River Mole Strategy Study

Inception Report

Part 1 – Where we are now
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EXECUTIVE SUMMARY

One of the main aims of both, the Department of Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (the Agency), is to reduce the risk of flood damage to property and people. Their objectives are to ensure best use of public money and better decision making in flood risk management, by a consultative appraisal of technical, economic, environmental and social issues. One method of achieving this is by undertaking high level strategy studies to ensure that the significant issues are addressed on a broad basis early during investigations, involving key stakeholders.

A Flood Defence Strategy Study should aim to provide a high level, holistic understanding of flooding in a defined area, or particular catchment flood process. It forms an important element of DEFRA’s strategy for flooding and fluvial flood defence. Strategy studies are often preceded by Catchment Flood Management Plans (CFMP), which on a broader scale, aim to identify all flood management and flood process issues across the whole catchment. However, where a CFMP has not been concluded, the Strategy will require information and investigation which is common to both studies. This information will then feed into any subsequent CFMP.

The River Mole Strategy aims to identify the significant factors that influence flood flows and levels at identified hotspot locations in the catchment, and determine how these factors affect the built and natural environment. It will consider future climate change and changes in land use in seeking to investigate long term measures for flood risk management at these hotspot locations.

The River Mole flows from its upper reaches to the south of Crawley on the Surrey/Sussex Border, through Gatwick (under the airport runways) and the urban areas of Horley, Reigate, Dorking, Leatherhead, Cobham and Esher to its confluence with the River Thames at Molesey.

The Mole has experienced flooding on a number of occasions in recent times, with property and asset damage. The 1968 event was significant in the catchment, as it was for many places in the south east. In particular, this led to the construction of the Lower Mole Flood Alleviation Scheme (FAS) from Esher to the Thames confluence. Flooding in the year 2000 occurred in the upper reaches around Crawley and Horley and a number of the urban areas along the Middle Mole.

The River Mole Strategy Study has been divided into three convenient sub-catchment areas:

1. The Upper Mole is from the headwaters at Crawley to the Kinnersley Manor gauging station, north of Crawley.
2. The Middle Mole is from the gauging station at Kinnersley Manor to the upstream end of the Lower Mole Flood Alleviation Scheme (near the Esher railway bridge).
3. The Lower Mole extends to the confluence with the River Thames at Molesey, through the Lower Mole Flood Alleviation Scheme.

Environmental considerations will be integrated throughout the development of suitable flood management measures for the River Mole. Account will be taken of important environmental
resources within the catchment and of potential environmental opportunities and enhancements.

The Inception stage of the Strategy Study has drawn together data and information on flooding in the catchment, as well as set out the objectives for consultation and further investigation. This report therefore summarises:

- the aims, objectives and boundaries for the River Mole Strategy Study.
- the flood risks and hotspots identified,
- key issues and flooding mechanisms at each hotspot,
- the data collected and knowledge gained to date,
- details of the Communication Plan and consultee feedback,

The Inception report also proposes a way forward for the study:

- a combination of existing and new hydraulic models will enable the assessment of the mechanisms which cause flood damage to assets, in most key hotspot locations
- a range of flood risk management measures will then be modelled and tested at a broad scale, to assess possible improvements to the flood regime
- where hotspots are away from major watercourses, and perhaps beyond Agency direct responsibility, flood mechanisms will be identified and consultation undertaken with operating authorities, to determine where improvements may be made.
1. INTRODUCTION

The Department of Environment, Food and Rural Affairs (DEFRA) has overall ministerial responsibility for flood risk management in England. They aim to reduce flood risks by:

- encouraging the provision of adequate and cost effective flood warning systems
- encouraging the provision of adequate technically, environmentally and economically sound and sustainable flood defence measures
- discouraging inappropriate development in areas at risk from flooding.

DEFRA and the Environment Agency (the Agency), have recognised the need to review previous approaches to flood management. Flood alleviation and flood management are now being advanced in a more pro-active way, identifying flood risk areas and developing preventative measures before events occur. This is being undertaken at several levels, and Strategy Studies aim to investigate those flood risks in a defined area or particular catchment process. Where the catchment is not yet covered by the higher level Catchment Flood Management Plan (CFMP), as in the case of the Mole, the Strategy will undertake a broader spectrum of activities, in order to accelerate the identification of possible measures. The CFMP will then utilise this information at a later date.

The Mole catchment has experienced extensive flooding on several occasions in recent times, which has led to property and asset damage. The following two events were particularly significant:

- The 1968 event caused extensive property damage in the Mole. In response to this event, the Lower Mole Flood Alleviation Scheme (FAS) was constructed in the 1980s, from Esher to the Thames confluence.
- The 2000 event affected properties mainly in the upper reaches around Crawley, particularly in the recently developed area of Maidenbower. A number of the urban areas along the Middle Mole also experienced inundation.

2. DEVELOPMENT OF MOLE STRATEGY

2.1 DEFRA policy

This Inception report has followed DEFRA’s Flood and Coastal Defence Policy Appraisal Guidance 2 (FCDPAG2), which requires five stages:

- Identification of problems and key issues (taking into account issues which have been identified in the high-level plans).
- Establishment of strategic aims and objectives
- Data gathering and analysis, consultation, option appraisal and resolution of conflicting interests
- Decision on preferred policy and implementation options
River Mole Inception Report

- Establishment of arrangements for ongoing monitoring, review and feedback to subsequent versions of the strategy.

2.2 **Mole Strategy objectives**

The overall objective of the Mole Strategy is to identify those areas where there is significant damage to property and assets, understand why and how these areas become inundated, and determine what may be done about it. The study is to be undertaken in two Stages and was commissioned by the Agency and described in their brief dated 18 September 2002.

This report covers the first, Inception stage, which reports on the:

- Establishment of aims and objectives of the study
- Identification of key flood risk management issues and locations
- Data gathering and consultation
- Interconnection with other studies
- Baseline appraisal of the various flood mechanisms and environmental issues.
- Determination of appraisal methods and techniques for the second stage of the study

The second, assessment stage of the study includes:

- Continuation of data gathering and analysis
- Appraisal of flood management measures, through the hydraulic modelling
- Determination of flood issues and way forward at hotspots away from main rivers or critical ordinary watercourses (COWs) which are not to be modelled
- Completion of the Strategic Environmental Assessment (SEA) for the measures identified.

2.3 **Catchment processes and specialist areas**

Investigating the dominant catchment processes is crucial in identifying where property inundation occurs and why. In order to achieve understanding of flood risks, specialist areas will be investigated:

- Hydrology
- Hydraulics in the main rivers and some critical ordinary watercourses (COWs)
- Drainage issues at some hotspot areas
- Geomorphology and sediment transport
- Economics
- Environmental assessment
- Rural and urban land use
- In addition, future changes which may occur in the catchment will be assessed:
- Future development and land use changes
• Climate change

2.4 **Strategy and CFMP interaction**

The now accepted practice by DEFRA is to carry out the high-level CFMP in order to look at all of the catchment-wide issues. The methodology at Inception Phase is largely common to that of the strategy but at the second phase, the CFMP will use broadscale modelling to give a coarse appraisal of the flood and environmental issues across the catchment, whereas the Strategy will focus on the ‘hotspots’ with the aim of leading quickly to schemes via pre-feasibility and feasibility studies.

The Mole Strategy Study intends to undertake a method of broad scale catchment modelling which will enable the effects of flood risk management measures, in various locations, to be assessed at each major hotspot, or groups of hotspots. This will avoid flood risks being investigated in isolation.
3. **THE MOLE CATCHMENT**

3.1 **Description of the catchment and study area**

The River Mole rises to the south of Crawley, and flows generally northwards towards its confluence with the Thames at Molesey. The catchment area is 487km$^2$, and is contained within the counties of Surrey and West Sussex. Although largely rural, it is home to approximately 296,000 people, mainly within the principal towns of Crawley, Horley, Reigate, Redhill, Dorking, Leatherhead and Esher. The river is approximately 80km in length and falls approximately 95 metres from its source to the Thames confluence. It runs broadly in a south to north direction and flows between a gap in the North Downs, between Dorking and Leatherhead, known as the Mole Gap.

Tributaries include the Gatwick Stream, Burstow Stream, DeanOak Brook, Salfords Stream, Redhill Brook, Leigh Brook, Gad Brook, Tanners Brook, Pipp Brook and River Rye.

The catchment has been divided into three well defined areas that match the Section 105 study areas. These are the upper, middle and lower Mole:

- **The Upper Mole** is from the headwaters south of Crawley to the Kinnersley Manor gauging station. This area has previously been modelled under the Section 105 initiative, and this is currently under review. It also includes major infrastructure, such as the M23 motorway, main London to Brighton railway and Gatwick International Airport (the Mole runs underneath the runways).

- **The Middle Mole** is between Kinnersley Manor and the upstream end of the Lower Mole Flood Alleviation Scheme (near Esher railway bridge).

- **The Lower Mole** covers the Lower Mole Flood Alleviation Scheme reaches (which was constructed in the early 1980s) to the Thames discharge at Molesey.

- Figures 1 and 2, and maps in Appendix A1 shows the study area covered by this strategy plan.
3.2 Current understanding of the catchment

In order to determine the current understanding of the catchment, consultations were undertaken with all interested parties within the Agency, as well as with key external stakeholders by questionnaire. A workshop was held with internal consultees to present the data collected and agree the adequacy of data collected during the Inception phase. The key issues, boundaries and strategic aims for the strategy study were also discussed to ensure that the Inception Report would adequately enable a brief for Phase 2 to be prepared. A workshop was also held with Local Authorities, and their comments are also incorporated within this report.

3.2.1 Particular catchment features

The River Mole is typical of rivers found in Southern England. Particular features in the catchment include:

- Discrete, urban areas, interspersed with extensive rural and agricultural stretches

Figure 2 – Mole catchment study area
• The North Downs forms a dominant feature of the topography, with the flatter Weald forming the basin through which the Mole flows for a large part of its length. The Mole forces its way through the Downs at the Mole Gap, north of Dorking.

• Major infrastructure within the catchment includes
  - the M25 and M23 motorways, as well as other south coast trunk roads,
  - Gatwick International Airport, at which further expansion is under review,
  - the main London-Brighton railway.

• Areas of environmental and recreation significance, including the Surrey Hills and High Weald Area of Outstanding Natural Beauty (AONB)

• The town of Crawley, which has expanded rapidly in recent years, and is likely to continue to do so.

### 3.2.2 Flood records and risk

#### Flood records

Meetings and site visits with Operations staff from the Agency enabled flood risk ‘hotspots’ to be mapped based primarily on year 2000 flooding. The site visit included a walk-over of key sites and the issues were discussed in detail. The map is included in Appendix A2.

The indicative flood plain map and flood envelopes for a number of significant flood events since 1947 were obtained from the Agency in GIS format. These were for the years 1947, 1960, 1968, 1974, 1979, 1990 and 2000 and will be used to assist option development in phase 2.

Other Flood history documents on the Horley Flood study and Gatwick Stream study were consulted. This indicated that the events of 1968 and 2000 were the most significant with the maximum number of properties being readily identified as having been flooded.

Following assessment of the available records, it is clear that the 1968 flooding was the worst ever recorded in this area, with disastrous consequences throughout the entire catchment. The towns of Molesey and Esher in the Lower Mole were the worst affected, with more than 8000 properties flooded, thousands evacuated from their homes and roads, shops, factories and schools closed. Further upstream considerable damage was caused with several bridges completely destroyed including Downside Bridge at Cobham and Boxhill Bridge near Dorking.

The records show that the autumn floods of 2000 were the most severe since 1968. In 2000, 74 properties reported flood damage. This flood is reported as 1 in 30 flood event. This incident caused flooding on the M25 at Leatherhead causing traffic to gridlock. The A245 at Cobham was affected for several days.


Table 3.1 shows major rainfall events and the greatest flow levels in the Mole since 1951 with some related consequences.
<table>
<thead>
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<th>Start Date</th>
<th>End Date</th>
<th>Flow (m³/s)</th>
<th>Consequences</th>
</tr>
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<tr>
<td>06/10/1987</td>
<td>11/10/1987</td>
<td>120.6</td>
<td>Meath Green area of Horley particularly affected. Meath Green bridge closed.</td>
</tr>
<tr>
<td>28/09/1993</td>
<td>03/10/1993</td>
<td>100.4</td>
<td>Borough Bridge, Brockham closed. Flooding in Dorking and Betchworth</td>
</tr>
<tr>
<td>13/11/1970</td>
<td>18/11/1970</td>
<td>82.2</td>
<td>No flooding information available</td>
</tr>
<tr>
<td>29/07/1969</td>
<td>03/08/1969</td>
<td>82.0</td>
<td>No flooding information available</td>
</tr>
<tr>
<td>10/06/1971</td>
<td>15/06/1971</td>
<td>80.5</td>
<td>No flooding information available</td>
</tr>
<tr>
<td>03/08/1997</td>
<td>08/08/1997</td>
<td>80.4</td>
<td>No flooding information available</td>
</tr>
<tr>
<td>13/09/1975</td>
<td>18/09/1975</td>
<td>79.1</td>
<td>Houses on Lee Street affected through to Lodge Lane at Salford. Estimated return period of 2 years</td>
</tr>
<tr>
<td>29/01/1990</td>
<td>03/02/1990</td>
<td>79.0</td>
<td>Surrey Advertiser stated “Two men died, thousands of families suffered damage to cars and property” – torrential rain and storm force winds</td>
</tr>
<tr>
<td>16/11/1951</td>
<td>21/11/1951</td>
<td>77.7</td>
<td>No flooding information available</td>
</tr>
<tr>
<td>25/07/1962</td>
<td>30/07/1962</td>
<td>77.2</td>
<td>No flooding information available</td>
</tr>
<tr>
<td>30/06/2000</td>
<td>05/07/2000</td>
<td>76.1</td>
<td>Possibly a contributing factor to the events of September of the same year</td>
</tr>
<tr>
<td>02/10/1976</td>
<td>07/10/1976</td>
<td>75.8</td>
<td>Crossoak Lane off Bonehurst Lane, Horley under approx. 300mm water. Broadbridge Lane flooded to the extent it was closed.</td>
</tr>
</tbody>
</table>

Table 3.1: Mickleham (Dorking) Rain Gauge Major Rainfall Events and corresponding flooding consequences for Middle Mole (sorted by flows). From Ref 4.

Flood risks identified

Thirty three sites have been identified as being at risk from flooding: seventeen in the Upper Mole, fifteen in the Middle Mole and one in the lower Mole. The sites are mapped in Appendix A2 and further detail may be found in Appendix B2 – Key Flood Risk Site Specific Information. The problem areas can be grouped as follows:
Upper Mole – study area: sites that are included in either the Horley Flood Study or Gatwick Stream Feasibility Study, e.g. Maidenbower and Smallfield.

Upper Mole - Non-study sites, e.g. Ifield Green.

Middle Mole - Individual properties with potential local solutions, e.g. Burford Bridge Hotel.

Middle Mole – Groups of properties at several sites – potential for high level solution, e.g. Brockham, Fetcham and Cobham.

Lower Mole - Individual definable problems with local solutions, e.g. Albany Bridge and QEII Reservoir culvert.

Three Flood Events appear to have had the greatest impact on flooding in the Mole: 1968, 1990 and 2000. Interestingly, the 1947 event which had significant impact on the Thames, mainly only affected the Lower Mole; the actual number of properties has not yet been identified. The interface between the Mole and the Thames needs to be investigated to define future flood risk.

Lower Mole

In 1968 it was reported that 8000 thousand of 20,000 properties at Esher were flooded in what was estimated to be a 1 in 200 year flood event. The Lower Mole Flood Alleviation Scheme (FAS) was completed over the next decade, and therefore in the year 2000 event, few properties were affected in this area.

Middle Mole

In 1968, over 200 properties flooded in the Middle Mole, mainly at Fetcham, Leatherhead where approximately 180 were reported flooded. Two bridges were also destroyed, Downside at Cobham and Boxhill near Dorking.

In 2000 only eight properties were reported flooded at Fetcham and Dorking during a 1 in 30 year flood event.

Upper Mole

With the rapid growth in urbanisation being concentrated around Crawley and Gatwick Airport in the last 10 years, the 2000 flood event is most relevant. In this event, approximately 90 properties were reported flooded in the Upper Mole Catchment. Of these, 44 were in Maidenbower, 20 at Furnace Green and 14 at Ifield Green.

3.2.3 Existing flood defences

The Lower Mole Flood Alleviation Scheme (FAS) extends from Esher to the River Thames at Molesey. This scheme was implemented after the 1968 flood severely affected residents in the Lower Mole valley when some 8000 properties were flooded. The scheme does not have any statutory levels for flood defence but the indicative standard of protection used for the scheme design was a 200:1 annual chance event. The banks are inspected as part of the Mole Flood Defence assets.
Other flood defence assets exist on the River Mole but these are in the process of being redefined by the Agency’s Operations Section.

3.2.4 Geology, hydrogeology, soils and geomorphology

Geology and Hydrogeology

The Mole catchment lies over two of the main geological structural units of south-east England; the Wealden anticline to the south and the London Basin to the north. The Wealden anticline is highly faulted and comprises sandstone, silts and clay. The London Basin comprises of younger deposits of chalk, gravels, sands, silts, gravels and clays. The Basin is essentially elongated with the Lower Greensand Series and the chalk strata lying in east-west ridges across the middle of the catchment. They form major aquifers in which the predominant groundwater flow direction is to the north/north west, with some minor variations.

The River Mole rises on the Cretaceous Weald Clay and from small springs in the Hastings Beds. From here, the strata dip northwards as part of the northern limb of the Wealden anticline. The R. Mole flows over Weald Clay to the south east of Dorking where it crosses the outcrop of Lower Greensand (which forms and east-west range of hills: The North Downs). The River then flows northwards over Gault Clay and Upper Greensand onto the Chalk through the ‘Mole Gap’ from Dorking to Leatherhead, with Box Hill to the east and Ranmore Common to the west. In the southern area of the ‘Gap’, as far north as Micklesham, the river is connected to the underlying aquifer by swallow holes. Occasionally, in dry weather, the river can dry up as water is lost from the river to groundwater. It then emerges as powerful springs in the river bed south of Leatherhead. Chalk springs are also present at Fetcham. The chalk aquifer provides the major input of groundwater to the flow of the R. Mole, maintaining flows north of Leatherhead in dry weather. The Strategy will consider any potential impact that a flood defence scheme could have on this existing situation.

North of Leatherhead the River flows across Tertiary strata (London Clay and Bagshot Beds) to the River Thames. In the Lower Mole valley, much of the tertiary strata are overlain by drift deposits of silty sand and gravel.

Regionally Important Geological/Geomorphological Sites (RIGS) would need to be identified at the SEA stage. RIGS are geological sites other then SSSIs, which are considered worth protecting for their educational importance and their research, historical or aesthetic appearance from proposed development. In Surrey, RIGS have been identified by the County Council in partnership with English Nature and the Surrey Wildlife Trust (the Surrey RIGS Group).
Soils

In the Upper Mole, south of Crawley, the soils are of variable permeability. North of Crawley, the soils are impermeable with a clay texture; where farmed the soils are tile-drained but remain susceptible to winter water-logging and as a result are often artificially drained.

Where the River Mole passes through the ‘Mole Gap’, the soils of the North Downs are shallow with chalk/rubble at 30cm depth. North of Leatherhead there is a belt of clayey and fine loamy impermeable and seasonally waterlogged soil with clay alluvial soils bordering the river. As for the Upper Mole, soils are likely to be artificially drained for farming. As the river passes through from the middle to the lower Mole, south of the River Thames, it is bordered by coarse-textured soils with gravel subsoil on river terraces, behind which lies very acid sandy heathland soils.

River flows are strongly influenced by soil conditions. River response to rainfall will be highlighted in areas dominated by permeable soils which inhibit vertical percolation and lead to lateral movement of water across the surface or within the soil. Infiltration rates will be higher for freely draining soils, although cultivation and compaction can result in artificially high runoff rates.

Geomorphology

At present, there is relatively little information available regarding the geomorphology of the River Mole catchment. A basic assessment of channel type is provided in the River Mole Landscape Assessment (1993). However, the Agency is planning to undertake a project on geomorphological assessment of the Mole catchment (Agency to confirm dates). The primary aims of this project are likely to be:

- Sensitivity: Characterise catchment in terms of geomorphological conservation values and sensitivity to degradation;
- Sediment issues: Identify sediment sources and storage zones with a view to examining the long-term effectiveness of any dredging regimes;
- Management Issues: Identify specific potential problems with, or opportunities for, river management on a catchment and reach-to-reach basis, highlighting any landscape, ecological or general restoration areas that may benefit from additional management.

The Agency draft River Mole CFMP Scoping Study (2002) identified that the impact of sedimentation on the efficiency of the Lower Mole FAS has led to annual surveys being carried out to establish a rate of disposition prior to any decisions being made regarding silt removal.

3.2.5 Water resources and quality

Water Resources

The mean annual rainfall across the catchment is 761mm, allowing for losses such as evaporation and transpiration, the mean annual effective rainfall is 310mm. Most of the effective rainfall in the Upper Mole enters the river system due to the impermeable nature of
the soils. Only in the ‘Mole Gap’ does the effective rainfall enter through the soil to recharge the aquifer.

Approximately 65% of the total licensed volume of water abstracted in the Mole catchment is from groundwater resources and the remaining 35% is from surface water. The majority of abstraction is for public water supply.

Recent changes to the Abstraction Licensing System (1999) have resulted in the introduction of local Catchment Abstraction Management Strategies (CAMS). The aim of CAMS are to make more information on water resources and licensing practised available to the public and also to ensure that they are developed in consultation with the local community and other interested parties. The production of CAMS for the Mole began in 2002 and is currently out for initial consultation. The final publication of the Mole CAMS is due to be complete by summer 2004. The CAMS is intended to be reviewed again in spring 2008.

As part of the SEA the Mole CAMS should be reviewed in further detail to identify any impact on/integration with a flood defence strategy as part of the SEA.

As outlined above, the implications of the EU Water Framework Directive should be assessed to identify its requirements for developing a flood defence strategy.

**Water Quality**

Annual assessment of general water quality is made under the General Quality Assessment (GQA) scheme, which considers chemical, biological, nutrient and aesthetic aspects of the river reach assessed, and through the River Quality Objectives (RQO) scheme.

Chemical GQA comprises six grades from A, highest quality, to F. 176km of river within the Mole catchment are monitored using the chemical GQA scheme. Data is available for 1993 and 1998 (LEAP, 1999). Generally, there has been an improvement in chemical GQA in the catchment. The Upper Mole is designated a Sensitive Area (Eutrophic) under the Urban Waste Water Treatment Directive (UWWTD).

Biological GQA involves an assessment of the macroinvertebrates present in the reach being assessed which reflect changes in water quality and intermittent and low-level pollutants, which often remain undetected by chemical methods. Biological GQA comprises six grades (a - f): Very Good, Good, Fairly Good, Fair, Poor and Bad. The biological status of rivers in the catchment was sampled once during 1996/7. The Gatwick Stream was the only main river reach in the catchment found to be Poor. Generally, the River Mole and main tributaries range from Fairly Good to Fair, and only the Leigh Brook, Bookham Brook and the Mole just south of Dorking was found to be Good.

The RQO scheme uses a classification scheme called the River Ecosystem (RE) scheme which has five classes (RE1: very good quality for fish, to RE5: poor quality likely to limit coarse fish populations). The classes reflect chemical quality required by different types of ecosystem including fisheries. Progress concerning RQOs would be identified and reviewed at the next stage of the Strategy.
**3.2.6 Existing maintenance regimes**

The Maintenance on the River Mole is aimed to maintain the assets in a serviceable condition and to keep the watercourses clear to reduce flood risk in an environmentally sensitive manner.

The existing maintenance programme is included in Appendix B5

The maintenance regime will be reviewed in phase 2 of the strategy to seek harmony between future flood risk requirements and sustainable practices.

**3.2.7 Climate change in the Mole catchment**

**Relevant research**

One of the most comprehensive recent research studies into the possible impact of climate change on fluvial flood flows was undertaken by CEH-Wallingford (2001) in a programme for the European Community.

The project involved the modelling of current and future hydrological conditions for eight case study catchments in the UK. These catchments were chosen to sample the range of hydrological conditions around Great Britain. Of most relevance to the River Mole Strategy were the case study catchments of the Beult at Stile Bridge (40005) and the Thames at Kingston (39001). The Beult catchment (277 km$^2$) has a similar area to that of the River Mole, drains the eastern end of the Weald, and has similar soils to that of the Upper Mole catchment. Geographically it is close to the River Mole and is therefore likely to experience a similar future climate. The Thames catchment (9948 km$^2$) is perhaps of slightly less relevance, being that much larger, but does actually incorporate the Mole catchment within its overall catchment area.

In the CEH Wallingford work, climate change scenarios were derived from different Global Climate Models (GCMs), using simple spatial and temporal downscaling techniques. After calibration of a rainfall-runoff model using observed data under current conditions, continuous flow simulation under current and changed conditions was undertaken using GCM outputs. The impact on the flood regimes were compared.

**Implications of Climate Change**

The modelling results in general suggested that there will be an increase in the severity and magnitude of high flow and flood events across all of Britain (ranging between 0 and +25% for the 20-year event by the 2050s), though in general less pronounced in the southern regions. In addition it was predicted that there will be a lengthening of the period of high flow everywhere, and an increase in the frequency of large flood events, and also a possible increase in the variability of the flood regime. Interestingly, the predictions for Beult at Stile Bridge, the most similar case study catchment to that of the Mole, suggested the smallest increases in extreme flood magnitude (almost no change in the 20-year peak flow by the 2050s). For the Thames catchment the predicted increase was between +5 and +10%. Predicted changes were slightly greater for more frequent events (e.g. 2-year events). No predictions for more extreme events were given. In terms of frequency the return period of
the present 20-year peak flow was predicted to be unchanged by the 2050s at the Beult at Stile Bridge, and reduced to a 7-year event on the Thames at Kingston Bridge.

These projected changes to the flood regime in Britain broadly agree with the earlier guidance given by the UK government (MAFF, 2001). This recommended that consideration of possible increases in peak flow be included in the sensitivity analysis of river flood alleviation schemes. In particular, it recommended that the sensitivity analysis of river flood alleviation schemes should take account of potential increases of up to 20% in peak flows to reflect the prediction for 2050.

It is important to note that neither of the above projections was based upon the latest climate change scenarios. The most recent climate change impact scenarios for the UK were released at the start of 2002 and are known as the UKCIP02 scenarios (Hulme et al, 2002). The emission scenarios suggested that the 20-year return period daily precipitation depth change by the 2050s for the Mole catchment might be between 0 and +5% (for all emission scenarios) and that winter and spring will be the seasons that experience the biggest increases. Intense rainfall days per season in general are projected to increase mainly in the winter months. Although annual decreases of 0 -10% in the total amount of rainfall are predicted for the Mole by the 2050s (by all emission scenarios), total winter rainfall is consistently suggested to increase by between 10 and 20%. Rainfall in other seasons is predicted to decrease. Until the convolution of the projected future event rainfall and catchment wetness has been properly investigated, in terms of flood hydrology, it is difficult to predict how these new climate change scenarios are likely to affect flood projections. However, the above magnitudes of change, appear at first sight, not to result in radically different flood magnitude projections.

From the above information it seems appropriate to use the DEFRA guidance for the River Mole. In particular, it recommended that the sensitivity analysis of river flood alleviation schemes should take account of potential increases of up to 20% in peak flows to reflect the prediction for 2050.

### 3.2.8 Hydrological and other studies

A number of hydrological studies have completed or are on-going in the catchment.

#### Upper Mole
- Upper Mole - modelled for Section 105; hydrology done by the Agency in-house using Ribaman; hydraulic modelling by Babtie using Mike 11 in the late 1990s.
- The Horley Flood Study – an Upper Mole Hydrological Study centred on Horley but covering much of the northern Crawley/Gatwick and Horley area. This is updating the hydrological data and studying the flood issues on Mole tributaries in the area.
- Burstow Stream - extensive hydrological modelling done in late 1980s for development control to try and establish a return period for the 1968 flood, and to estimate a 100 year flood.
- Salfords Stream - S105 study completed using Hydro-1D.
- Gatwick Stream Diversion - watercourse diverted because of airport extensions, losing floodplain.
• Gatwick Stream at Crawley - new (Oct 2001) model for 'Gatwick Stream Flood Alleviation' pre-feasibility study (BBR ref BWA290108).

• The Gatwick Stream Feasibility Study – an Upper Mole study looking at specific flood issues on Gatwick Stream and the Crawley areas.

• The Agency reported that the resulting flood map is very controversial because of heavy development pressure and very flat and dubious data. Public enquiry led to further modelling. Investigations still going on (7/02).

• Ifield Green Flood alleviation pre-feasibility study - no new model built for this scheme which proved uneconomic.

**Middle Mole**

The Section 105 study for the Middle Mole is not now expected to be undertaken until 2004. No hydrological study or hydraulic modelling has commenced.

The Agency has identified the reaches to be modelled in their Middle Mole Flood Risk Mapping Study – Inception Report (Sep. 2002). These reaches are shown in table 3.3 and indicate the detail of model proposed, by type. A schematic map has been included in Appendix A4.

<table>
<thead>
<tr>
<th>Reach Name</th>
<th>Status</th>
<th>Length (km)</th>
<th>Model type</th>
<th>Upstream NGR</th>
<th>Downstream NGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Mole 1</td>
<td>Main</td>
<td>34</td>
<td>Detailed</td>
<td>516400 155150</td>
<td>513100 166150</td>
</tr>
<tr>
<td>River Mole 2</td>
<td>Main</td>
<td>6</td>
<td>Simplified</td>
<td>517100 151900</td>
<td>516400 155150</td>
</tr>
<tr>
<td>River Mole 3</td>
<td>Main</td>
<td>6</td>
<td>Detailed</td>
<td>519600 149650</td>
<td>517100 151900</td>
</tr>
<tr>
<td>River Mole 4</td>
<td>Main</td>
<td>15</td>
<td>Simplified</td>
<td>526250 146650</td>
<td>519600 149650</td>
</tr>
<tr>
<td>The Rye 1</td>
<td>Main</td>
<td>2</td>
<td>Simplified</td>
<td>516210 158260</td>
<td>514750 157400</td>
</tr>
<tr>
<td>The Rye 2</td>
<td>Non Main</td>
<td>5</td>
<td>Simplified</td>
<td>519700 158460</td>
<td>516210 158260</td>
</tr>
<tr>
<td>Pipp Brook</td>
<td>Non Main</td>
<td>5</td>
<td>Simplified</td>
<td>513750 148850</td>
<td>517450 150800</td>
</tr>
<tr>
<td>Bookham Brook</td>
<td>Non Main</td>
<td>2</td>
<td>Simplified</td>
<td>512050 156760</td>
<td>511710 158380</td>
</tr>
</tbody>
</table>

**Total length** | **75**

**Table 3.2: Hydraulic Model Extent for the Middle Mole**

**Lower Mole**

The upstream limit of the Lower Mole is at the commencement of the Flood Alleviation Scheme. Section 105 work on the Lower Mole has not yet commenced.

Other studies and reports on the Mole are listed in Appendix B4.
3.2.9 Land use

As stated in the LEAP (1999), at that time, approximately 25% of the catchment was urban, 8% woodland and the remainder agriculture. Much of the urbanised area has been built in the last 30 years.

Upper Mole

Crawley is one of the original ‘new towns’. Its population is more than 90,000 and is expected to grow to 105,000 by 2006. Several headwaters of the Mole run through Crawley. The largest recent development is Maidenbower to the southeast of Crawley, which experienced significant flooding in 2000. These towns are under significant pressure for housing and industrial development.

Gatwick Airport is a significant land use feature within the catchment. The number of passengers the Airport handles is expected to increase significantly by 2008. The River Mole has been moved on several occasions during the Airport’s development: it now passes under the runway through a culvert. In 1999, 1.5km of the River Mole was diverted to enable optimum use of the Airport’s operational land.

Between Cobham and Esher, there is a green corridor containing golf courses, racecourses, sports fields and riding schools.

The main agricultural land use within the catchment is pasture. The LEAP (1999) notes that since 1983 there has been a significant decline in the area used for crops and fallow and an increase in woodland. The fertile soils on the alluvial flats on the outskirts of Esher and Hersham are classified as Grade 1 and 2 agricultural lands and are intensively cultivated for market gardening and Pick-your-own fruit.

3.2.10 Planning issues

Development Allocations

The following allocations of land for development within the catchment currently exist in local authorities’ Local Plans. Further information on current and known forthcoming development proposals will be collected at a meeting with Planning Officers scheduled for 12th February 2003:

Upper Mole

Reigate and Banstead Borough: the Local Plan (Revised Deposit Draft 2000) includes a significant allocation for housing in Horley of around 3000 new homes after 2006. Some of the allocated land is shown on the Proposals Map as encroaching into the Indicative Flood Plain. Flooding is an important issue in Horley and the subject has been raised during the Public Inquiry into the proposed revised plan. A specialist report into flood risk was commissioned which concluded that the flood envelope shown on the map cannot be relied on. The Inspector has therefore concluded (in January 2002) that further work is required to validate the flooding model and floodplain information. The Agency is currently investigating this as part of the Horley Flood Study.
No new major commercial development is envisaged in Horley, although up to 1000 square meters of office development is proposed in the North West Sector. Elsewhere in the borough, no major new developments are proposed.

Crawley Borough: the Local Plan includes provision for a new residential neighbourhood and for commercial development in the North East Sector of the town. The neighbourhood will provide for the development of between 2,200 and 2,700 new houses and 5,000 sq m of employment floor space. However, no permission will be granted until 2003 unless the Government has published the new national airports policy and it is confirmed that the proposed development is compatible with the combined effects of that policy and PPG24 (Planning and Noise).

36 further allocated housing sites are included within the plan, 7 of which have been completed. All of these sites together provide for around 800-900 new houses. In addition, 8 sites for new employment generating development are identified (38,000 square meters of new floor space) plus a number of previously identified sites yet to be completed.

Mid Sussex District: The Local Plan (deposit) includes one housing site, at Pease Pottage, for 65 dwellings, and a small business site in the same area. A small business development site and a site for a new school are identified at Copthorne.

Horsham District: In Horsham, an area of 1.75 ha is allocated for the development of around 12 houses in Rusper, on the boundary of the catchment.

Ifield Green: A floodplain area under consideration for a development of up to 2000 houses.

**Middle Mole**

Elmbridge Borough: The Elmbridge Local Plan includes two major housing sites, in Hinchley Wood (5 ha) and Oxshott (1.8 ha), suitable for a total of approximately 167 houses. A further 0.4 ha site, for approximately 45 houses, is allocated on the boundary of the catchment at Walton on Thames.

Mole Valley District: The Mole Valley Local Plan includes housing allocations at three sites – in Ashtead (1.85 ha), Dorking (1.35 ha) and North Holmwood (0.43 ha). The total number of houses on these sites is estimated at 65. In addition, 2.2 ha of land in Dorking are allocated for industrial/commercial development.

**Lower Mole**

Elmbridge Borough: a 3.2 ha housing site is identified within the Lower Mole part of the catchment, in Molesley, for around 80 dwellings. The Local Plan does not allocate specific sites for employment use - the Council will consider proposals within town and village centres and within existing employment areas on an individual basis;

**General Planning Issues**

Further planning issues identified during data gathering were:

- The shorter term view of local plans (usually 15-20 years) compared with the longer term issues and impacts of climate change;
The planners’ need to balance many different issues when considering applications for example the requirement to provide a certain number of new homes in each district (imposed nationally), the requirement to achieve a certain percentage of development on brownfield sites;

- The possible cumulative impact of development within the catchment but outside of the flood plain, where flooding is not necessarily identified as an issue and therefore not considered in the decision-making process;

- The impact of politics (particularly local) on the decision making process;

- The publication of PPG25 (Development and Flood Risk) in 2001 and how it is being implemented;

- The practicalities of requiring Sustainable Drainage Systems e.g. space taken up, adoption, maintenance and planning issues;

- The accuracy of flood risk information and variation in levels of consultation between local authorities and the Environment Agency;

- How to deal with the historical legacy of development permitted and/or already built in areas at risk of flooding.

### 3.2.11 Ecology and nature conservation

#### International/National Designated areas

English Nature were consulted and provided a number of citations for designated sites in and around the immediate vicinity of the Mole catchment. A summary of these sites is provided in Appendix C2. There are a number of internationally and nationally designated sites for nature conservation value within and immediately adjacent to the Mole catchment. Appendix A3 provides a list of all sites identified (by English Nature, December 2002).

There are no Ramsar sites or Special Protection Areas (including proposed/candidate sites) located within the Mole catchment boundary. One Ramsar site (Thursley and Ockley Bogs) is located adjacent to the catchment, approximately 20 miles to the west of Crawley.

A further Ramsar site, also designated as a Special Protection Area (SPA) (South West London Water Bodies) is located approximately 2 miles to the northwest of the Mole catchment boundary, north of Staines. There is one proposed SPA located approximately 15 miles to the west of the Mole catchment (Thames Basin Heaths), near Guildford.

There is one site designated as candidate Special Area of Conservation (cSAC) within the catchment; the Mole Gap to Reigate Escarpment. This area has been recommended as a cSAC as it contains habitat types and/or species which are threatened in a European context. In addition, a further cSAC (known as Thursley, Ash, Pirbright and Chobham) was identified outside of the catchment, approximately 10 miles to the west of Crawley. These sites are registered under the Conservation (Natural Habitats &c) Regulations 1994.

Ten Sites of Special Scientific Interest (SSSIs) were identified within the catchment, and a further 51 SSSIs were identified adjacent to the catchment boundary (within a 15 mile radius of the catchment).
Other designations that will be considered at the next stage of the SEA will include other nationally designated sites including National Nature Reserves, Ancient Woodland, and others, and an assessment would be made to identify sites that would/could be affected by any of the strategic flood risk management measures identified by reviewing how they are hydrologically linked to the Mole catchment.

Regionally/Locally Designated areas

Within the Mole catchment are a number of regionally and locally designated sites of ecological and nature conservation value, including these listed below. At the next stage, as part of the SEA, the following sites located within the catchment or those that could be affected by a flood defence scheme/Strategy should be identified:

- Sites of Nature Conservation Importance;
- Local Nature Reserves;
- County Wildlife Trust Nature Reserves;
- Sites of Interest for Nature Conservation;
- Others

Habitats

River Corridor Surveys (RCS) and River Habitat Surveys (RHS) were undertaken for the River Mole and its tributaries by the NRA (superseded by the Agency), in 1992. This survey is now out-of-date. A contract has just been awarded for a suite of RCSs to be conducted of the R Mole and its tributaries over the next few years up to 2006. The first phase in 2003 is in the Upper Mole, Burstow area.

In June 1992, the Convention of Biological Diversity was signed at the Earth Summit, Rio de Janeiro. It entered into force December 1993 and it was the first treaty to provide a legal framework for biodiversity conservation. The treaty called for the creation and enforcement of national strategies and action plans to conserve, protect and enhance biological diversity. In 1994, the UK produced ‘Biodiversity: the UK Action Plan’ which detailed a number of activities for conservation works over the next 20 years. Three types of action plans have been developed which set priorities for nationally important and locally important habitats and wildlife – Species Action Plans (SAP), Habitat Action Plans (HAP) and Local Biodiversity Action Plans (LBAP).

Action Plans are effective at regional level through the Thames Region BAP and at County level. Both Surrey County Council and Sussex County Council are partners with a number of organisations in their respective county Biodiversity Partnerships to develop the SAPs, HAPs and LBAPs.

The Surrey Biodiversity Partnership includes, English Nature; Environment Agency; Farming and Wildlife Advisory Group; The Herpetological Conservation Trust; Royal Society for the Protection of Birds; Surrey County Council; Surrey Wildlife Trust, and Woking Borough Council.
The Sussex Biodiversity Partnership includes, Brighton and Hove Unitary Authority; Country Landowners and Business Association; East Sussex County Council; English Nature; Environment Agency; Farming and Wildlife Advisory Group; National Farmers Union; Royal Society for the Protection of Birds; Sussex Downs Conservation Board, Sussex Wildlife Trust, West Sussex County Council; District Councils and Non Government Organisations (NGOs) on a sector basis.

Two types of documents are produced regarding habitats - Broad Habitat Statements and Priority Species Action Plans. Broad Habitat Statements provide summary descriptions of all habitats found within Surrey. In addition to a general description of the habitat type these Statements identify the current issues affecting the habitat and the broad policies which can be put in place to address these. Priority Habitats provide more detailed descriptions for specific types of habitats and set out detailed actions that can be taken by a number of agencies in order to safeguard and enhance these habitats.

Details of both the Surrey and Sussex Biodiversity Action Plans are found on the UK Biodiversity website as follows:


Other surveys are being undertaken by specific organisations such as the Surrey Wildlife Trust. Details can be found on the respective websites.

**Fisheries**

Fisheries in the River Mole are dominated by populations of roach, gudgeon, dace and chub. Pike are common up to Dorking and perch and eels are present up to Gatwick Airport. Natural populations of brown trout are present in a number of tributaries including the Gatwick Stream through Crawley. The Agency wishes to promote expansion of these populations as they are important biodiversity resources with a unique genetic pool. They are also an indicator of high water quality and habitats.

Due to improvements in water quality, the fish populations have improved over the last 10-15 years in many of the Mole’s tributaries. The River Mole itself is broken up by a variety of weirs and other impoundments which may impede fish movement upstream.

The Agency’s Fisheries Officer for the Mole encourages the use of ORSUs (Off River Supplementation Unit) and oxbow lakes in future schemes to provide sheltered habitat for fish during flood flows.

Upstream of Brockham, fisheries have been constrained in the past by poor water quality from effluent discharges and storm water run-off from Crawley. Downstream of Brockam, high quality coarse fisheries exist all the way to the Thames, although these have deteriorated as a result of past flood alleviation schemes between Hersham and Molessey.

Fisheries surveys (at 8/9 sites) on the River Mole are planned for 2003.
3.2.12 Landscape and visual amenity

There are two Areas of Outstanding Beauty (ANOB) within the Mole catchment: Surrey Hills AONB and High Weald AONB.

English Nature have since 1993 been working on a new bio-geographical framework which they call the *Natural Areas Strategy*. This strategy states as its primary objective that natural areas need to provide a system that integrates planning and management of the countryside. The Mole catchment includes five natural areas: London Basin; North Downs; Wealden Greensand; Low Weald and Pevensey; and High Weald. (Appendix A3). Although the Natural Area strategy is a concept conceived by English Nature it is likely that the issues it has identified will be tackled in partnership with other organisations. The Countryside Agency has shown willingness to co-operate by allowing the incorporation of their Countryside Character Programme and Map with the Natural Areas map to produce a joint Character Map.

Although responsibility for management of landscape within the catchment is well dispersed amongst various organisations and landowners, the Agency aims to help safeguard the specially designated landscapes as well as protecting and enhancing highly valued river landscapes. A full landscape assessment was commissioned by the NRA in 1993 and undertaken by WS Atkins. The assessment prioritises works required to enhance landscape quality in the catchment. This is the most up-to-date landscape assessment for the Mole catchment.

The landscape assessment identified fourteen different generic landscape types, these included: Sandstone Ridges, Clay Plain, Rural Floodplain, Greensand Hills, Greensand Ridge, Chalk Scarp Vale, Chalk Plateau, Chalk Gap, Suburban Floodplain, Common, Suburban Fringe, Urban Floodplain, Urban Areas and Airport.

3.2.13 Recreation, tourism and amenity

Several long distance footpaths and bridleways cross the Downs and Weald: North Downs Way, Pilgrim’s Way, Greensands Way, Sussex Border Path and Worth Way. However, both these strategic footpaths and the local footpaths only marginally impinge on the rivers. There are very few stretches of footpath or disused towpaths which run adjacent to the watercourses within the Mole catchment.

The Agency seeks to balance the different demands which arise from the increasing number of user groups wishing to access the river and lakes to enjoy their chosen recreational activities. The Agency has produced guidance which is designed to help riparian land owners, fishery owners, fishery occupiers and canoeists draw up access agreements taking in to account all relevant interests on or adjacent to the waters concerned. The guide titled *Agreeing Access to Water for Canoeing* is published on behalf of the National Angling and Canoeing Liaison Group and as a result of this publication the Agency, when requested will act as an ‘impartial mediator’ where establishing agreement between user groups proves problematic.
Canoeing along the Mole and its tributaries requires the permission of the relevant landowners, although the British Canoe Union has negotiated with landowners to allow canoeists to utilise a 24 mile long stretch of the River Mole and is in ongoing negotiation with the Agency to allow their member's access to the Lower Mole Flood Alleviation Scheme.

The Mole catchment is also popular with anglers, with over twenty different fish species currently fished, including chub, roach, dace, pike, eel and perch. The main river is currently intersected by weirs which restrict fish movement, although some weirs (e.g. Horley Weir) incorporate fish passes to limit this problem. Significant improvements in water quality over the last 10 -15 years have led to improvements in fisheries. Below Brockham high quality course fisheries exist all the way down to the Thames, although between Hersham and Molesey they have deteriorated as a result of past flood alleviation schemes. The Agency promotes appropriate recreational access when it has involvement in environment enhancement schemes (e.g. the diversion of the Mole at Gatwick Airport) and through the Countryside stewardship scheme. One of the key objectives in any enhancement project should be 'improved opportunities for countryside enjoyment'.

The National Trust owns a great deal of land within the catchment particularly along the North Downs. The close proximity of the area to London and the fact that the area is served by good transport links have meant that the Trust's properties within the catchment, perhaps most notably Box Hill, are intensively used for informal recreation. Box Hill is one of the best known summits of the North Downs attracting almost a million visitors each year. The National Trust also owns three sizeable commons within the catchment, each are very different and immensely valuable given that they are located on the fringes of London

### 3.2.14 Cultural heritage, archaeology and material assets

There are a number of Scheduled Ancient Monuments (SAMs) within the catchment. A review of the Sites and Monument Records (SMR) held by each County Council should be reviewed at the SEA stage to identify any key sites of archaeological/cultural heritage importance that could be affected by any proposal for flood defence schemes within the Mole catchment.

It is essential that water related cultural heritage features are integrated into the development of a flood defence strategy. Wetland areas can contain important archaeological and palaeo-environmental evidence within the alluvial deposits. Preservation of such areas is dependent on the anaerobic conditions maintained by high water levels.

Listed Buildings also require consideration, particularly where flood alleviation schemes may affect them.
3.2.15  Traffic and transport

Two motorways run through the catchment: the M23 which runs through the eastern area of the catchment in a north-southerly direction, and the M25 which passes through the north of the catchment in an east-westerly direction. In addition to the motorways there are a number of other key strategic routes including the A23, A24, A25 and the A217 trunk roads.

There are six railway lines crossing through the catchment. In addition, and of key importance to the catchment, is Gatwick Airport, located in the Upper Mole between Crawley and Horley. As a result of these good transport links, there are constant pressures for further development.

The Local Area Structure Plans should be reviewed to establish if any future proposed transport link will affect flood defence within the catchment.
4. **CATCHMENT DATA**

The following key catchment data issues have been identified.

4.1 **Relevant plans and initiatives**

A number of relevant plans and initiatives have been developed for all or part of the Mole catchment. These include the following:

- Local Contribution Plans supersede the Local Environmental Action Plan; however, most data held within the LEAP is still relevant.
- Water Resources, Hydrology and Water Quality
- The River Mole CAMS;
- Local Environmental Action Plans (to be considered as a historical document only).
- Ecology and Nature Conservation
- Environment Agency Regional Biodiversity Strategy headwater survey for the Mole catchment;
- River Corridor Surveys (RCS) and River Habitat Surveys (RHS).
- Landscape and Visual

**Land use, built Environment and socio-economic Issues**

- Regional planning Guidance:
- Structure Plans and Local Plans (and supplementary Planning Briefs/Guidance).

**Recreation, Tourism and Amenity**


**Cultural Heritage**

- Environment Agency SMR GIS data (potentially does not contain the most recent information);
Up-to-date information should be obtained from the Sites and Monuments Records from the County Archaeologists.

Waste and Mineral Plans;

Other
- Structure Plans and Local Authority Development Plans;
- Policy guidance

A list of National and International Legislation and Policy Guidance is included in Appendix C3.

4.2 Survey information

It is clear that modelling will be required within the Strategy Study. Therefore, the extent of existing and required survey is crucial. A schematic map indicating survey status is attached as Appendix A4. This diagram does not show all tributaries in the catchment but outlines all the survey work that has been commissioned by the Environment Agency. Details are as follows:

Upper Mole
There is aerial photogrammetry coverage for floodplains of all main watercourses in the Upper Mole.

Topographical channel survey is available for Section 105 level modeling for the Upper Mole and more detailed surveys for specific sites in relation to the Horley Flood Study and Gatwick Stream Feasibility Study. See Appendix A4 for survey coverage schematic map. A GIS map is proposed to be completed in Phase 2 to show exact survey coverage.

Middle Mole
The most significant gap affecting progress on both the CFMP/Strategy and section 105 Study for Middle Mole is that there is no Digital Terrain Modelling or photogrammetry readily available for flood plain modelling.

In general the topographical survey status as reported by Mott MacDonald's Middle Mole Inception Report is as follows:
- 310 channel cross-sections exist for the Mole and 73 for the Rye.
- There is channel survey data for approximately half of the length of river to be modelled. On the River Mole this covers the area around Cobham, from Leatherhead to Castle Mill Gauging Station, around Brockham and a small section just downstream of Kinnersley Manor Gauging Station. The Rye has cross sectional survey data extending from the Tesco Superstore on Kingston Road up to the A24 Dorking Road. These cross sections are liable to change when the planned river restoration work takes place.
The existing cross-section survey to be used in the Main Study amounts to approximately 380 cross-sections. Approximately 400 further cross sections will need to be surveyed, 104 of these being structures.

There is some ground surface data for The Rye floodplain, however, as with the channel cross sections, this is likely to change when the planned restoration scheme takes place.

**Lower Mole**

The Lower Mole survey status is as mapped at Appendix A4. There is channel survey data for the Lower Mole FAS. As in the case of Middle Mole there is no Digital Terrain Modelling or photogrammetry available for flood plain modelling.

**IfSAR DTM**

It is clear from the above, that there is not a catchment wide Digital Terrain Model (DTM) available in LIDAR or photogrammetry. However, the Agency is procuring a new IfSAR (Interferometric Synthetic Aperture Radar) DTM on a national basis, which will cover the Mole catchment to an accuracy of +/- 0.5m and which will supplement the more accurate surveys. This is expected to be available by the end of September 2003. It should be noted, however, that this DTM has not been used for floodplain modelling before.

Suitable aerial photography has been identified from a 1991 survey that can be processed into photogrammetry to provide an accurate DTM for the main river or hotspots if required.
5. **KEY CATCHMENT ISSUES**

The study has identified the following particular key issues:

### 5.1 Flood hotspots

- It is clear from the flood assessment that there are hotspots spread throughout the catchment. However, the greatest concentration of these are within the Upper Mole area.

### 5.2 Hydraulics and drainage

- Culverts and flood storage inadequate capacity in Upper Mole. Need to determine the effect on downstream flooding if all culverts were enlarged. A benefit locally but possible exacerbation to flooding downstream.
- Variation in design parameters. Development drainage design risk of up to 1 in 10 year storm shorter than the Agency risk return period events of 1 in 25 to 1 in 100 for future schemes. Water company Combined sewers Overflows to 1 in 30?
- Sustainable Urban Drainage Systems, reluctance of adoption for maintenance.
- Uncertain planned maintenance of ditches and non-main river water courses mainly due to historically low budget provision. Crawley Borough Council (CBC) is correcting this in the light of experience – but all Local Authorities need to take a common approach.
- Uncertain effect on downstream flooding if all ditches and watercourses were maintained. A benefit locally but possible exacerbation to flooding downstream.
- Need to identify potentially perched watercourses in development areas that may have resulted from watercourse realignment. Perched watercourses are old channels above or below ground, whose natural flow path was disrupted but still collect water. They do not have a natural outlet and may be a factor in groundwater flooding.
- Some critical flooding as at Fetcham for example, may be due to, or compounded by, surface water and sewer networks requiring liaison with Water Company, Local Authority and highway Drainage Engineers.
- No flood-plain survey, nor hydrological studies, have commenced in Middle or Lower Mole, these are currently deferred until 2004.
- Climate change - Allowance for an increase of up to 20% peak flows by 2050 is applicable to this catchment.
- Channel roughness and the impedance of flow as been raised as an issue on the Gatwick stream. Maintaining roughness is important for maintaining the fisheries value, therefore a detailed assessment of this issue will enable an informed decision to be made.
- Improving agricultural drainage i.e. land mole drains to facilitate arable production in the upper catchment may have increased peak flows. There is some indication of bed
lowering, which has resulted in bank instability and increased siltation downstream. This needs top be investigated.

- Agricultural improvement and urbanisation may well have contributed in creased silts within the channel. A sediment transport study must be included.

5.3 Flood storage areas

- All potential flood storage sites, especially in the upper catchment that may alleviate flooding downstream, should be assessed for feasibility at strategy level.

- Potential for further attenuation may be limited by available land, and restriction on permanent open-water within 13km of Gatwick airport due to bird-strike risk.

- With regard to the construction of Flood Storage Areas within 13km of a safeguarded aerodrome i.e. Gatwick, this is still possible if a risk assessment is undertaken and mitigation measures either in design and or management is incorporated.

- Some potential sites in the upper reaches outside the M23 would impact on brown trout and crayfish populations.

- Underground storage, for example under Gatwick Airport, may need to be explored.

- Opportunity to explore flood meadow utilisation with some form of control to store only the peak flow.

- Consideration to be given to ‘sacrificial flooding’ of farm land normally protected up to a certain level of protection but then allowed to flood to prevent high-density developments flooding.

5.4 Planning and development control

- General - the Agency is generally only consulted on developments with clear, direct impact on the watercourses. However, many issues within the Mole catchment relate to surface-water run-off from developments situated away from the main watercourse. These issues are within the remit of Local Authorities who are under no obligation to consult the Agency. However, these issues can have an impact on flood management in the main-rivers. The strategy needs to ensure that Local Authorities and key stakeholders participate early in the development of the plan. In other cases, the Agency is preparing standard requirements for minor developments in order to delegate to Local Authorities and thus allow both organisations to concentrate consultation on the significant issues.

- Urbanisation – the rapid increase of development in the Upper Mole area. The urban area has almost doubled in 10 years from 12% to 23%. Reports of 10,000 more houses to be built in the area if Gatwick gets a second runway. SuDS (Sustainable Drainage Systems) built into new development.

- Proposed development – developments so far identified appear to be mainly on sites that flooded in year 2000, e.g. Smallfield, Tinsley Green and Ifield Green. The proposed new hospital at Pease Pottage has been rejected by the Strategic Health
Authority and further development in Crawley and Redhill East Surrey Hospital can be expected but may have less impact on run-off than a new site.

- Dormant Planning Applications can be enacted without warning within 5 years of approval.
- Riparian Ownership Duties - Channel capacity is affected in some sites by failing river-banks. This is a Riparian Owner responsibility. In one known case the owner is the Local Authority.

5.5 Environmental

- Solutions to flooding should not reduce the Dry Weather Flow (DWF).
- Any new work to alleviate flooding to incorporate habitat improvement.
- Floating pennywort (*Hydrocotyle ranunculoides*), as resulted in the lower mole channel being blocked. This can be a significant hazard and a watching brief is required to monitor its distribution.
- Weir removal/modification, or the construction of by-pass channels can result in habitat improvements. A possible example of this is at Brockham

6. STRATEGY PROPOSAL

7. PROGRAMME FOR THE STRATEGY

8. REFERENCES


3. MAFF, 2001. Flood and Coastal defence project appraisal guidance (Overview including general guidance, FCDPAG1

4. Mott MacDonald, Flood History Report, September 2002