
20	10.96	6.97	5.94	4.90	3.85	2.20
50	13.62	8.67	7.36	6.04	4.74	2.71
100	15.71	9.99	8.47	6.95	5.50	3.14

When the flows predicted by MicroFSR are compared to the flows predicted by Arups in their reports of December 1994, the following observations can be made:

1. The predicted flows in Halgut Burn are very similar
2. The flows predicted in the Cockshaw Burn by Arups are approximately 20% - 25% less than the estimates shown in Table 3.3

The flows predicted by Micro-FSR (Table 3.3) were used to calculate the flows entered into the river model. The flow estimates were used in the model on the reaches immediately upstream of the location where each flow estimate was made. This ensured that the flow and consequently the water level were not underpredicted.

3.2 HEC-RAS Modelling

HEC-RAS River Analysis System is a one dimensional steady state model produced by the US Army Corps of Engineers. HEC-RAS has the ability to assess water levels and velocities in open channel river systems. It can model steady flow water surface profiles, branched channel networks, supercritical, subcritical or mixed flow regimes and a variety of structures. These features make it suitable for modelling the reaches being investigated here.

The cross sectional survey data was entered into HEC-RAS. A series of derived cross sections had to be entered into the model in order to ensure its functionality.

Chainage 0m on Cockshaw Burn is at the confluence with the River Tyne. Chainage 0m on Halgut Burn is at the confluence with Cockshaw Burn. All other chainages were measured in an upstream direction from these points.

To model a bridge or a culvert four cross-sections are required: two immediately downstream and upstream of the structure and the other two cross sections sufficiently downstream and upstream for the flow not to be affected by the structure. A series of cross-sections have therefore been derived from the one surveyed in order to produce a complete model. Whenever new cross-sections were added to the model their bed level was determined by linear interpolation between the two nearest surveyed cross-sections. Again without an extremely extensive survey this is the most suitable way forward to produce results of an accuracy appropriate to all the available data.

The survey shows fourteen sections taken along Cockshaw Burn. Seven of them were taken at the proximity of a bridge.Three bridges were not considered to affect the flow and were not modelled in HEC-RAS; these are:

- a small footbridge immediately downstream of the Ridley Terrace/Railway culvert at NGR NY933 649, deck dimension small, no abutment and no pier in the water.
- a footbridge in Tanners Row at NGR NY933 643
- a wide and tall steel bridge at NGR NY 929 638 near Fairfield

Three culverts on the Cockshaw Burn were surveyed. The size of the un-surveyed culverts were taken from the data contained within Arup's report.

The Cockshaw culvert has been recently improved at its downstream end. The brick arch beneath Tanners Row is now linked to a concrete box culvert. The brick arch was modelled using the dimensions given in Arup's report and the dimensions of the new culvert were estimated from the survey.

At the time of the site visits to the catchment, work was taking place to the Ridley Terrace masonry culvert. This culvert, which is linked to the Tyne Green concrete box culvert and the twin box culverts beneath the railway, was being replaced with a culvert with greater capacity. During the construction of the model it was assumed that the twin box culverts beneath the railway would be the limiting section of culvert so this was included in the model.

Eight sections along Halgut Burn were surveyed. Three of the sections were at a culvert location, two at a bridge and the others were taken along the channel.

A footbridge at St Wilfrid's Onteway (downstream of the bowling green) at NGR NY 934 642 was not surveyed but the upstream cross-section at a small distance from the foot bridge was used to estimate the bridge dimensions and to model the bridge in HEC-RAS. The bed level was adjusted after considering the bed level of the cross-sections surveyed immediately upstream and downstream of the footbridge.

The only weir in the catchment is on Cockshaw Burn within the area known as The Seal. HECRAS version 1.2 does not facilitate the modelling of weirs and it recommends that the bridge modelling interface is used instead. This was done by inputting the underside of the bridge deck with the same levels as the bed of the channel and the top of the bridge deck at the same level as the crest of the weir. The flow is forced over the top of the bridge deck and the head of water is calculated using the standard weir equation.

The junction between Cockshaw Burn and Halgut Burn was constructed using the junction facility within HECRAS. It is not possible to model the junction between the watercourse occurring within the culverts in HECRAS so for modelling purposes the culverts have been interrupted immediately upstream of the junction, to be modelled again immediately downstream.

It was necessary to extend the widths of some cross-sections when the predicted water levels were above the highest ground level. This was done by plotting a higher ground level, taken from the position of the nearest 5m contour on a 1:25000 scale map.

3.3 Model Parameters

Several types of coefficient are utilized by HECRAS to evaluate energy losses. They are:

(1) Mannings n values for friction loss due to the roughness of the channel section material
(2) Contraction and expansion coefficients to evaluate transition losses.
(3) Bridge and culvert coefficients to evaluate losses related to weir shape, pier configuration, pressure flow and entrance and exit conditions.

A Manning's value of 0.03 has been used for a natural channel and for the concrete channel a value of 0.02 has been used.

All cross-sections had an expansion coefficient of 0.3 and contraction coefficient of 0.1 except for those immediately upstream and downstream of the bridges and culverts. These cross-sections had an expansion coefficient of 0.5 and contraction coefficient of 0.3. These parameters are those suggested when the changes in river cross-section are small and for typical bridge sections. HECRAS models the overtopping of bridge decks by considering them as a weir. A weir coefficient of 1.7 was used on all culverts and bridges. This is the suggested value for weir flow over bridges.

The culverts entrance and exit loss coefficient were taken as 0.5 (the culverts are square-edged on three edges) and 1, except for the interruption to the Halgut/Cockshaw culverts at the Alexandra Place/Eilansgate junction. At the entrance to the Cockshaw culvert, where there is a trash-screen, an entrance loss coefficient of 0.8 was used.

At the sluice (NGR NY 931 641) and at the Ridley Terrace/Railway culvert (NGR NY 933 646) low flows through the structures were calculated using Yarnell computation method and the momentum balance method. The technique that produced the greatest energy loss through the structure was used.

For all the other structures, the low flows were calculated using the Energy Equations and Momentum Balance Method and the technique that produced the greatest energy loss through the structure used.

High flows were calculated using the Energy Equation at three structures location:

- the culvert running underneath the Augustine Priory (Halgut Reach)
- the footbridge situated just downstream of this culvert
- the Cockshaw culvert at Cockshaw/Halgut confluence.

The pressure flow computation was used to calculate high flows for all the other structures.

The model was run with a mixed flow regime to allow the flow regime to pass from subcritical to supercritical, or supercritical to subcritical. The water level at the downstream boundary and upstream boundary was equal to the normal depth.

3.4 Flooding Mechanism

The mechanism of flooding is influenced by the culverts and other restrictions within the town. Recent flood events have displayed a similar pattern. Flood flows from the Cockshaw Burn are diverted into Tanners Row at the Cockshaw Burn road bridge and the entrance to the Cockshaw culvert. Flood waters in the Halgut Burn flow from the entrance of the culvert in Tanners Yard through Holy Island. The two flows combine before crossing Eilansgate and flowing into Burn Lane. The floodwater is effectively trapped behind the railway embankment, and the Haugh Lane Industrial Estate becomes inundated as the floodwater builds up. In the past the Ridley Terrace culvert has caused floodwater from the joint channel to enter Tyne Green Road.

During the larger return period events the floodwater covers the lower lying areas around the confluence of the two burns and the Haugh Lane Industrial Estate. In parts of this area, although the flood flows have spilled out of the channel further upstream and flooded the surrounding land, the floodwater is within the channel at that location. This explains the extensive areas of flooding shown on the flood plain maps in some locations where the flow in the model output is within bank.

3.5 Areas Predicted to Flood

Three areas of flooding are most significant. Other out of bank flow does occur but it is unlikely that the flooding at these locations will affect properties.

The model predicts flooding to residential property at Maidens Croft (ch 1832). Historically the lack of capacity of the culvert has forced water out of bank. A capital scheme has been completed over winter 1997 which will alleviate this problem.

Flooding is predicted on Cockshaw Burn at the entrance to the culvert which connects to Halgut Burn. This problem is a result of the lack of capacity within the culvert and the inlet control conditions that exist at Tanners Row. Hand calculations have shown that with the 100-year flow the entrance is submerged and the headwater depth at the entrance exceeds the height of the headwall.

The most extensive flooding occurs at the lower end of the reach. Insufficient channel capacity results in a significant area of flooding.

4.0 SURVEY OF FLOODING PROBLEMS (BRIEF 3.2)

4.1 Identified Flooding Problems

No flooding problems were identified through discussions with the Agency during the work completed for the Catchment Drainage Studies.

4.2 Other Problem Areas

Other flooding problems on this reach not associated with fluvial inundation are covered in the "Report on Survey of Flooding Problems Volume 1 March 1997" Posford Duvivier. This report includes the responses and information gathered through consultation with councils.

5.0 CATCHMENT DRAINAGE STUDIES (Brief 3.3)

5.1 Development Proposals

Within the Agency's brief one development site was identified as requiring examination for possible effects on the undeveloped catchments predicted water levels. Site details included in the Agency's brief had been supplied by the Local Planning Authority (LPA). There are proposals to develop Haugh Lane and Burn Lane Industrial Estates. As these sites have already been developed any redevelopment will not change the Urban Fraction of the catchment. Therefore the development would not have an impact on the predicted flows and waterlevels.

5.2 Engineering Works

The culvert in place at the time of the survey at Maidens Croft (ch 1832) caused flooding to residential property. A capital scheme to replace the Maidens Croft culvert supported by Environmental Agency, Tynedale Council and Home Housing Association was completed during winter 1997.

The size of the culvert downstream of the confluence of the Cockshaw Burn and Halgut Burn has been increased. This should have eliminated the problem of flow backing up from this culvert.

The flooding from the culvert on the Cockshaw Burn in Tanners Row caused by the limited capacity of the culvert and the restriction of the culvert entrance could be alleviated in two ways. Improvements to the entrance and capacity of the culvert up to the Halgut Burn junction would be an expensive option compared to the cost of raising the flood walls or river widening to increase the size of the channel upstream of the culvert. Providing a solid head wall replacing the river wall with a high wall and providing a new wall which gives a wider channel would all reduce the amount of overtopping. A more detailed study of the points of overtopping is recommended so that appropriate mitigation works could be suggested. The survey of the existing flood defence levels will determine how far upstream from the entrance of the culvert the works will need to extend. The estimated cost of replacing the existing 800mm high wall with a 1200mm high wall for 200m upstream of the culvert and replacing the headwall at the culvert entrance is £120,000.

To alleviate the problem of flooding downstream of the confluence of the Halgut Burn and Cockshaw Burn, existing restrictions in this reach need to be removed. The Cockshaw Burn flows within an open channel between the Eilansgate culvert and the Ridley Terrace culvert. Along this 300m long reach the flow is restricted by the twin culverts beneath the West Cumberland Farmers Building. These culverts cause backing up and the flow overtops the left bank in the reach immediately upstream of them. Downstream of the culverts the capacity of the channel is such that extensive overopping of the left bank occurs. Consideration should be given to the widening of the channel or the raising of the left river wall over a 150m length. Raising the river walls to a height of 1000mm over 50m is estimated to cost £60,000. It is understood that this area has been designated a conservation area and that this should be taken into account when considering new works.

5.3 Flood Warning Recommendations

The existing flood warning system needs revision to include the properties which have been identified as being at risk. Those properties within the flood plain shown on the 1:10,000 scale map require consideration. These areas are:

- Cockshaw Road
- Tanners Row
- Holy Island
- Burn Lane and Haugh Lane Industrial Estate
- Tyne Green Road

A detailed survey of threshold levels of the properties at risk is recommended to determine the levels of alert.

6.0 RESULTS AND CONCLUSIONS

6.1 Discussion of Results

The modelling results have been used to identify flood risk areas on the accompanying Flood Plain Maps. The model predicts the width of flooding using the cross-section data. Where the survey has not been extended to ground higher than the 100 year water level the flooded area has been estimated by interpolation between the point furthest from the river which has been surveyed and the 5m contours shown on a 1:25,000 scale plan. The maps generally show that predicted flood risk areas coincide with the previously identified flooding problems. These results have been achieved without any calibration of the model. There is no suitable data in existence with which to undertake calibration therefore the level of confidence is very low. In order to calibrate this model, gauge data covering a significant time frame would be required.

The associated development plan which identifies the development at risk from flooding shows predicted water levels for the existing catchment.

The predicted extent of flooding identifies a number of areas that are at risk from flooding and these are summarised in Table 6.1.

Table 6.1

Flood Risk Area

Reach and Chainage	Location	Comments	Threshold of Flooding	Highest Water Level
Cockshaw 2591	Highford Lane Bridge	Water overtops the bridge and floods the Highford Lane	1 in 5 years	113.1m
Cockshaw 1832	Culvert at Maidens Croft	Insufficient culvert capacity causing flooding to residential property	1 in 10 years	64.5m
Cockshaw 1036	Cockshaw Road footpath	Water overtops left bank and floods the road	1 in 100 year only	43.3m
Cockshaw 899	U/S of Cockshaw Culvert at Cockshaw/Halgut confluence	Water goes through the culvert deck opening to the road	1 in 20 years	41.5m
Cockshaw 634	Twin culverts beneath West Cumberland	Water overtops the left bank wall and runs along the street	U/S 1 in 5 years	38.6m
616	Farmers Building		D/S 1 in 20 years	37.9m
Cockshaw 511	Culvert between Railway/Ridley Terrace	Water overtops the left bank wall and runs along the street	1 in 10 years	37m
Halgut 740	U/S of Culvert (near Priestland's Lane)	Water overtops left bank and goes to the road	1 in 5 years	63.4m
Halgut 251	Footbridge in the grounds of The Priory.	The deck is high enough for the water not to overtop the footbridge deck but goes around the abutment causing local flooding	1 in 50 years	46.5m
Halgut 140	Halgut Culvert U/S of the confluence Cockshaw/Halgut	Water runs over the right bank and floods the roads	1 in 100 years	42.4m

6.2 Conclusion

The predictions made for the 100 year water level have a low level of confidence although in some locations the predicted water level closely matches the recorded level. The reason for this is because of the limitations of the data sets used. The flow data has been predicted using Micro FSR. If it had been collected from a gauging station ie. real data, then a high degree of confidence would have been expected. If the topographical survey had been more detailed then greater confidence could have been achieved. Having cross-sections that extend further across the flood plain would give the greatest benefit as the need to interpolate using 5m contours would be eliminated. However it is unlikely that having a greater number of cross-sections would influence the predicted water levels but it would assist in identifying the areas where out of bank flow occur. The number of cross section required to produce this outcome would possibly be in the order of ten times those actually surveyed. Improving the accuracy of the parameters discussed in Section 3.0 would help to increase confidence in the predicted results.

To enhance the model as constructed the following work should be considered.

- Extend the width of survey at cross-sections where the existing survey does not extend to a level equal to the 100 year water level.

- Survey bank levels in areas where flooding occurs so the extent of the out of bank flow can be estimated.

- Establish a gauging station so that the flows associated with each event can be predicted with greater accuracy.

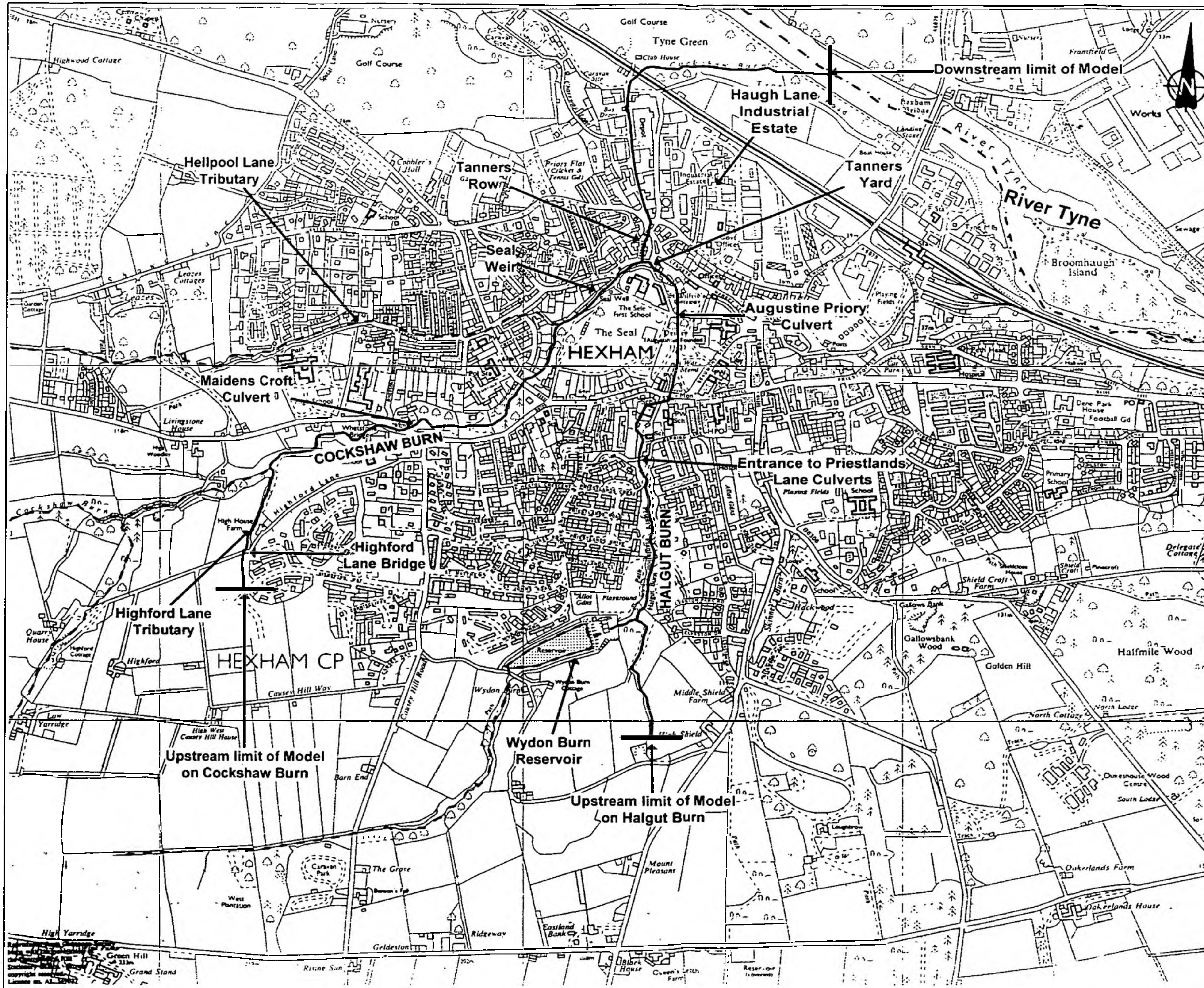
- Calibrate the model so that the parameters discussed in Section 3.0 can be accurately predicted.

A suitable location for a gauging station within the catchment on the Cockshaw Burn, would be in the area known as The Seal close to the position of the existing weir. Gauging on the Halgut Burn would similarly be best done at the downstream end of the reach to obtain the most accurate record of the flows entering the low lying land near the confluence with the Cockshaw Burn. The grounds of Hexham House would be appropriate although this is a public area. Gauging of the larger events on the the joint channel would be pointless due to the large volumes of flow that are out of bank in this part of the reach.

Improvements to the telemetry on the Cockshaw Burn and Halgut Burn catchment would produce a more reliable set of data from which flood flows can be estimated. More accurate flood flows would be beneficial when designing improvement works. The gauge readings would also provide the data required when trying to establish a warning system predicting high water levels. The catchment is such that flood levels are reached very quickly. This flashy nature means that it would be difficult to predict flood water levels much in advance.

It should also be noted that river modelling is not an absolute science and that no amount of additional data will produce a 100% accurate answer. Equations within the model are theoretical, modelling of this nature is a useful tool in indicating possible scenarios and comparative analysis only.

Sensitivity testing at this stage would have limited benefit. Although it would give an indication to the impact that a parameter has on the flood levels, it is not possible to determine whether the change to the variable has given a better prediction.



POSFORD DUVIVIER
CONSULTING ENGINEERS

ENVIRONMENT AGENCY
North East Region

Project

Section 105 - C30/92

Surveys

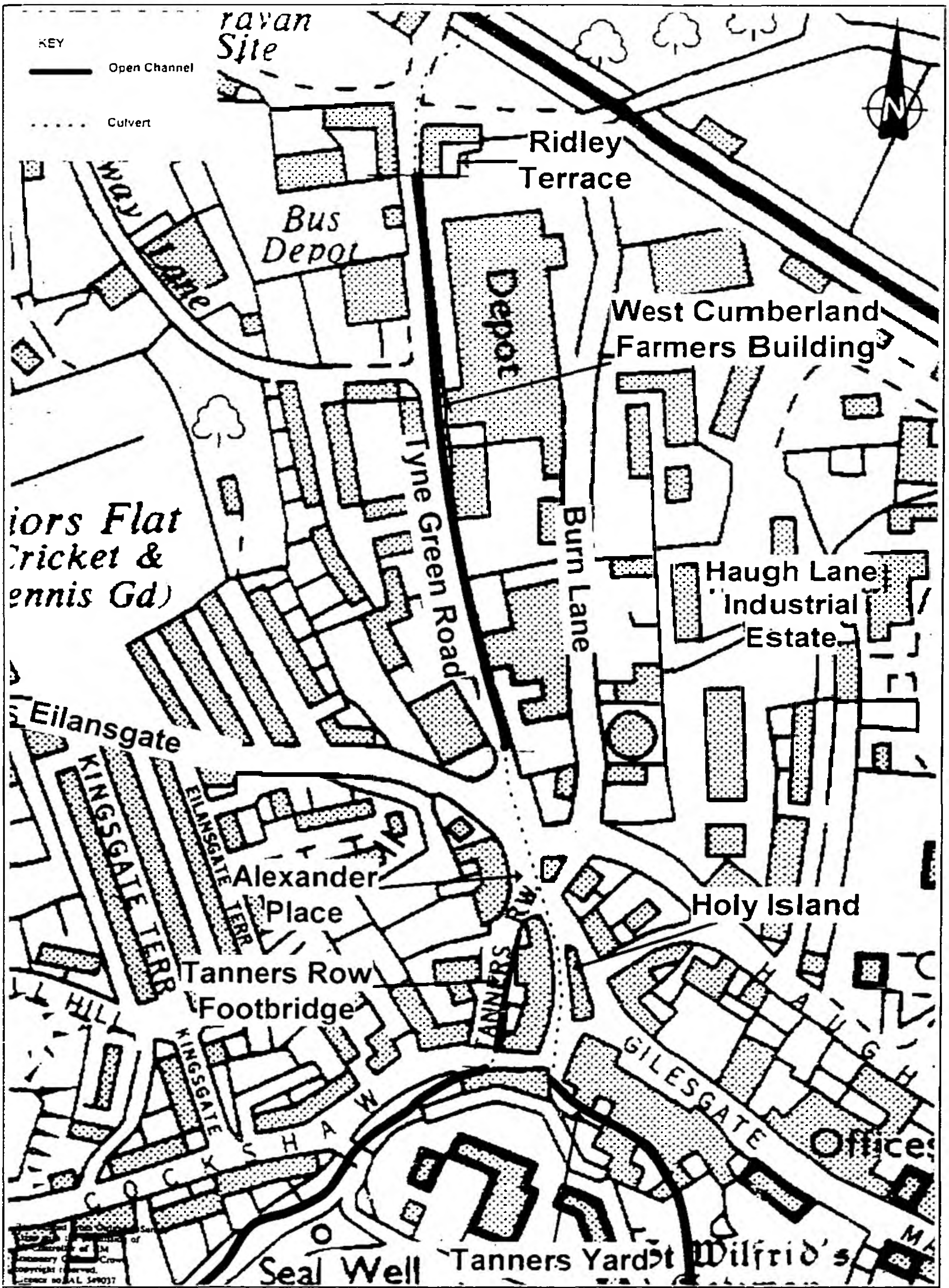
Title

Northumbria Area

Cockshaw Burn
and
Halgut Burn

LOCATION PLAN

Date: 23/03/98	Scale: 1 : 10,000
Drawn MDWP	Chkd. TE
Drg. No.	Figure 1.1



ENVIRONMENT AGENCY

TITLE
Northumbria Area

Section 105 - C30/92 Surveys
Cockshaw Burn & Halgut Burn

POSFORD DUVIVIER
CONSULTING ENGINEERS

DATE 23/03/98	SCALE 1:2500
DRAWN MDWP	CHKD TS
CONFLUENCE PLAN	Figure 1.2

APPENDIX A PHOTOGRAPHS

PHOTOGRAPH 1- Looking downstream of the railway culvert at Ridley Terrace, chainage 511.

PHOTOGRAPH 2- Looking downstream of the bus depot bridge, chainage 631.

PHOTOGRAPH 3- Looking at the Tanners Row culvert entrance, chainage 890.

PHOTOGRAPH 4- Looking downstream the Cockshaw Street/Tanners Row bridge, chainage 986.

PHOTOGRAPH 5- Looking downstream the Cockshaw Street footbridge, chainage 1036.

PHOTOGRAPH 6- Culvert at Maidens Croft, chainage 1832.

PHOTOGRAPH 7- Looking downstream the Whetstone bridge (B6365 culvert), chainage 1952.

PHOTOGRAPH 8- Looking downstream the culvert entrance at Tanners Yard, chainage 137.

PHOTOGRAPH 9- Culvert entrance at Priestlands Lane, chainage 740.

APPENDIX B MODEL OUTPUT

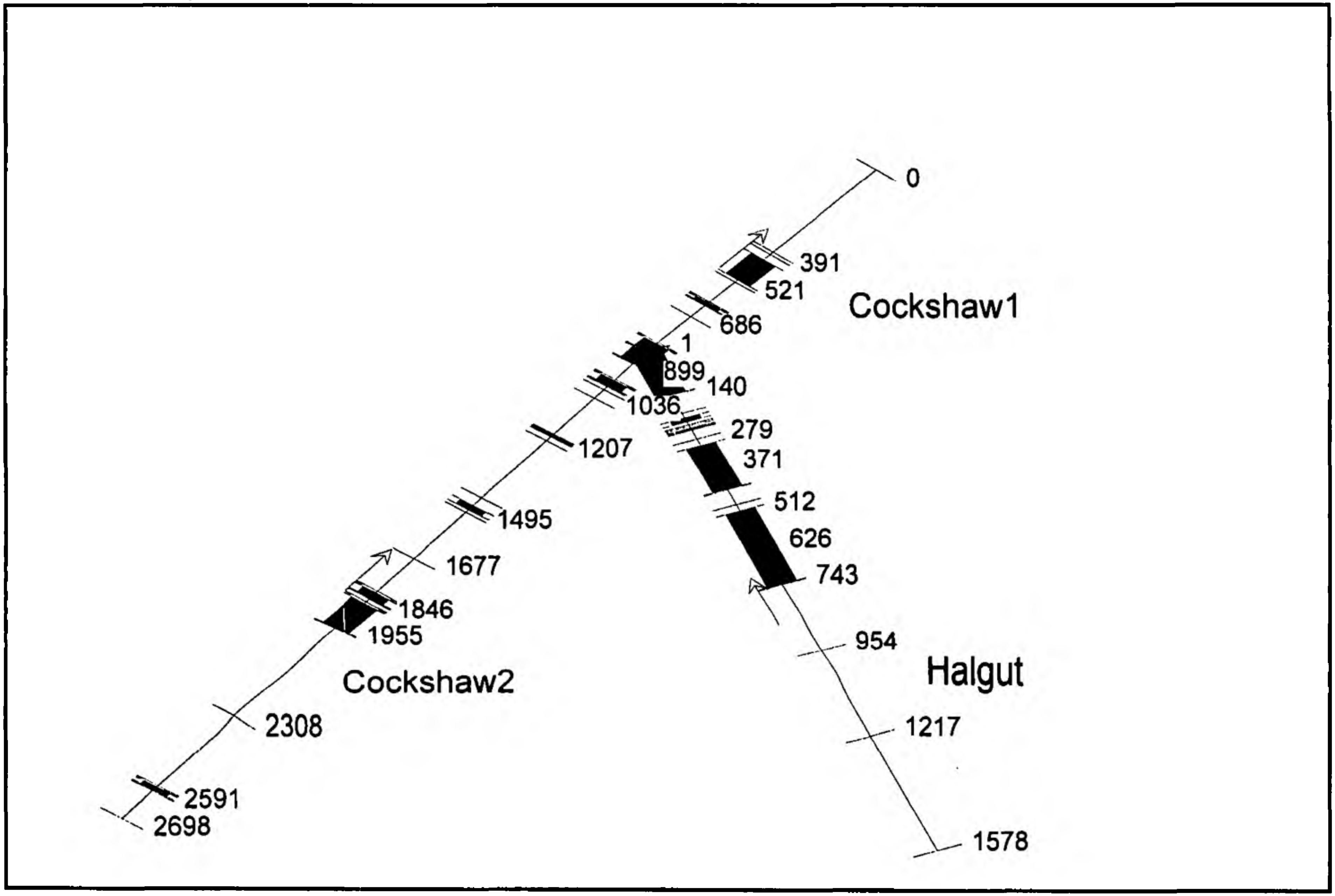
APPENDIX B

B.1 MODEL OUTPUT

Appendix B contains a selection of the output generated by HECRAS. The model run shown used the flows predicted for the catchment that included proposed development. The table lists each river station and the reaches that they are on. For each river station the total flow, water surface elevation, top width of the flow and the velocity within the channel has been given for flows with return periods of 100 years, 50 years, 20 years, 10 years and 5 years. For each river station, the results for the largest event are given first with the following result representing the next largest return periods. The model included 15 significant structures, all of which were bridges. The schematic drawing included in Appendix B shows the relative locations of River Stations.

The attached disc contains the files of all data used including cross-sections which can be output in hard copy as required.

Final Geometry File	Cock.GO2
100,50,20,10,5 year flows for existing catchment	Cock.FO1



0
391
521
Cockshaw1
686
1
899
140
1036
279
1207
371
512
1495
626
1677
743
1846
1955
954
Halgut
Cockshaw2
2308
1217
2591
2698
1578

HEC-RAS Plan: EXISTING 3/18/98

Reach	River Sta.	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Halgut	1578		3.14	106.26	3.33	2.09
Halgut	1578		2.71	106.21	3.21	2.03
Halgut	1578		2.20	106.15	3.07	1.91
Halgut	1578		1.89	106.11	2.98	1.84
Halgut	1578		1.57	106.06	2.87	1.76
Halgut	1217		5.50	87.10	3.55	3.03
Halgut	1217		4.74	87.05	3.44	2.87
Halgut	1217		3.85	86.99	3.28	2.70
Halgut	1217		3.31	86.94	3.18	2.57
Halgut	1217		2.75	86.90	3.07	2.42
Halgut	954		5.50	73.16	3.74	2.62
Halgut	954		4.74	73.10	3.59	2.53
Halgut	954		3.85	73.02	3.41	2.38
Halgut	954		3.31	72.97	3.29	2.30
Halgut	954		2.75	72.91	3.15	2.19
Halgut	743		5.50	63.47	18.24	0.39
Halgut	743		4.74	63.44	17.88	0.35
Halgut	743		3.85	63.39	17.36	0.31
Halgut	743		3.31	63.36	16.97	0.28
Halgut	743		2.75	63.32	16.50	0.24
Halgut	740		5.50	63.47	20.00	0.32
Halgut	740		4.74	63.44	19.63	0.29
Halgut	740		3.85	63.39	19.14	0.25
Halgut	740		3.31	63.36	18.79	0.22
Halgut	740		2.75	63.32	18.36	0.19
Halgut	626		5.50			
Halgut	626		4.74			
Halgut	626		3.85			
Halgut	626		3.31			
Halgut	626		2.75			
Halgut	512		5.50	53.73	8.02	3.92
Halgut	512		4.74	53.58	7.58	3.73
Halgut	512		3.85	53.40	7.01	3.48
Halgut	512		3.31	53.28	6.72	3.31
Halgut	512		2.75	53.15	6.68	3.12
Halgut	492		5.50	51.92	6.57	2.02
Halgut	492		4.74	51.87	6.35	1.95
Halgut	492		3.85	51.82	6.07	1.85
Halgut	492		3.31	51.78	5.90	1.77
Halgut	492		2.75	51.74	5.69	1.69
Halgut	445		5.50	49.67	3.84	3.94

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta.	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Halgut	445		4.74	49.63	3.83	3.78
Halgut	445		3.85	49.59	3.83	3.55
Halgut	445		3.31	49.56	3.82	3.38
Halgut	445		2.75	49.53	3.82	3.12
Halgut	442		5.50	49.53	3.84	3.99
Halgut	442		4.74	49.50	3.83	3.81
Halgut	442		3.85	49.46	3.83	3.54
Halgut	442		3.31	49.43	3.82	3.38
Halgut	442		2.75	49.40	3.82	3.11
Halgut	371		5.50			
Halgut	371		4.74			
Halgut	371		3.85			
Halgut	371		3.31			
Halgut	371		2.75			
Halgut	300		5.50	47.51	6.24	2.05
Halgut	300		4.74	47.46	6.22	1.90
Halgut	300		3.85	47.39	6.21	1.75
Halgut	300		3.31	47.33	6.19	1.68
Halgut	300		2.75	47.26	6.17	1.58
Halgut	279		5.50	46.91	4.33	2.33
Halgut	279		4.74	46.82	3.45	2.38
Halgut	279		3.85	46.68	2.64	2.44
Halgut	279		3.31	46.62	2.58	2.33
Halgut	279		2.75	46.55	2.52	2.21
Halgut	251		5.50	46.46	7.10	1.12
Halgut	251		4.74	46.32	6.22	1.20
Halgut	251		3.85	45.70	2.56	2.82
Halgut	251		3.31	45.64	2.51	2.70
Halgut	251		2.75	45.58	2.45	2.56
Halgut	248		5.50	46.40	7.23	1.47
Halgut	248		4.74	46.27	6.41	1.47
Halgut	248		3.85	45.61	2.55	2.87
Halgut	248		3.31	45.55	2.50	2.75
Halgut	248		2.75	45.69	2.63	1.77
Halgut	246		5.50	46.40		
Halgut	246		4.74	46.27		
Halgut	246		3.85	45.61		
Halgut	246		3.31	45.55		
Halgut	246		2.75	45.69		
Halgut	244		5.50	45.76	3.65	2.75
Halgut	244		4.74	45.69	3.13	2.61

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta.	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Halgut	244		3.85	45.46	2.51	3.16
Halgut	244		3.31	45.41	2.46	3.04
Halgut	244		2.75	45.47	2.52	2.21
Halgut	239		5.50	45.29	2.48	4.77
Halgut	239		4.74	45.44	2.62	3.11
Halgut	239		3.85	45.30	2.49	3.28
Halgut	239		3.31	45.25	2.44	3.19
Halgut	239		2.75	45.23	2.42	2.77
Halgut	234		5.50	45.23	3.02	4.32
Halgut	234		4.74	45.29	3.18	3.28
Halgut	234		3.85	45.21	2.95	3.22
Halgut	234		3.31	45.17	2.84	3.05
Halgut	234		2.75	45.13	2.74	2.79
Halgut	224		5.50	45.56	3.71	1.74
Halgut	224		4.74	45.48	3.58	1.64
Halgut	224		3.85	45.37	3.46	1.51
Halgut	224		3.31	45.30	3.38	1.42
Halgut	224		2.75	45.23	3.30	1.31
Halgut	218		5.50	45.56		
Halgut	218		4.74	45.48		
Halgut	218		3.85	45.37		
Halgut	218		3.31	45.30		
Halgut	218		2.75	45.23		
Halgut	212		5.50	45.17	3.60	1.87
Halgut	212		4.74	45.10	3.52	1.75
Halgut	212		3.85	45.00	3.41	1.60
Halgut	212		3.31	44.94	3.34	1.50
Halgut	212		2.75	44.87	3.26	1.38
Halgut	197		5.50	44.91	3.31	2.54
Halgut	197		4.74	44.84	3.24	2.44
Halgut	197		3.85	44.77	3.21	2.27
Halgut	197		3.31	44.71	3.19	2.17
Halgut	197		2.75	44.65	3.07	2.07
Halgut	140		5.50	42.34	5.01	5.77
Halgut	140		4.74	42.31	4.93	5.60
Halgut	140		3.85	42.29	4.83	5.42
Halgut	140		3.31	42.27	4.76	5.26
Halgut	140		2.75	42.25	4.67	5.06
Halgut	137		5.50	40.27	3.99	8.15
Halgut	137		4.74	40.22	3.97	8.10
Halgut	137		3.85	40.17	3.95	7.91

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Halgut	137		3.31	40.14	3.94	7.77
Halgut	137		2.75	40.10	3.92	7.60
Halgut	69		5.50			
Halgut	69		4.74			
Halgut	69		3.85			
Halgut	69		3.31			
Halgut	69		2.75			
Halgut	1		5.50	41.11	3.60	0.71
Halgut	1		4.74	40.90	3.56	0.68
Halgut	1		3.85	40.51	3.47	1.21
Halgut	1		3.31	40.35	3.44	1.15
Halgut	1		2.75	40.18	3.42	1.08
Halgut	0		5.50	41.11	3.60	0.71
Halgut	0		4.74	40.90	3.56	0.68
Halgut	0		3.85	40.53	3.48	0.67
Halgut	0		3.31	40.37	3.44	0.64
Halgut	0		2.75	40.20	3.43	0.60
Cockshaw2	2698		6.95	113.54	16.49	0.93
Cockshaw2	2698		6.04	113.43	14.67	0.94
Cockshaw2	2698		4.90	113.34	13.22	0.86
Cockshaw2	2698		4.14	113.27	12.13	0.80
Cockshaw2	2698		3.47	113.20	11.58	0.74
Cockshaw2	2591		6.95	113.33	13.08	1.24
Cockshaw2	2591		6.04	113.13	11.18	1.48
Cockshaw2	2591		4.90	113.07	10.87	1.35
Cockshaw2	2591		4.14	113.03	10.67	1.23
Cockshaw2	2591		3.47	112.99	10.43	1.14
Cockshaw2	2588		6.95	113.32	12.93	1.25
Cockshaw2	2588		6.04	113.11	11.06	1.54
Cockshaw2	2588		4.90	113.05	10.78	1.40
Cockshaw2	2588		4.14	113.02	10.58	1.28
Cockshaw2	2588		3.47	112.97	10.36	1.18
Cockshaw2	2582		6.95	113.32		
Cockshaw2	2582		6.04	113.11		
Cockshaw2	2582		4.90	113.05		
Cockshaw2	2582		4.14	113.02		
Cockshaw2	2582		3.47	112.97		
Cockshaw2	2577		6.95	113.15	11.31	1.63
Cockshaw2	2577		6.04	113.10	11.05	1.55
Cockshaw2	2577		4.90	113.04	10.70	1.44

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Cockshaw2	2577		4.14	112.99	10.44	1.36
Cockshaw2	2577		3.47	112.94	10.18	1.28
Cockshaw2	2572		6.95	112.97	10.35	2.37
Cockshaw2	2572		6.04	112.94	10.16	2.25
Cockshaw2	2572		4.90	112.88	9.86	2.11
Cockshaw2	2572		4.14	112.84	9.63	2.00
Cockshaw2	2572		3.47	112.79	9.40	1.90
Cockshaw2	2308		8.47	77.83	2.39	18.46
Cockshaw2	2308		7.36	77.81	2.34	18.54
Cockshaw2	2308		5.94	77.77	2.27	18.84
Cockshaw2	2308		5.06	77.75	2.22	19.17
Cockshaw2	2308		4.23	77.73	2.01	19.91
Cockshaw2	1955		8.47	69.88	5.51	0.95
Cockshaw2	1955		7.36	69.64	5.25	0.96
Cockshaw2	1955		5.94	69.32	4.90	0.98
Cockshaw2	1955		5.06	69.12	4.67	0.99
Cockshaw2	1955		4.23	68.95	4.47	0.98
Cockshaw2	1952		8.47	69.77	5.48	1.65
Cockshaw2	1952		7.36	69.54	5.23	1.62
Cockshaw2	1952		5.94	69.23	4.88	1.60
Cockshaw2	1952		5.06	69.03	4.66	1.59
Cockshaw2	1952		4.23	68.86	4.46	1.54
Cockshaw2	1902	Culvert #2	8.47			
Cockshaw2	1902	Culvert #1	8.47			
Cockshaw2	1902	Culvert #2	7.36			
Cockshaw2	1902	Culvert #1	7.36			
Cockshaw2	1902	Culvert #2	5.94			
Cockshaw2	1902	Culvert #1	5.94			
Cockshaw2	1902	Culvert #2	5.06			
Cockshaw2	1902	Culvert #1	5.06			
Cockshaw2	1902	Culvert #2	4.23			
Cockshaw2	1902	Culvert #1	4.23			
Cockshaw2	1852		8.47	65.19	3.10	2.51
Cockshaw2	1852		7.36	65.30	3.10	2.01
Cockshaw2	1852		5.94	64.97	3.10	2.10
Cockshaw2	1852		5.06	64.72	3.10	2.32
Cockshaw2	1852		4.23	64.68	3.10	2.04
Cockshaw2	1846		8.47	65.24	3.10	1.70
Cockshaw2	1846		7.36	65.34	3.10	1.40
Cockshaw2	1846		5.94	65.01	3.10	1.40
Cockshaw2	1846		5.06	64.77	3.10	1.45
Cockshaw2	1846		4.23	64.71	3.10	1.27

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta.	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Cockshaw2	1835		8.47	65.28	24.89	0.98
Cockshaw2	1835		7.36	65.36	25.15	0.76
Cockshaw2	1835		5.94	65.01	24.05	1.00
Cockshaw2	1835		5.06	64.76	6.96	1.09
Cockshaw2	1835		4.23	64.71	3.22	0.94
Cockshaw2	1832		8.47	64.50	1.60	3.51
Cockshaw2	1832		7.36	64.44	1.60	3.77
Cockshaw2	1832		5.94	64.24	1.60	3.52
Cockshaw2	1832		5.06	64.55	1.60	2.02
Cockshaw2	1832		4.23	64.57	1.60	1.67
Cockshaw2	1822	Culvert #1	8.47			
Cockshaw2	1822	Culvert #1	7.36			
Cockshaw2	1822	Culvert #1	5.94			
Cockshaw2	1822	Culvert #1	5.06			
Cockshaw2	1822	Culvert #1	4.23			
Cockshaw2	1812		8.47	63.82	1.60	3.31
Cockshaw2	1812		7.36	63.67	1.60	3.77
Cockshaw2	1812		5.94	63.47	1.60	3.52
Cockshaw2	1812		5.06	63.35	1.60	3.34
Cockshaw2	1812		4.23	63.22	1.60	3.15
Cockshaw2	1806		8.47	63.41	1.60	3.73
Cockshaw2	1806		7.36	63.28	1.60	3.56
Cockshaw2	1806		5.94	63.11	1.60	3.33
Cockshaw2	1806		5.06	63.00	1.60	3.14
Cockshaw2	1806		4.23	62.88	1.60	2.97
Cockshaw2	1677		8.47	58.11	3.46	3.23
Cockshaw2	1677		7.36	58.03	3.34	3.14
Cockshaw2	1677		5.94	57.92	3.17	3.01
Cockshaw2	1677		5.06	57.85	3.07	2.88
Cockshaw2	1677		4.23	57.77	2.95	2.79
Cockshaw2	1495		8.47	51.48	5.63	1.38
Cockshaw2	1495		7.36	51.39	5.55	1.31
Cockshaw2	1495		5.94	51.25	5.42	1.22
Cockshaw2	1495		5.06	51.19	5.37	1.12
Cockshaw2	1495		4.23	51.11	5.29	1.03
Cockshaw2	1485		8.47	51.41	5.57	1.47
Cockshaw2	1485		7.36	51.33	5.49	1.39
Cockshaw2	1485		5.94	51.19	5.37	1.31
Cockshaw2	1485		5.06	51.13	5.32	1.19
Cockshaw2	1485		4.23	51.06	5.25	1.11

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Cockshaw2	1477		8.47	51.41		
Cockshaw2	1477		7.36	51.33		
Cockshaw2	1477		5.94	51.19		
Cockshaw2	1477		5.06	51.13		
Cockshaw2	1477		4.23	51.06		
Cockshaw2	1469		8.47	50.96	5.16	2.53
Cockshaw2	1469		7.36	50.90	5.11	2.42
Cockshaw2	1469		5.94	50.82	5.03	2.26
Cockshaw2	1469		5.06	50.77	4.98	2.16
Cockshaw2	1469		4.23	50.71	4.93	2.04
Cockshaw2	1439		8.47	49.42	3.27	3.51
Cockshaw2	1439		7.36	49.34	3.21	3.41
Cockshaw2	1439		5.94	49.23	3.12	3.28
Cockshaw2	1439		5.06	49.30	3.17	2.50
Cockshaw2	1439		4.23	49.10	3.02	3.01
Cockshaw2	1207		9.99	46.47	7.33	1.26
Cockshaw2	1207		8.67	46.39	6.79	1.18
Cockshaw2	1207		6.97	46.28	6.73	1.05
Cockshaw2	1207		5.98	46.21	6.69	0.97
Cockshaw2	1207		4.99	46.15	6.66	0.87
Cockshaw2	1191		9.99	46.40	6.80	1.34
Cockshaw2	1191		8.67	46.33	6.76	1.24
Cockshaw2	1191		6.97	46.23	6.70	1.11
Cockshaw2	1191		5.98	46.17	6.67	1.02
Cockshaw2	1191		4.99	46.11	6.64	0.91
Cockshaw2	1187		9.99	46.38	6.79	1.36
Cockshaw2	1187		8.67	46.31	6.75	1.26
Cockshaw2	1187		6.97	46.22	6.70	1.12
Cockshaw2	1187		5.98	46.16	6.66	1.03
Cockshaw2	1187		4.99	46.10	6.64	0.92
Cockshaw2	1186		9.99	46.38		
Cockshaw2	1186		8.67	46.31		
Cockshaw2	1186		6.97	46.22		
Cockshaw2	1186		5.98	46.16		
Cockshaw2	1186		4.99	46.10		
Cockshaw2	1185		9.99	45.55	6.76	1.42
Cockshaw2	1185		8.67	45.55	6.76	1.23
Cockshaw2	1185		6.97	45.55	6.76	0.99
Cockshaw2	1185		5.98	45.55	6.76	0.85
Cockshaw2	1185		4.99	45.55	6.76	0.71
Cockshaw2	1181		9.99	44.91	6.51	3.58

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta.	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Cockshaw2	1181		8.67	44.84	6.49	3.67
Cockshaw2	1181		6.97	44.76	6.47	3.83
Cockshaw2	1181		5.98	44.71	6.46	3.95
Cockshaw2	1181		4.99	44.67	6.45	3.95
Cockshaw2	1036		9.99	43.30	21.26	1.80
Cockshaw2	1036		8.67	43.19	5.44	2.52
Cockshaw2	1036		6.97	43.10	5.32	2.35
Cockshaw2	1036		5.98	43.05	5.30	2.24
Cockshaw2	1036		4.99	42.99	5.28	2.11
Cockshaw2	1002		9.99	42.40	17.11	4.03
Cockshaw2	1002		8.67	42.39	17.11	3.77
Cockshaw2	1002		6.97	42.50	6.14	3.21
Cockshaw2	1002		5.98	42.47	6.14	3.06
Cockshaw2	1002		4.99	42.43	6.13	2.87
Cockshaw2	990		9.99	42.05	15.69	3.86
Cockshaw2	990		8.67	42.11	5.85	3.45
Cockshaw2	990		6.97	42.00	5.82	3.78
Cockshaw2	990		5.98	41.96	5.81	3.66
Cockshaw2	990		4.99	41.93	5.80	3.45
Cockshaw2	986		9.99	41.06	5.57	5.33
Cockshaw2	986		8.67	41.00	5.54	5.43
Cockshaw2	986		6.97	40.94	5.51	5.52
Cockshaw2	986		5.98	40.92	5.49	5.33
Cockshaw2	986		4.99	40.89	5.48	5.15
Cockshaw2	976		9.99	41.06		
Cockshaw2	976		8.67	41.00		
Cockshaw2	976		6.97	40.94		
Cockshaw2	976		5.98	40.92		
Cockshaw2	976		4.99	40.89		
Cockshaw2	966		9.99	41.79	5.96	1.67
Cockshaw2	966		8.67	41.69	5.91	1.59
Cockshaw2	966		6.97	41.51	5.81	1.57
Cockshaw2	966		5.98	41.40	5.75	1.57
Cockshaw2	966		4.99	41.28	5.69	1.59
Cockshaw2	961		9.99	41.49	3.86	2.67
Cockshaw2	961		8.67	41.50	3.86	2.28
Cockshaw2	961		6.97	41.20	3.79	2.66
Cockshaw2	961		5.98	41.13	3.77	2.51
Cockshaw2	961		4.99	41.06	3.76	2.38
Cockshaw2	899		9.99	41.55	3.03	1.47
Cockshaw2	899		8.67	41.55	3.03	1.28

HEC-RAS Plan: EXISTING 3/18/98 (continued)

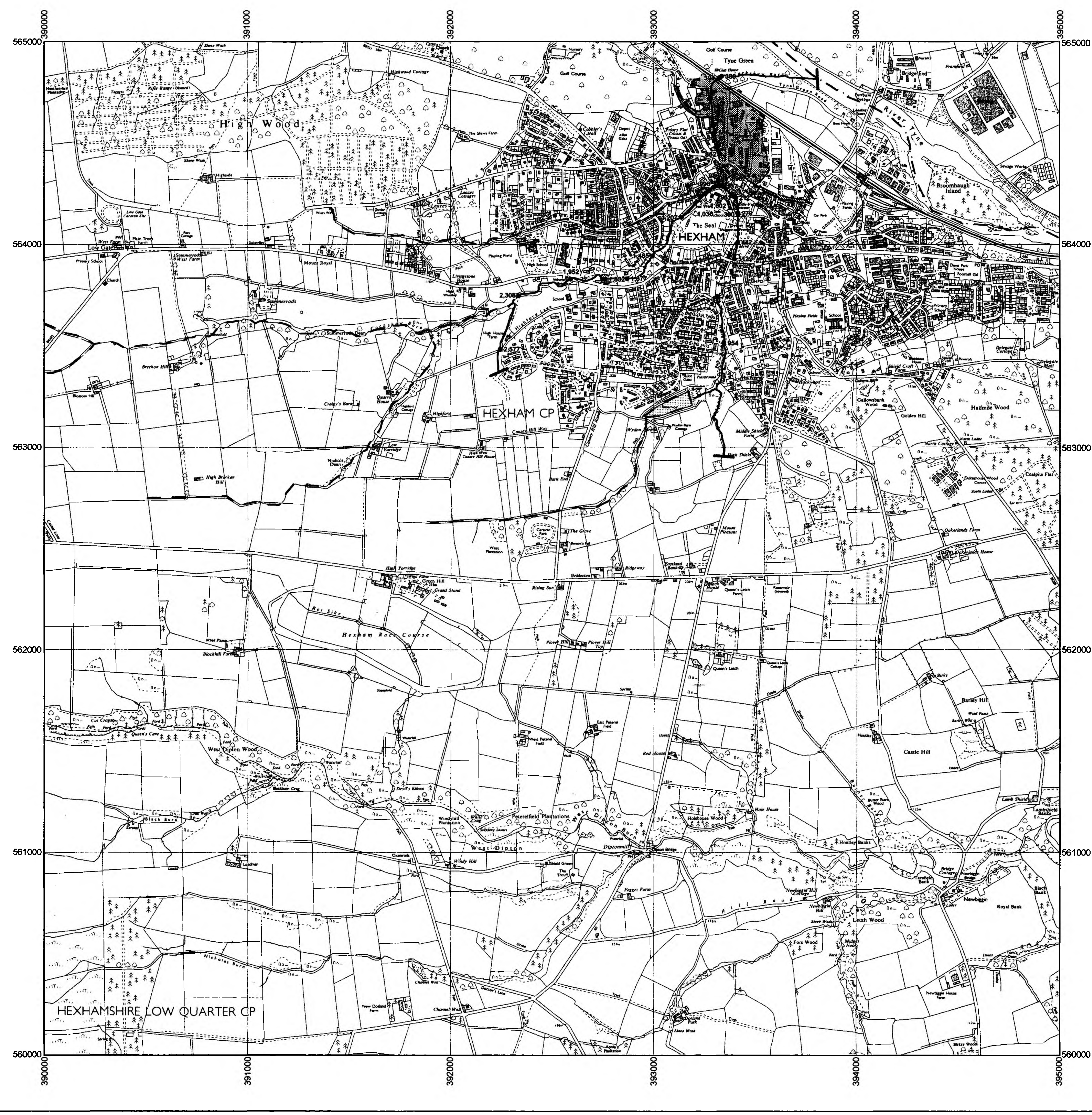
Reach	River Sta.	Culvert ID.	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Cockshaw2	899		6.97	41.03	2.93	1.33
Cockshaw2	899		5.98	40.75	2.88	1.36
Cockshaw2	899		4.99	40.43	2.83	1.43
Cockshaw2	896		9.99	41.53	3.04	1.58
Cockshaw2	896		8.67	41.53	3.04	1.37
Cockshaw2	896		6.97	41.02	2.94	1.39
Cockshaw2	896		5.98	40.74	2.89	1.40
Cockshaw2	896		4.99	40.43	2.84	1.44
Cockshaw2	875	Culvert #1	9.99			
Cockshaw2	875	Culvert #1	8.67			
Cockshaw2	875	Culvert #1	6.97			
Cockshaw2	875	Culvert #1	5.98			
Cockshaw2	875	Culvert #1	4.99			
Cockshaw2	853.2		9.99	41.03	3.58	1.34
Cockshaw2	853.2		8.67	40.82	3.54	1.29
Cockshaw2	853.2		6.97	40.42	3.45	1.70
Cockshaw2	853.2		5.98	40.27	3.43	1.61
Cockshaw2	853.2		4.99	40.11	3.42	1.52
Cockshaw2	853		9.99	41.03	3.58	1.34
Cockshaw2	853		8.67	40.82	3.54	1.29
Cockshaw2	853		6.97	40.46	3.46	1.28
Cockshaw2	853		5.98	40.30	3.43	1.22
Cockshaw2	853		4.99	40.14	3.42	1.15
Cockshaw1	852		15.71	40.76	3.53	2.42
Cockshaw1	852		13.62	40.57	3.49	2.33
Cockshaw1	852		10.96	40.15	3.42	2.50
Cockshaw1	852		9.45	40.02	3.41	2.40
Cockshaw1	852		7.88	39.88	3.41	2.26
Cockshaw1	851		15.71	40.76	3.53	2.42
Cockshaw1	851		13.62	40.55	3.48	2.40
Cockshaw1	851		10.96	40.11	3.42	2.62
Cockshaw1	851		9.45	39.78	3.40	3.04
Cockshaw1	851		7.88	39.68	3.39	2.86
Cockshaw1	832	Culvert #1	15.71			
Cockshaw1	832	Culvert #1	13.62			
Cockshaw1	832	Culvert #1	10.96			
Cockshaw1	832	Culvert #1	9.45			
Cockshaw1	832	Culvert #1	7.88			
Cockshaw1	813		15.71	39.96	3.42	3.57
Cockshaw1	813		13.62	39.85	3.41	3.41

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Cockshaw1	813		10.96	39.69	3.40	3.17
Cockshaw1	813		9.45	39.59	3.40	3.02
Cockshaw1	813		7.88	39.48	3.39	2.84
Cockshaw1	808		15.71	39.92	3.42	3.56
Cockshaw1	808		13.62	39.80	3.42	3.40
Cockshaw1	808		10.96	39.64	3.41	3.16
Cockshaw1	808		9.45	39.54	3.40	3.02
Cockshaw1	808		7.88	39.44	3.39	2.84
Cockshaw1	686		15.71	38.36	4.52	4.35
Cockshaw1	686		13.62	38.28	4.46	4.16
Cockshaw1	686		10.96	38.18	4.37	3.89
Cockshaw1	686		9.45	38.12	4.32	3.71
Cockshaw1	686		7.88	38.05	4.27	3.48
Cockshaw1	634		15.71	38.55	23.87	0.39
Cockshaw1	634		13.62	38.40	23.84	0.40
Cockshaw1	634		10.96	38.19	23.80	0.42
Cockshaw1	634		9.45	38.07	23.78	0.44
Cockshaw1	634		7.88	37.92	23.75	0.49
Cockshaw1	631		15.71	38.55	33.79	0.41
Cockshaw1	631		13.62	38.40	32.37	0.42
Cockshaw1	631		10.96	38.20	30.45	0.44
Cockshaw1	631		9.45	38.07	29.24	0.46
Cockshaw1	631		7.88	37.92	27.89	0.50
Cockshaw1	625	Culvert #1	15.71			
Cockshaw1	625	Culvert #1	13.62			
Cockshaw1	625	Culvert #1	10.96			
Cockshaw1	625	Culvert #1	9.45			
Cockshaw1	625	Culvert #1	7.88			
Cockshaw1	621		15.71	38.56	41.26	0.34
Cockshaw1	621		13.62	38.41	39.03	0.35
Cockshaw1	621		10.96	38.20	36.02	0.36
Cockshaw1	621		9.45	38.07	34.12	0.37
Cockshaw1	621		7.88	37.93	32.00	0.40
Cockshaw1	616		15.71	37.91	32.27	3.17
Cockshaw1	616		13.62	37.81	30.90	3.02
Cockshaw1	616		10.96	37.67	28.85	2.86
Cockshaw1	616		9.45	37.58	4.49	2.74
Cockshaw1	616		7.88	37.49	4.41	2.60
Cockshaw1	521		15.71	37.09	15.20	0.85
Cockshaw1	521		13.62	36.94	15.18	0.88
Cockshaw1	521		10.96	36.91	15.18	0.73

HEC-RAS Plan: EXISTING 3/18/98 (continued)

Reach	River Sta	Culvert ID	Q Total	W.S. Elev	Top Width	Vel Chnl
			(m3/s)	(m)	(m)	(m/s)
Cockshaw1	521		9.45	36.78	15.16	0.76
Cockshaw1	521		7.88	36.07	5.46	3.81
Cockshaw1	511		15.71	37.04	15.21	1.28
Cockshaw1	511		13.62	36.89	15.19	1.29
Cockshaw1	511		10.96	36.44	6.31	2.99
Cockshaw1	511		9.45	36.35	6.21	2.85
Cockshaw1	511		7.88	36.24	6.00	2.75
Cockshaw1	463	Culvert #1	15.71			
Cockshaw1	463	Culvert #1	13.62			
Cockshaw1	463	Culvert #1	10.96			
Cockshaw1	463	Culvert #1	9.45			
Cockshaw1	463	Culvert #1	7.88			
Cockshaw1	415		15.71	36.02	4.24	3.60
Cockshaw1	415		13.62	35.90	4.23	3.44
Cockshaw1	415		10.96	35.77	4.22	3.12
Cockshaw1	415		9.45	35.72	4.21	2.82
Cockshaw1	415		7.88	35.65	4.21	2.51
Cockshaw1	391		15.71	36.00	7.40	2.34
Cockshaw1	391		13.62	35.91	7.14	2.24
Cockshaw1	391		10.96	35.79	6.77	2.09
Cockshaw1	391		9.45	35.71	6.54	2.00
Cockshaw1	391		7.88	35.62	6.28	1.89
Cockshaw1	380		15.71	35.80	7.18	2.73
Cockshaw1	380		13.62	35.72	6.88	2.63
Cockshaw1	380		10.96	35.60	6.45	2.48
Cockshaw1	380		9.45	35.53	6.18	2.37
Cockshaw1	380		7.88	35.45	5.88	2.25
Cockshaw1	0		15.71	32.00	7.18	2.74
Cockshaw1	0		13.62	31.92	6.87	2.63
Cockshaw1	0		10.96	31.80	6.45	2.48
Cockshaw1	0		9.45	31.73	6.18	2.38
Cockshaw1	0		7.88	31.65	5.87	2.26



Key:

Fluvial Floodplain (100yr unless noted otherwise)	
Tidal Floodplain (200 yr unless noted otherwise)	
Washland	
Controlled Washland	
Limit of reach	
Floodplain extent (High confidence)	
Floodplain extent (Medium confidence)	
Floodplain extent (Low confidence)	
Known event line with estimated return period	eg 150 yr
Main river included in survey	
Ordinary watercourse included in survey	
Main river excluded from survey	
Ordinary watercourse excluded from survey	
Culvert / tunnel	
Model node Point	2883

Note :- for clarity only indicative model node points have been included on this plan. For full listing please refer to model output

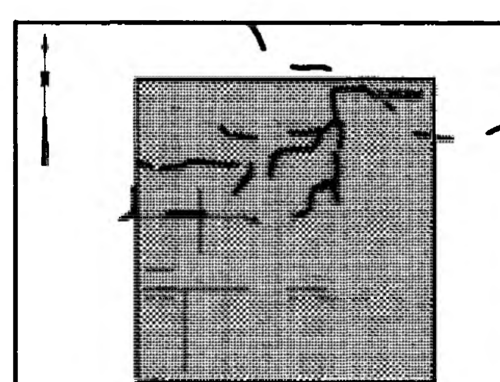
Originated	Date	Details
Drawn By	Date	
Checked	Date	

List of revisions

ENVIRONMENT AGENCY
NORTH EAST REGION

PROJECT TITLE

SECTION 105 - C30/92 SURVEYS FLOOD PLAIN IDENTIFICATION 1 IN 100 YEAR EVENT



DRAWING TITLE

NORTHUMBRIA AREA COCKSHAW AND HALGUT BURN

ORIGINATED BY	DRAWN BY	CHECKED BY	APPROVED BY
SPT	TH-R	TJS	
DATE	DATE	DATE	DATE

SCALE
1:10,000

PROJECT NO. / DRAWING NO. / REV
C1395/FPM/01/050

USER NOTE
This plan has been produced with the requirements of Department of the Environment Circular 30/92. Because the information is indicative rather than specific,local planning authorities will nevertheless need to consult the Environment Agency on individual applications. Flood plain extent is based on the information available at the time of survey. Amendments will be required in future to account for information gathered subsequently eg. changes in hydrological river response or observations following flood events.
It should be noted that locations adjacent to rivers not included in this stage of the survey may be at risk of flooding. When in doubt the Environment Agency should be consulted.

POSFORD DUVIVIER

27-03-98

394000

564000 564000

394000

KEY:

Development Site

Main river, hydraulic model node and cross section 154

Non-main river, hydraulic model node and cross section 154

Culvert / Tunnel main river

Culvert / Tunnel non-main river

Weir

Indicative 100 year flood event

Indicative 50 year flood event

Indicative 20 year flood event

Indicative 10 year flood event

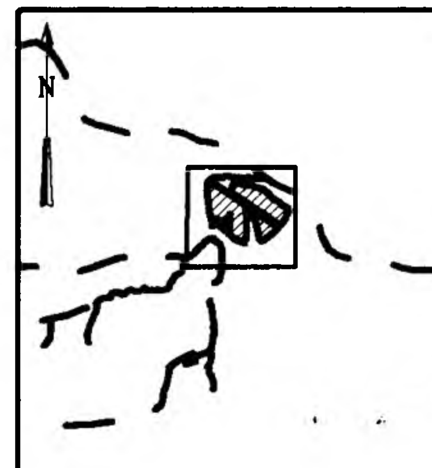
Indicative 5 year flood event

List of revisions

ENVIRONMENT AGENCY
NORTH EAST REGION

PROJECT TITLE

SECTION 105 - C30/92 SURVEYS
IDENTIFICATION OF
DEVELOPMENT AT
RISK FROM FLOODING



USER NOTE

This plan has been produced with the requirements of Department of the Environment Circular 30/92. Because the information is indicative rather than specific, local planning authorities will nevertheless need to consult the Environment Agency on individual applications. Flood plain extent is based on data available at the time of survey. Amendments will be required in future to account for information gathered subsequently eg. changes in hydrological river response or observations following flood events.

It should be noted that locations adjacent to rivers not included in this stage of the survey may be at risk of flooding. When in doubt the Environment Agency should be consultated.

DRAWING TITLE

NORTHUMBRIA AREA.
COCKSHAW BURN
&
HALGUT BURN,
HEXHAM
SHEET 1 OF 1

ORIGINATED BY	DRAWN BY	CHECKED BY	APPROVED BY
SPT	TH-R	TJS	
DATE	DATE	DATE	DATE

SCALE 1 : 2,500

PROJECT NO. / DRAWING NO. / REV C1395/DP/01/050

POSFORD DUVIVIER

09/10/1997