A10.3 Detailed Terrestrial and Freshwater Ecology Methods

This appendix presents the detailed methodologies used to obtain and evaluate baseline information for the terrestrial and freshwater Ecological Impact Assessment (EcIA) of the proposed scheme. Survey methods followed IEEM best practice guidance and were agreed with SNH through consultation. This appendix has been ordered to present methods for terrestrial and freshwater ecological receptors and includes: terrestrial habitats, badger, bats, terrestrial breeding birds, terrestrial wintering birds, otter, water vole, red squirrel, amphibians, reptiles, terrestrial invertebrates, river habitat, aquatic macroinvertebrates, freshwater macrophyte and freshwater fish.

1 Terrestrial Habitats

1.1 Background

1.1.1 The standard methodology as described in the Handbook for Phase 1 habitat survey-a technique for environmental audit (Joint Nature Conservation Committee; JNCC), 2007) has become a widely accepted method for surveying habitats and is regarded as an essential part of the EIA process whenever ecological receptors are likely to be affected by a development (Institute of Environmental Management and Assessment (IEMA), 1995; Institute of Ecology and Environmental Management (IEEM), 2006).

1.1.2 Phase 1 habitat survey has been further recognised as a standard ecological assessment tool in the DMRB, and is recommended as an essential part of the assessment of ecological impacts associated with road and bridge construction (Highways Agency et al., 1993a).

1.2 Existing Information

1.2.1 Consultation regarding the presence of existing data for the study area was undertaken with a variety of organisations to inform the terrestrial habitats baseline (a full list of consultees is provided in Chapter 6 (Scoping and Consultation)). Organisations consulted were as follows:

- Botanical Society of the British Isles (BSBI);
- Centre for Ecology and Hydrology (CEH);
- City of Edinburgh Council;
- Edinburgh Biodiversity Partnership;
- Fife Coast and Countryside Trust;
- Forestry Commission;
- Local Community Councils;
- Lothian Wildlife Information Centre (LWIC);
- National Biodiversity Network Gateway (NBN Gateway);
- Scottish Government Rural Directorate;
- SNH;
- Take a Pride in Fife Environmental Information Centre (TAPIF EIC);
- University of Edinburgh;
- University of Glasgow;
- University of Stirling; and
- West Lothian Council.

1.2.2 A review of relevant literature was undertaken to obtain information on plant species and habitat abundance, distribution and susceptibility to impacts. These documents include:

- ERM (1996). Setting Forth: Environmental Statement. Draft 1 - 04 March 1996 on behalf of the Scottish Office Development Department.
- Jacobs Arup (2008a). Forth Replacement Crossing, Stage 2 Environmental Assessment Report on behalf of Transport Scotland.
- Transport Scotland (2007). Strategic Transport Projects Review, Report 4, Appendix D Environment. Jacobs UK Ltd.

1.3 Phase 1 Habitat Survey

1.3.1 An extended Phase 1 habitat survey was undertaken within a 1km wide study area between March and August 2008 using standard Phase 1 habitat survey methods (JNCC, 2007). Target notes were taken where applicable and included incidental sightings of protected species; the abundance of plant species was noted using the DAFOR (D=dominant; A=abundant; F=frequent; O=occasional; R=rare) scale.

1.3.2 Aerial photographs and Ordnance Survey (OS) maps were also studied to identify potential habitat areas of nature conservation importance within the study area.

1.3.3 During the survey of woodlands within the study area, particular note was paid to the presence of ancient woodland indicator species as identified by Ray & Moseley (2007) (shown in Table 1.1).

Table 1.1: List of Ancient Woodland Indicators (identified in survey) (Ray & Moseley, 2007)

English Name	Latin Name
Bluebell	*Hyacinthoides non-scripta*
Chickweed-wintergreen	*Trientalis europaea*
Common cow-wheat	*Melampyrum pratense*
Common wintergreen	*Pyrola minor*
Dog's mercury	*Mercurialis perennis*
Enchanter's-nightshade	*Circaea lutetiana*
Giant bellflower	*Campanula latifolia*
Giant fescue	*Festuca gigantea*
Hairy wood-rush	*Luzula pilosa*
Lords-and-Ladies	*Arum maculatum*
Moschatel	*Adoxa moschatellina*
Pendulous sedge	*Carex pendula*
Pignut	*Conopodium majus*
Ramsons	*Allium ursinum*
Sanicle	*Sanicula europaea*
Slender St. John's-wort	*Hypericum pulchrum*
Wood dock	*Rumex sanguineus*
Wood meadow-grass	*Poa nemoralis*
Wood melick	*Melica uniflora*
Wood millet	*Milium effusum*
Woodruff	*Galium odoratum*

Note: Botanical names, scientific and English, follow that of Stace (1997)

1.4 Phase 2 Habitat Survey

1.4.1 A Phase 2 habitat survey was carried out in habitats where it was identified there could be an impact resulting from the proposed scheme or where there was an overriding conservation interest. Sites were selected based on the information gathered during the Phase 1 habitat survey and/or on proximity to the route corridor or associated infrastructure.

1.4.2 The survey comprised a detailed walkover of the selected area combined with a botanical assessment using quadrats at a variety of scales. This information was used to create habitat maps of the selected area based on the communities defined in the National Vegetation Classification (NVC) system.

1.4.3 Vegetation surveys for determination according to NVC were carried out as detailed below:

- an area of homogeneous vegetation to be sampled was identified by a quick walk over the area;
- a quadrat was laid out with the size dependant on the scale of the vegetation sampled as prescribed by Rodwell (1991 et seq.); short vegetation was sampled using 2x2m quadrats, taller vegetation was sampled using 4x4m quadrats;
- species presence was recorded and cover estimated using the Domin scale (see below for further information);
- five quadrats were assessed in each habitat except in smaller areas where only four quadrats were assessed; and
- any other species of note which were observed in the community but not found in the quadrats were recorded and their abundance estimated using the DAFOR scale.

1.4.4 The Domin scale (shown in Table 1.2) as developed by Karel Domin is a variation of the Braun-Blanquet scale (Dahl & Hadac, 1941), for describing an area of vegetation. This method provides a quantitative measure of the abundance of plant species recorded in a quadrat. The percentage cover of each species is assessed by eye as a vertical projection on the ground of all the live, above ground parts of the species in the quadrat.

Table 1.2: The Domin Scale

% Cover	Domin Value
91-100	10
76-90	9
51-75	8
34-50	7
26-33	6
11-25	5
4-10	4
>4 with many individuals	3
>4 with several individuals	2
>4 with few individuals	1

1.4.5 Data were analysed by ecologists with expert knowledge of community types, and by comparison to floristic tables (Rodwell, 1991 et seq.), use of Match (Malloch, 1995) and Tablefit software (Hill, 1996). Frequency and abundance tables were drawn up to facilitate this. Where data were collected from only four quadrats, professional experience and judgement was also used to interpret the data.

Woodland NVC Surveys

1.4.6 As the selected woodland areas were generally small and relatively homogeneous, a minimalist approach to data collection for use with NVC keys was adopted, as recommended in the Field Guide to Woodland (Hall, Kirby & Whitbread, 2004) booklet. These surveys varied slightly from the method described above and are laid out below:

- for the groundflora, a quadrat of 5x5m was laid out and species presence and percentage cover were recorded using the Domin scale; and
- tree and shrub species presence and cover over the plot and in the immediate vicinity (10-15m surrounding the plot) were recorded. In long thin strips of woodland the shape of this area was adjusted to ensure that an equivalent area was surveyed.

Wetland NVC Surveys

1.4.7 St. Margaret's Marsh SSSI (an area of reedbed, saltmarsh and tall ruderal/scrub vegetation), was identified through the Phase 1 habitat survey as requiring further detailed investigation for its botanical composition. A walkover survey of the area within the SSSI boundary was carried out to accurately determine the extent and boundaries of the various habitat types. NVC assessments were subsequently carried out on these habitat types using the quadrat method detailed in paragraph 1.7.3.

Dates of Survey

1.4.8 Reconnaissance surveys were carried out on 25-26 February 2008. Phase 1 habitat surveys were undertaken between 26 March-01 August 2008. NVC assessments were carried out on 06-13 October 2008 for woodland communities, and 13-14 October 2008 for wetland communities.

1.5 Habitat Assessment

Habitat Importance

1.5.1 For the purpose of site evaluations, a set of assessment criteria to determine the importance of habitats was used as shown in Table 1.3. The assessment criteria focus on the presence of species or habitats of conservation importance, and on habitat characteristics such as diversity, size, extent, naturalness and representativeness.

Table 1.3: Habitat Assessment Criteria

Habitat Importance	Criteria
High	Areas that contain habitats of high conservation value (of international or national importance) for their rare taxa or species richness, and are natural or as near-natural habitats as possible. Habitats that are a suitable size (whether it is represented by area, length, depth or volume), are continuous and have good connectivity with other habitats of similar status/value. A habitat that best represents a particular habitat type and possess as many desirable habitat characteristics and special features as possible.
Medium	Areas that contain habitats of medium conservation value (of authority area or local importance), but are managed in such a way that their naturalness has somewhat deteriorated. Habitats that have reduced size and extent, with some level of fragmentation but relatively good continued connectivity with other semi-natural habitats remains. Habitats with medium representativeness of a particular habitat of interest, and posses some desirable habitat characteristics and special features.
Low	Areas that contain habitats of low conservation value (of less than local importance), and are highly managed resulting in little naturalness remaining. For example, habitats including arable land and improved grassland. Habitats which are small in size and are highly fragmented, resulting in huge edge effects. Habitats with little representativeness of a particular habitat of interest, and posses few desirable habitat characteristics and special features.

1.6 Limitations to Assessment

1.6.1 Woodland NVC surveys were carried out once the most ecologically important woodlands had been identified and the Stage 3 study area had been verified. As the woodland NVC surveys were carried out outside the optimum time of year for woodland groundflora, the species composition was assessed based on flowering plants and vegetation growth present during early October, and dead vegetation persisting from earlier in the year.

1.6.2 For health and safety reasons, distance surveys were undertaken for areas alongside railway lines, embankments and cuttings of motorways. As such, lists of plant species within these areas may be incomplete. In addition, not all areas within the study area were included in the survey as some were inaccessible; these areas have been left blank in Figure 10.2. However, of the inaccessible areas present within the study area, only one area (cliff habitats adjacent to St. Margaret's Hope) is directly affected by the proposed scheme, and baseline data obtained from the distance survey of this site is considered sufficient to inform the impact assessment.

2 Badger

2.1 Existing Information

2.1.1 Consultation to obtain existing data on badger (*Meles meles*) activity within the study area was undertaken with the following statutory and non-statutory organisations:

- Edinburgh and Lothian Badger Group (ELBG);
- Fife Environmental Recording Network (FERN);
- LWIC;
- Scottish Badgers (SB);
- Scottish Wildlife Trust (SWT);
- SNH; and
- The Mammal Society (MS).

2.1.2 Incidental sightings made during other surveys associated with the proposed scheme were also recorded.

2.2 Badger Survey

2.2.1 The study area was surveyed for evidence of badger between 11 March-25 April 2008 and 13-17 October 2008. Additional surveys were undertaken in January and May 2009 to provide additional information with respect to the status of setts identified in the 2008 surveys.

2.2.2 Field signs including badger setts, badger paths, evidence of foraging and dung pits were searched for, based on methodologies described in DMRB (Highways Agency et al.,1993b) and Harris et al. (1989) and can be summarised as follows:

- All hedgerows, field boundaries, watercourses, paths and other linear features within the study area were walked to locate badger field signs. In addition, all areas of woodland and scrub were systematically searched for evidence of badger activity.
- Badger paths were identified through the observation of field signs including prints, badger hairs on barbed wire or vegetation, dung pits and scratching posts.
- The interiors of fields were surveyed in addition to their boundaries, where they exhibited evidence of badger foraging or where badger paths passed through them.

- Other areas offering the potential to contain badger setts, identified during survey, from OS maps and Phase 1 habitat maps, were actively searched where practicable.

2.2.3 Bait marking was not undertaken as a satisfactory evaluation of the impacts of the proposed scheme could be achieved and specific mitigation derived without this level of detail.

Badger Sett Interpretation

2.2.4 Where badger setts were found, the number of entrances was recorded, along with activity level and sett status. Sett status was based on recommendations given by (Harris et al., 1994) and are categorised as follows:

- Main sett: used throughout the year and constitutes the main breeding sett. Where a sett exhibits much activity and appears to be the largest (normally at least five holes) and most well used sett within a badger territory it is categorised as the main sett. Always have active badger runs leading away from them and are normally marked by latrines.
- Annexe sett: categorised where assumed to form a part of the main sett area but where the sett is unlikely to be directly linked by an underground passage to the main sett either due to a barrier (e.g. separated by a watercourse or ditch) or by distance. Normally linked to the main sett by a well used path and lie within 150m of a main sett entrance.
- Subsidiary sett: categorised where believed to offer an alternative large sett complex to the main sett. Subsidiary setts are normally at least 50m away and are not always obviously linked by a well used path. Subsidiary setts often exhibit moderate levels of activity, are larger than outlier setts but smaller than main setts. Often marked by latrines.
- Outlier sett: often comprise just one or two holes. Used infrequently and can be found at the extremes of a badger group's territory.
- Disused sett: appears abandoned by the group for at least a year. Differs from 'inactive' setts which are judged to be temporarily disused. Often completely blocked with vegetation or collapsed.

2.2.5 Sett status can quickly change. It is not uncommon for badgers to switch the location of their main sett to the location of a previously identified subsidiary sett and an outlier sett can be developed to provide a subsidiary sett.

Badger Path Interpretation

2.2.6 Where field signs were intermittent or scattered, badger paths could be assumed, using professional judgment based on landscape features (such as the assumption that badgers would travel along ditch banks and hedgerows and through gaps in boundary features such as push-throughs in fencing).

Social Group/Population Interpretation

2.2.7 Social groups/populations were identified by relating them to a main sett/s. Each social group or population was identified by a letter and each sett within this group by a number. Non-main setts were attributed to each social group/population using professional judgment, based upon their distance from main setts and the locations of assumed boundary latrines.

2.3 Badger Habitat Assessment

Habitat Importance

2.3.1 Habitat features of key importance to the viability of individual social groups/populations were identified during survey and were based on descriptions by Kruuk (1978) and Neal & Cheeseman (1996). Such key areas include areas of rich pasture land, pockets of woodland, key setts etc.

Criteria for determining the importance of these habitats to badger social groups are shown in Table 2.1.

Table 2.1: Badger Habitat Assessment Criteria

Habitat Importance	Criteria
High	Features assessed as being fundamental to the survival of the social group. Without the described feature it is believed that the social group would be permanently lost.
Medium	Features assessed as being fundamental to the badger group maintaining its current population level. Without the described feature, it is believed that the social group would ultimately survive, but in reduced numbers.
Low	Features considered to enrich the quality of the social group's habitat but are not fundamental to the maintenance of the social group's current size.

2.3.2 Rarity of habitat was taken into account during the evaluation of features of importance. Throughout the majority of the proposed scheme, badgers have access to extensive areas of pasture. When taken as a whole, this represents a resource of 'high' value to the local badger population. However, individual pasture fields are less important given the ubiquitous nature of this land use and the amount of alternative pasture habitat available. Some areas of grassland are judged to be of greater value when alternative grassland foraging is not in the immediate area or if grassland is of a particularly high quality. Features of importance to the maintenance of individual social groups/populations are assessed in Appendix A10.5 (Confidential Badger and Otter Information).

2.3.3 All areas of habitat of potential value to badgers were categorised into areas of woodland, areas of scrub, areas of short grassland (either pasture or amenity grassland) and areas of arable land. Each of these habitat types can provide an important year-round or seasonal food source (Neal & Cheeseman, 1996).

Evaluation of Badger Habitat (Landscape Scale Assessment)

2.3.4 The results of consultation information, field survey and habitat assessment were combined to provide an evaluation of the ecological value of the habitats within the territory of each badger social group/population based on the criteria detailed in Table 2.1.

2.3.5 This assessment examined the overall value of the landscape by considering the number and quality of small scale habitat features of importance to badgers and examines the density of badgers present. Small scale habitat features are those which affect the viability of individual social groups/populations.

2.3.6 The evaluation also examined the density of badger groups currently supported by the habitat and the habitat's potential to support higher densities of social groups in the future.

2.4 Limitations to Assessment

2.4.1 There are no identified limitations to the methods employed.

3 Bats

3.1 Existing Information

3.1.1 Consultation was undertaken with a variety of statutory and non-statutory organisations including:

- Bat Conservation Trust (BCT);
- Central Scotland Bat Group;

- Echoes Ecology Ltd;
- Fife Bat Group;
- Lothian's Bat Group;
- LWIC;
- SEPA;
- SNH; and
- TAPIF EIC.

3.1.2 Consultees were asked for data regarding bats in and around the study area and for their advice and recommendations regarding ecological constraints and opportunities in the study area.

3.2 Bat Survey

3.2.1 Survey methods were developed by experienced bat ecologists, following best practice guidance issued by the IEEM (IEEM, 2006) and bat survey guidelines (BCT, 2007a), and in consultation with the BCT (A. Youngman, BCT, , pers.comm. 03 November 2008.) and SNH (R. Raynor, SNH, pers.comm. 03 November 2008.).

3.2.2 The survey objectives were to establish the conservation status of bat species within the study area through:

- identification of the presence and distribution of bat populations within the study area;
- identification of valuable features and habitats for roosting, foraging and commuting bats; and
- evaluation of the importance of bat populations, features and habitats in the local-national context.

3.2.3 Field surveys were carried out by appropriately trained and, where required, licensed ecologists.

3.2.4 A data search of existing information including aerial photographs, OS 1:25,000 scale maps and bat records was carried out to determine which species of bats were likely to be present and where they were most likely to be found.

3.2.5 An initial walkover survey was undertaken over the entire study area to locate and delineate habitats and features of potential value to bats.

3.2.6 The results of the desk study and walkover survey were used to provide preliminary data on the presence and distribution of habitats and features of potential value to bats, and to identify and prioritise any requirements for further survey.

Bat Roost Surveys

3.2.7 Bats have different roost requirements at different times of year, and their requirements vary according to species and the availability of roosting opportunities.

3.2.8 Bats use a variety of natural and manmade structures for roosting such as trees, underground features (e.g. caves and tunnels) and buildings/structures (e.g. ice-houses and bridges). In addition, bats have been shown to frequently switch between roosts in response to a range of biological/environmental factors. The identification of roosts within the study area was therefore focussed to individual and small groups of trees and buildings. Large areas of woodland and urban areas were also given an overall assessment of suitability for providing roosts based on composite sampling of trees and buildings combined with the results of night-time surveys (shown in Table 3.3).

3.2.9 Trees and structures were examined during the daytime from the ground for signs which indicate the presence of bats or their resting places, including insect remains, droppings, grease marks, urine stains, the presence of dead or live bats and smoothing or lack of cobwebs (Mitchell-Jones, 2004). In addition, trees and structures were assessed for potential roost access points including loose bark, splits, holes, gaps in masonry, tiles and woodwork, and spaces in doors and windows. An endoscope and binoculars were used where necessary to investigate accessible cracks, and, when appropriate, landowners and tenants were asked whether they were aware of the presence of bats.

3.2.10 Dusk emergence surveys were carried out at buildings which were considered most likely to support roosting bats, based on the findings of daytime surveys. Where necessary, dawn re-entry surveys were undertaken to confirm numbers of bats returning to roost and locate roost entrances. Dawn surveys were carried out only on buildings where emergence had been confirmed at dusk, or at locations where there was a strong possibility of emergence having occurred even though it had not been confirmed on the dusk survey.

3.2.11 Buildings were monitored between 20 minutes before and up to two hours after sunset, and between two hours before and 20 minutes after sunrise.

3.2.12 During the surveys ecologists were positioned around the building(s) and used hand-held (Duet) dual mode (heterodyne and frequency division) bat detectors to observe bat activity. The time, species and number of bats emerging and/or re-entering the roost were recorded along with additional details about the locations of roost entrances, and notable bat behaviour including direction of travel to or from the roost.

3.2.13 A list of buildings subjected to night-time surveys and where bat roosts were confirmed is included in Appendix A10.4 (Section 3.3).

3.2.14 It was not feasible to monitor bat use of all potential tree roosts following the above methods. This was due to the number of trees supporting potential roosts within the study area which totalled several thousand individuals. However, the technique of ‘back-tracking’ was used as a means of countering the above. Back-tracking was undertaken during the bat survey transects (see below) with the aim of following bats back to roosts in buildings and trees.

3.2.15 Trees and structures were assigned a roost potential category according to the criteria outlined in Table 3.1, based on the results of roost surveys.

Table 3.1: Roost and Potential Roost Category (adapted from Mitchell-Jones, 2004)

Main Category	Sub Category	Category description (Trees)	Category Description (Structures)	Indicator
1 (Roost)	A	Trees with evidence of current or historic use by bats.	Buildings/man-made structures with evidence of current or historic use by bats.	Sighting/sound of bats (including emergence/swarming). Presence of fresh or old droppings, staining, smoothing and lack of cobwebs.
	B	Trees with anecdotal evidence of current or historical use by bats.	Buildings/man-made structures with anecdotal evidence of current or historical use by bats.	Roosts identified by personal communication from reliable source (e.g. property owner) or unconfirmed roost identified during field surveys.
2 (Potential Roost)	A	Trees with high potential for use as roost.	Buildings/man-made structures with high potential for use as roost.	Presence of cracks, splits, knot holes, loose bark, woodpecker holes, snag ends and other hollows in trees
	B	Trees with some potential for use as roost.	Buildings/man-made structures with some potential for use as roost.	Presence of dense ivy cover, dead wood or other features with lower potential as roost sites.
3 (No potential)		Trees with no or low potential for use as roost.	Buildings/man-made structures with low potential for use as roost.	No such features. Isolated from foraging or commuting routes.

Bat Survey Transects

3.2.16 Bat survey transects were undertaken manually along pre-determined routes, based on the desk study and initial walkover survey in order to observe and record bat activity in the study area (Figure 10.4).

3.2.17 Transect routes focused on habitats and features that are likely to be used by bats including woodland, water, linear features and roosting habitat; taking account of the ecology of the bat species present in the area (Bat Conservation Trust, 2007).

3.2.18 Bat survey transects were undertaken between sunset and two hours after sunset, and from two hours before sunrise to sunrise. Each transect was surveyed twice at dusk and dawn. Where possible, dusk and dawn survey transects were carried out on successive days.

3.2.19 Survey teams walked slowly along the transect route using heterodyne (Duet) and/or frequency division (AnaBat) detectors to observe bat activity. Each time a bat was heard or observed ecologists stopped for two minutes and recorded the time, species and number of bat passes (discrete bursts of bat echolocation). Detailed notes were made on the type of activity (foraging, commuting and social calling) and specific behaviour including direction and height of travel, swarming behaviour and use of landscape features.

3.2.20 During transect surveys efforts were made to follow bats back to their roosts using back-track methods. The method assumes that the earlier a bat is recorded at sunset or sunrise, then the closer it is likely to be to its roost. Where bats were encountered during the transect surveys, ecologists walked quickly towards flying bats at sunset and in the same direction as flying bats at dawn, and noted the presence of roosts as described in the previous section (Bat Roost Surveys).

Commuting Route Surveys

3.2.21 Survey effort to identify linear routes along which bats fly between roosting and foraging habitats (commuting routes) involved the deployment of static remote frequency division (AnaBat) detectors which ran throughout the night recording and saving bat echolocation calls as electronic data files. Potential commuting routes were selected at linear features, including roads, hedgerows, shelterbelts, walls and other boundary features which would be directly impacted by the various route options.

3.2.22 Detectors were deployed directly onto each potential commuting route, facing perpendicular to the feature at the proposed crossing point or midline so that echolocation calls from bats flying along the feature would be picked up.

3.2.23 Detectors were deployed for one night on two occasions between May and September 2008 at each linear feature.

3.2.24 Analysis of bat echolocation data files using AnaLook Software enabled species identification, number of bat passes (whereby one pass is defined as a single data file) and further details on the time and intensity of bat activity.

3.2.25 The importance of commuting routes is dependent upon the rarity and number of bat species shown to use them, along with aspects of the landscape that enable bats to use them, such as the distance of each commuting route from roosting habitat and the suitability of the linear feature to support commuting bats. A scoring matrix based on Wray et al. (2007) was developed to enable an assessment of the relative importance of each commuting route to bats (Table A10.3.6) through consideration of the following:

- the rarity and number of bat species shown to use them;
- aspects of the landscape that enable bats to use them;
- the distance of each commuting route from roosting habitat; and
- the suitability of the linear feature to support commuting bats.

3.2.26 It is important to note that only one score is assigned per criterion, and where there are multiple criteria, the score should be assigned to the highest value attribute. This principle is applied to each of the four criteria as described below.

Bat Species

3.2.27 This was dependent on the species present, for example, if common species such as the soprano (*Pipistrellus pygmaeus*) and common pipistrelles (*P. pipistrellus*) are present along the same commuting route then a total score of 1 is assigned irrespective of the number of bats present from each species. Conversely, if an assemblage of species are recorded comprising Daubenton's bat (*Myotis daubentonii*), whiskered bat (*Myotis mystacinus*), Leisler's bat (*Nyctalus leisleri*) and barbastelle bat (*Barbastella barbastellus*), then a total score of 5 is assigned in recognition of the value of the highest scoring species within the assemblage (Barbastelle bat).

3.2.28 It should be noted that none of the species identified as being of international importance are known to occur in Scotland

Number of Bat Passes

3.2.29 The overall levels of activity along a commuting route are a good indication of how important a commuting route is for bats within the study area. Therefore, levels of activity were assigned a score ranging from low activity (between 1-20 bat passes) receiving a total score of 1, to high activity (>200 bat passes) receiving a total score of 5.

Distance to Roost/Roost Potential

3.2.30 The farther the roost/potential roost from the commuting route, the lower the score assigned, for example, if the distance to a roost/potential roost is >200m, a total score of 1 is given. However, if the commuting route is within 20m of a roost/potential roost, a total score of 5 is given.

Linear Features

3.2.31 Linear features have varying importance as commuting route within the study area depending on the context of the local environment, for example, a fence/small burn is unlikely to support high levels of commuting bats, but it is still a potential commuting route, therefore it would be assigned a total score of 1. However, a large feature such as a large river/canal is known to be an important feature for commuting bats would be given a higher total score of 5.

3.2.32 Once commuting route criteria have been assigned their appropriate values, then an overall total for that commuting route was derived by adding the value for each criterion together, for example, common pipistrelle and soprano pipistrelle present (1), between 21-60 bats present (2), >200m to roost (1) and along a burn (4). On this basis, a total score of 9 would be assigned to the commuting route.

Table 3.2: Scoring of Commuting Route Evaluation Criteria (Max. Total Score=20)

Criteria	Assigned Score				
	1	2	3	4	5
Bat Species	Common pipistrelle Soprano pipistrelle	Daubenton's bat Natterer's bat (*Myotis nattereri*) Brown long-eared bat *(Plecotus auritus)*	Whiskered bat Noctule bat *(Nyctalus noctula)*	Leisler's bat Nathusius' pipistrelle *(P. nathusii)* Brandt's bat *(Myotis brandtii)*	Barbastelle bat Bechstein's bat *(Myotis bechsteinii)* Greater horseshoe bat *(Rhinolophus ferrumequinum*) All other species
Number of Bat Passes	1-20	21-60	61-100	101-200	>200
Distance to Roost/Potential Roost	>200m	101-200m	51-100m	20-50m	< 20m
Linear Features	Fence/small burn	>10m gaps in species poor hedge	<10m gap better edge/walls	Tree line/burn	Woodland edge/large rivers

3.2.33 Total scores were interpreted as follows:

- 0-4 (not valuable);
- 5-9 (low value);
- 10-14 (moderate value); and
- 15-20 (high value).

Autumn and Winter Surveys

3.2.34 Certain landscape features, in particular underground sites (e.g. quarries, caves, tunnels and ice houses) are important as mating and hibernating sites for bats as they provide the requisite temperature and humidity characteristics (Glover & Altringham, 2008). Bats will travel large

distances to the best sites and the availability of suitable hibernation sites can affect individual survival rates. Some species of bats have been observed to "swarm" around the entrances of underground sites in the autumn (Glover & Altringham, 2008) and this behaviour, which was used to inform the autumn surveys, can provide an indication of which underground sites may be used by bats for hibernation.

3.2.35 Based on the results of initial walkover surveys several features within the study area were assessed as providing suitable hibernation conditions for bats. These features, which include bridges, culverts, dovecots and quarries, were subjected to further survey effort in autumn and winter 2008/9.

3.2.36 With respect to autumn swarming, two survey techniques were employed to identify those features where bats may be swarming. The first involved deployment of AnaBat detectors set to record for 6 hours per night over 2-3 consecutive nights (the documented peak of swarming activity is between 2-6 hours after sunset (Glover & Altringham, 2008)). The second involved bat activity survey transects carried out between 2-3 hours after sunset at a slow walk. Survey transects were only undertaken in quarries as these features are considered too large to be accurately represented by AnaBat detectors alone. Behaviour associated with swarming activity (chasing and social calling) was recorded with the aid of Duet bat detectors and night vision monoculars.

3.2.37 Two survey techniques were employed in winter 2008/2009 to identify sites used by bats for hibernation. The first involved an internal inspection of the identified features by suitably licensed bat specialists once a month in accordance with the Bat Survey Guidelines (Bat Conservation Trust, 2007). A torch and endoscope were used to investigate accessible cracks. The second technique was to use AnaBat detectors to record bat activity over a period of four consecutive nights, with detectors set to record continuously between 30 minutes before sunset to 15 minutes after sunrise.

Dates of Survey

3.2.38 The initial walkover survey and desk study was undertaken in April 2008, although data collection and analysis was continuous throughout the survey period.

3.2.39 The majority of the tree surveys were undertaken at the same time as the initial walkover survey which coincides with the optimal time for searching for roosting features when there are no leaves on deciduous trees. Tree surveys outside this period were conducted at the same time as building surveys where trees were located adjacent to individual properties.

3.2.40 Building surveys were undertaken from April-August 2008; the precise dates of survey are included in Appendix A10.4 (Section 3.3, Tables 3.6and 3.7).

3.2.41 Bat activity, commuting route, dusk emergence and dawn re-entry surveys were undertaken from May-September; the precise dates of survey are included in Appendix A10.4 (Section 3.3, Tables 3.5, 3.6, 3.8 and 3.9).

3.2.42 Autumn swarming surveys were undertaken from September-October 2008; the precise dates of survey are included in Appendix A10.4 (Section 3.3, Tables 3.11 and 3.12).

3.2.43 Winter (hibernaculum) surveys were undertaken from December 2008-February 2009.

3.3 Bat Habitat Assessment

3.3.1 For the purpose of reporting, habitat features within the study area, including woodlands, water features, grassland, wetland, urban areas, linear features, man-made structures, underground and rock outcrop features were assessed for their potential importance to foraging, commuting and roosting bats taking the range of species present in the area into account, and in accordance with the criteria shown in Table 3.3.

Table 3.3: Habitat Profile Assessment

Bat Habitat Importance	Roosting	Foraging	Commuting
High	Woodlands and urban areas: High proportion of trees/buildings with roost potential. >1 tree/building in 50 with potential. Diverse choice of different roosts. Caves/tunnels/mines/ice houses with humid atmosphere and sheltered, stable temperature conditions suitable for hibernating. Low disturbance levels.	High insect abundance. Native woodland/trees/hedgerows offering shelter and diverse edge habitat; open parkland. Slow flowing/still freshwater features with sheltered vegetated edges. Low disturbance levels from lighting, pollutants, human activity.	Continuous, unbroken linear feature providing shelter and/or foraging opportunities and connectivity with other landscape features including roost and foraging areas. Includes tree lines, woodland edge, hedgerows, waterways, walls, woodland tracks, road and drainage networks, buildings.
Medium	Roost sites and access points in cracks, crevices and gaps present but not ideal due to size, disturbance levels, exposure. Between 1 in 50 and 1 in 100 trees/buildings have roost potential.	Moderately high insect abundance. Native woodland/trees/hedgerows offering some shelter and edge habitat. Fast flowing freshwater features offering little shelter.	Partly discontinuous feature (gaps up to 30m wide) offering some shelter and/or foraging opportunities.
Low	No suitable roost sites or access points visible. Fewer than 1 tree/building in 100 has roost potential. High disturbance levels.	Conifer woodland, improved agriculture and built up areas with low plant diversity and/or insect abundance. Lack of shelter, poorly connected to roost sites and commuting routes. High disturbance levels from lighting, pollutants, human activity.	Discontinuous feature (gaps greater than 30m wide) offering no shelter and/or isolated from potential roosting and/or foraging areas.

3.4 Limitations to Assessment

3.4.1 Bat roosts are difficult to locate, especially when signs of their presence or roost access points may be hidden or obscured. In addition, bats are also known to regularly change roosts in response to a range of factors such as climate (Cowan, 2003). As such, it is possible that potential roosts that were subject to emergence and/or hibernations surveys but where no evidence of roosting bats was recorded could still be used by bats.

3.4.2 AnaBat detectors provide an accurate representation of the number of bat passes, but not the number of bats using a structure or feature. In addition, information about the direction and height of travel cannot be obtained without simultaneous manual surveys (BCT, 2007).

3.4.3 The quality of the bat call recorded by an AnaBat depends on its characteristics, as well as the orientation and distance of the bat detector in relation to the bat and the level of background noise. This can lead to difficulties in identification especially when species emit calls at similar frequencies (for example Daubenton's and Natterer's bats). In addition the quiet calls of brown long-eared bats may not be picked up by the detector, leading to their under-representation (Russ, 1999).

3.4.4 Bats use of deep crevices during when hibernation is well documented in order to avoid disturbance and fluctuations in temperature. As such, bats are harder to locate and record during hibernations surveys. It is therefore possible, that hibernating bats may not have been recorded by the current surveys. However, every effort was made to locate hibernating bats during the surveys.

4 Terrestrial Breeding Birds

4.1 Existing Information

4.1.1 Consultation was undertaken with SNH and the Royal Society for the Protection of Birds (RSPB) regarding previous records of terrestrial breeding birds within the study area.

4.1.2 Reference was made to two previous reports relevant to the proposed scheme;

- The 1996 (draft) ES, produced for the Scottish Government for the 'Second Forth Crossing'. Part G entitled 'Terrestrial Ecology and Nature Conservation' and included ornithological survey results within the study area.
- The 2007 breeding bird survey report of St Margaret's Marsh SSSI, part of which lies within the study area. It was produced for Transport Scotland by Jacobs (Jacobs and Faber Maunsell/AECOM, 2007) and includes a detailed breeding bird survey of the SSSI using the Common Bird Census method (Gilbert et al., 1998) to map breeding territories.

4.2 Survey of Terrestrial Breeding Birds

Field Survey

4.2.1 Surveys were undertaken following the Bird Atlas 2007-2011 (British Trust for Ornithology (BTO), 2007) methodology. The adoption of this method was agreed through consultation with SNH (Jacobs Arup, 2008b). Typically the Bird Atlas method employs quadrats measuring 4x4km. However, due to the width of the study area considered by this assessment, quadrats were reduced in size to 1x1km. It should be noted that the time spent in each quadrat was not changed from that recommended by Bird Atlas methods which comprises a minimum of one hour survey time in each quadrat.

4.2.2 A series of 14 quadrats measuring 1x1km were employed to sample the study area for terrestrial breeding birds. The north side of the study area contained 3 quadrats (N1-N3) and the south side contained 11 quadrats (S1-S11). Figure 10.6 shows the layout of the quadrats in relation to the route alignment.

4.2.3 Quadrats were selected for surveys on the basis of the following:

- more than 50% of the quadrat lay within the study area (the exceptions being those quadrats either side of the crossing, covering estuarine habitats); or
- quadrats lay within 500m of 'offline' development (includes junctions but not tie-ins); and
- less than 50% of the quadrat consisted of built-up land.

4.2.4 Surveys were carried out during the morning when bird activity was expected to be greatest, commencing one hour after sunrise. Surveys were not undertaken during poor weather when bird activity was expected to be subdued.

4.2.5 Ecologists walked for a minimum of one hour within the quadrat along a transect route that covered a representative sample of habitat types. The number of individual birds (excluding juveniles) of all species was recorded, ignoring individuals flying over the square with the exception of raptors or hirundines. Colonial nesting species were recorded where present and where possible a count of occupied nests or individual birds was made.

4.2.6 The 'stop-clock' was paused when areas of high bird densities (colony, flock etc) were encountered to allow for counting. Evidence of breeding activity was recorded at the highest level evident, i.e. 'Possible'→'Probable'→'Confirmed'.

4.2.7 Population estimates of priority bird species listed on Annex 1 of the Birds Directive 1979 (79/409/EC), Schedule 1 of the WCA 1981 (as amended), as well as any red list and amber list species were made where possible.

4.2.8 The maximum number of each species recorded over the two surveys was taken as the sample population for the relevant quadrat.

4.2.9 Habitat areas comprising predominantly residential gardens and urbanised zones (including areas of existing road and/or hard standing) within each selected quadrat were not surveyed.

4.2.10 Coastal records have not been included within this section as these species are reported separately in, Chapter 11 (Estuarine Ecology).

Dates of Survey

4.2.11 The surveys were undertaken between 28 April-01 May 2008 and 09-12 June 2008.

Population Estimates

4.2.12 The surveyed number of birds within each quadrat was increased proportional to the area of habitats surveyed to calculate an estimate of the total population within the study area. The reduction in bird populations resulting from direct loss of habitat was calculated using the same method of a proportional reduction in habitat area. These calculations were completed for every species of interest in all quadrats.

4.3 Limitations to Assessment

4.3.1 The Bird Atlas survey method is a broad sampling exercise designed to provide population estimates of terrestrial birds over a wide area. As such, it does not provide fine detail of geographical location of breeding territories nor does it provide an exact count of the number of territories within a survey area. However, its application to the proposed scheme was appropriate as it allows a representative sample of terrestrial bird species and numbers to be made which can then be used to estimate total terrestrial populations within a given area as agreed through scoping with SNH (Jacobs Arup, 2008b).

4.3.2 The Bird Atlas survey method used is unlikely to record crepuscular (twilight) or nocturnal species, for example, owls. However, these species were recorded during the bat surveys that were undertaken at dusk/dawn throughout the study area and as such, any records of crepuscular or nocturnal have been included where appropriate.

5 Terrestrial Wintering Birds

5.1 Existing Information

5.1.1 Consultation regarding existing records of terrestrial wintering birds was undertaken in conjunction with the terrestrial breeding birds' study and is detailed in Section 4.2.1.

5.2 Survey of Terrestrial Wintering Birds

Field Survey

5.2.1 Field survey methods for terrestrial wintering birds followed those described for terrestrial breeding birds as detailed in, Section 4.2.1.

Dates of Survey

5.2.2 The surveys were undertaken from 24 November-04 December 2008 and between 19-27 February 2009.

Population Estimates

5.2.3 Population estimates for wintering bird species have not been made since wintering species are transitory and are not fixed to particular habitats as compared to the breeding season in terms of nesting requirements.

5.3 Limitations to Assessment

5.3.1 Limitations experienced during the wintering bird surveys are identical to those described under the terrestrial breeding birds (Section 4.3).

6 Otter

6.1 Existing Information

6.1.1 Consultation was undertaken with a variety of statutory and non-statutory organisations to provide information relating to potential otter (*Lutra lutra*) records in the vicinity of the study area:

- Dundas Estate;
- Edinburgh Biodiversity Partnership;
- Fife Coast and Countryside Trust;
- Forestry Commission Scotland;
- Hopetoun Estate;
- Fife Biological Records Centre;
- SWT;
- SEPA;
- TAPIF EIC;
- Vincent Wildlife Trust; and
- West Lothian Council.

6.1.2 A desk study using OS maps was undertaken to identify all water features including standing waterbodies and watercourses within the extended study area.

6.2 Otter Survey

Field Surveys

6.2.1 All watercourses and water features within 500m from the centre line of the proposed scheme were surveyed on foot by experienced ecologists, for signs of otters (Figure 3, Confidential Figure). Surveys were conducted from within the channel where possible, along the river bank and on ground within 10m of the watercourse. Where applicable, survey effort was extended beyond the study area boundary to consider potential impacts of junction and road layout options. Surveys were additionally carried out along coastal habitats on the south and northern shores of the Firth of Forth to a distance extending up to 2km from the alignment of the proposed Main Crossing.

6.2.2 Surveys within the study area concentrated on identifying the presence of otter signs which include spraint (droppings) and footprints. Resting sites including holts, couches and hovers (Chanin, 2003) were identified as confirmed or potential lying up sites. Additional potential signs of otter activity included: runs or other well-used access points to watercourses, feeding remains e.g. fish carcasses and sightings, including otter road accident casualties.

Dates of Survey

6.2.3 Otter surveys were undertaken between 19 May-25 June 2008.

6.2.4 Repeat surveys were undertaken at some water features where the presence of otter could not be confirmed on the initial visit due to watercourses being choked with vegetation or where access was limited. These surveys were undertaken from 20-22 October 2008.

6.2.5 Otter surveys were undertaken along coastal areas on 22-24 October and 24-27 November 2008.

6.3 Otter Habitat Assessment

6.3.1 In addition to the field surveys, data relating to the quality of identified water features were reviewed to make a general assessment as to the suitability of the habitat for otter. This involved a review of Appendix A10.4, Section 14 (Freshwater Fish) to obtain data on water quality classifications, riparian habitat and fish species availability. The four waterbodies described in the Freshwater Fish baseline section have been assigned values according to the SEPA river health category (SEPA, 2006).

6.3.2 Otter habitat is taken to be optimal when it provides otters with both food and the availability of lying up and/or breeding sites. Potential sources of direct mortality such as road traffic (causing deaths) and disturbance may also be important in assessing habitat quality. Otters are recorded on still water and in coastal areas as well as rivers and burns of all sizes. Otters will use burns and ditches including dry watercourses as regular commuting routes (Chanin, 2003) but also travel cross-country between watercourses.

6.3.3 Factors that are likely to influence the survival of local otter populations are judged to be of the greatest value when evaluating habitat importance. As otter populations may be limited by prey abundance, areas possessing or allowing access to optimal foraging habitat is judged to be of key importance. Areas possessing sub-optimal foraging habitat, but having other habitat qualities (e.g. low levels of disturbance and dense riparian cover) are of lesser importance and are less likely to be vital to local otter survival (Kruuk et al., 1993). Isolated waterbodies are less favoured, although they may be used. Criteria used to determine the importance of habitats to the local otter population are given in Table 6.1.

Table 6.1: Habitat Assessment Criteria for Otters

Habitat Importance	Criteria
High	Habitats considered to offer high potential for otters have plentiful prey items, optimal foraging habitat and availability of lying up and/or breeding sites. Habitats have a combination of the following; • Good water quality. • Low disturbance levels. • Commuting links to other rivers/burns. • Riparian habitat (to enhance availability of prey for fish populations and for cover and lying up sites i.e. holts and couches). • Reedbed islands for rest sites.
Medium	Habitats considered to be of medium potential to otters are habitats may have despite abundant prey items, they are considered sub-optimal due to either: • moderate disturbance levels; or • poor riparian habitat for cover and/or lying up-sites.

Habitat Importance	Criteria
Low	Habitats considered to offer low potential for otters are; • Isolated waterbodies with little connectivity. • Locations marginal food resources. • Poor habitat/cover. • Suffers from substantial disturbance.

6.4 Limitations to Assessment

6.4.1 Restricting surveys to a single survey season limited the ability to account for seasonality in otter activity.

6.4.2 Surveys were restricted to 10m either side of watercourses, therefore signs of overland otter routes may have been missed. Couches are not restricted to riparian area and otters often sleep several hundred meters from the river bank (Kruuk et al., 1998). However, signs of otters in woodland or other terrestrial habitats, if present, were identified during the various other ecological surveys.

7 Water Vole

7.1 Existing Information

7.1.1 Consultation was undertaken with of the following statutory and non-statutory organisations to provide information relating to potential water vole (*Arvicola terrestris*) records in the vicinity of the study area and to identify and delineate suitable areas for survey:

- Dundas Estate;
- Edinburgh Biodiversity Partnership;
- Fife Coast and Countryside Trust;
- Forestry Commission Scotland;
- Hopetoun Estate;
- Fife Biological Records Centre;
- SWT;
- SEPA;
- TAPIF EIC;
- Vincent Wildlife Trust; and
- West Lothian Council.

7.1.2 In addition to consultation, a desk study using OS maps was undertaken to identify all water features including standing waterbodies and watercourses within the extended study area.

7.2 Water Vole Survey

Field Surveys

7.2.1 All watercourses and water features up to 500m from the centreline of the proposed scheme were surveyed on foot by experienced ecologists for signs of water voles including evidence of burrows, nests, feeding stations, latrines, runs and foot prints following survey methods outlined in Strachan & Moorhouse (2006) (Figure 10.7). Surveys were conducted from within the channel where possible, along the river bank and on ground within 10m of the watercourse. Where applicable,

survey effort was extended beyond the study area boundary to consider potential impacts of junction and road realignments.

7.2.2 The water vole breeding season extends from spring to autumn (March to October) when latrine marking is at its peak (Woodroffe, 2000) and this is the optimal time to carry out water vole surveys. The Water Vole Handbook (Strachan & Moorhouse, 2006) recommends carrying out surveys in spring (mid April, May or June and a second visit in July, August or September). Surveys therefore coincided with the optimal period for surveying this species.

7.2.3 Surveys were conducted following periods of dry weather when high water levels were unlikely to have affected the presence of water vole field signs.

Dates of Survey

7.2.4 Water vole surveys were initially carried out from the 19 May-25 June 2008. Repeat surveys were undertaken from 20-22 October 2008 at water features at which the presence of water vole could not be confirmed on the initial visit due to watercourses being over-grown with vegetation or where access was limited.

7.3 Habitat Assessment

Habitat Importance

7.3.1 An assessment of water vole habitat quality was undertaken based on characteristics including flow rate of waterbody, water depth, suitability of vegetation, the composition of habitat, availability of non-linear foraging habitat and bank suitability.

7.3.2 Water voles prefer static to moderate flowing waterbodies at a minimum depth of 0.3m and stands of emergent vegetation or tall grasses on which to feed. Non-linear foraging habitat may provide refuge from mink predation. Water voles require areas of soft earth bank in which to excavate their burrows.

7.3.3 As a major predator of the water vole, the presence of American mink is likely to affect the suitability of a watercourse to support water voles. Any signs of mink including footprints, scats (faeces) were therefore recorded during the field surveys.

7.3.4 Each waterbody was assessed using a scale of high, medium or low to determine the habitat suitability for water voles. Suitability of vegetation and bank was given greater weight than flow rate and flow depth. Details of how values of importance to the local water vole populations were derived are shown in Table 7.1.

Table 7.1: Habitat Assessment Criteria for Water Voles

Habitat Value	Criteria
High	Characteristics of habitats considered to be of high value to water voles; • Good riparian vegetation/cover with emergent vegetation or tall grasses. • Soft river banks for burrow excavation. • Non-linear foraging habitat. • American mink absent.
Medium	Habitats considered to be of medium potential to water voles have; • Moderate flowing waterbodies at a min depth of 0.3m. • Non-linear foraging habitat. • Presence of American mink.
Low	Habitats considered to offer low potential for water vole have; • Heavily shaded or wooded banks. • Linear watercourse or foraging habitat (as presence and risk of predation by mink is enhanced). • Presence of American mink.

7.4 Limitations to Assessment

7.4.1 There are no limitations to the assessment.

8 Red Squirrel

8.1 Existing Information

8.1.1 In order to collate any existing information on the distribution of red squirrels within the proposed scheme corridor, and inform the scope of the baseline surveys, consultation was undertaken with a variety of statutory and non-statutory consultees including:

- Edinburgh Biodiversity Partnership;
- Forestry Commission;
- LWIC;
- NBN Gateway;
- SNH;
- Scottish Squirrel Group;
- Scottish Squirrel Survey;
- SWT;
- TAPIF EIC; and
- West Lothian Council.

8.2 Red Squirrel Survey

8.2.1 The scope of red squirrel (*Sciurus vulgaris*) surveys was determined through consultation with SNH (Jacobs Arup, 2008b).

Initial Site Walkover

8.2.2 An initial walkover survey was undertaken to familiarise ecologists with the study area and to provide information required for the identification of woodlands that would be subject to further detailed surveys.

Identification of Survey Sites

8.2.3 Survey effort focused on woodland areas assessed to be suitable for supporting red squirrel populations through considering factors such as size of woodland, degree of isolation and tree species present based on research undertaken by Verbeylen et al. (2003).

Field Surveys

8.2.4 A combination of visual counts and hair-tube surveys were undertaken within the study area as a combination of these two methods provides robust results in respect to identifying the presence of red squirrel (Gurnell et al., 2004).

Visual Counts

8.2.5 Drey counts and searching for squirrel feeding signs were only undertaken to determine which woodlands showed signs of any squirrel activity as these methods cannot differentiate between red and grey squirrels.

8.2.6 Although not the primary focus of this study, the presence of grey squirrels was also recorded. The purpose of this was to assess the potential for inter-specific competition between red (if present) and grey populations.

Hair-Tube Surveys

8.2.7 Hair-tube surveys were carried out in accordance to the methods outlined by Gurnell et al. (2001).

8.2.8 Hair-tubes were placed between 100-200m apart in suitable locations in order to maximise their success rate in detecting the presence of red squirrels (shown on Figure 10.8).

8.2.9 The hair-tubes were checked and re-baited with the nut and seed mix every seven days for a four week period following recommendations by Gurnell et al. (2001) to give squirrels sufficient time to locate the hair-tubes within their home-range.

Visual Surveys

8.2.10 Visual surveys were carried out in accordance with the method described by Gurnell et al. (2001) At least three repeats were carried out in each woodland area surveyed (with the exception of St. Margaret's Hope Wood where access was restricted to 9h30-17h30).

Dates of Survey

8.2.11 A walkover survey of the study area was undertaken between 02-26 February 2008. Detailed surveys of woodland areas (survey sites) were undertaken from 2 June-28 August 2008.

Squirrel Hair Analysis

8.2.12 Squirrel hairs collected from the hair-tubes were analysed using a negative staining technique to determine whether they originated from red or grey squirrels following methods detailed in Gurnell & Pepper (1994), Dagnall et al. (1995) and Teerink (1991).

Red Squirrel Habitat Assessment

8.2.13 Criteria for determining habitat importance to the local red squirrel population are shown in Table 8.1. It should be noted that coniferous woodland is generally regarded as being of higher importance for red squirrels compared with broad-leaved woodland. This is not because of the active selection of coniferous woodland by red squirrels as a preferred habitat type, rather than due to the limited success of grey squirrels in coniferous woodlands, inter-specific competition with grey squirrels is considered to be less pronounced.

Table 8.1: Habitat Assessment Criteria for Red Squirrel

Habitat Importance	Criteria
High	Habitat is considered to offer optimal foraging and breeding opportunities owing to locally abundant conifers and small-mast producing broad-leaved trees of varied age structure coupled with low disturbance and suitable contiguous woodland habitat for cover and dreys.
Medium	Despite abundant foraging opportunities, habitat is considered sub-optimal due to moderate disturbance levels, lack of cover, abundance of large-masted broad-leaved tree species or presence of grey squirrels.
Low	Habitat offers sub-optimal foraging opportunities, has poor cover, is highly fragmented, presence of grey squirrels and/or suffers from disturbance.

8.3 Limitations to Assessment

Survey Method

8.3.1 Although considered the most efficient methods for detecting squirrel presence/absence within woodlands (Gurnell et al., 2001), it is possible that the hair-tube and visual surveys failed to detect the presence of squirrels in some locations. This risk was minimised as far as possible by leaving the hair-tubes in-situ for four weeks.

9 Amphibians

9.1 Existing Information

9.1.1 Consultation was undertaken with a variety of statutory and non-statutory organisations regarding previous amphibian survey information/data for the study area including:

- British Herpetological Society;
- Lothian Amphibian and Reptile Group (LARG);
- LWIC;
- NBN Gateway; and
- SNH.

9.1.2 In addition to the above, ERM Ltd was consulted regarding amphibian surveys undertaken as part of the Edinburgh Airport Rail Link (EARL).

9.2 Amphibian Survey

Desk Study

9.2.1 OS maps (1:25000) and aerial photographs were examined to identify ponds showing the potential to support amphibian populations. Where these were identified, ponds were further subject to investigation through a site walkover survey following DMRB guidance (Highways Agency et al., 1993b).

Walkover Survey

9.2.2 A walkover survey was undertaken of each pond to collect information on the presence of standing water within each area as standing water is a critical factor in terms of the likely presence of breeding amphibian populations. Additional environmental and habitat information was collected in order to calculate the Habitat Suitability Index (HSI) score of each pond as developed by Oldham et al. (2000).

9.2.3 The walkover survey additionally enabled the identification of suitable amphibian breeding habitat that was overlooked or not identified by the desk study.

Habitat Suitability Index Assessment

9.2.4 The likely presence of great crested newts in ponds can be predicted by examining a series of criteria such as the presence of fish or waterfowl and the quality of the water, in addition to the presence and proportion of suitable terrestrial habitat and physical barriers to migration. For ponds, these data are weighted and combined and then used to calculate a HSI. The HSI score is represented by a number from 0 to 1, the higher the number the more likely the pond is to be occupied by great crested newt (*Triturus cristatus*).

9.2.5 Data gathered since 2003 on other projects such as the M80 Stepps to Haggs (Jacobs U.K. Ltd., 2003) and the Aberdeen Western Peripheral Route (Jacobs U.K. Ltd., 2007) has confirmed the findings by Oldham et al. (2000) that the HSI is a valuable tool that can be used to accurately predict the likely presence of great crested newt. They demonstrated that great crested newts avoid low scoring HSI ponds and will only occupy ponds with a low HSI score when they are located in close proximity to each another. Similarly, ponds with high HSI scores have been shown to frequently support great crested newt in areas where they are present.

Selection of Ponds Using HSI

9.2.6 Ponds which have historically been identified as breeding sites for great crested newts and all ponds within 500m of these were taken forward for amphibian survey irrespective of their HSI score as per recommendations made by SNH during consultation (Niall Corbet, SNH, 19 June 2008, pers. comm., John Fowbert, Jacobs Arup.).

9.2.7 In respect to all other ponds where great crested newts have not been historically recorded, ponds with a HSI score of 0.6 and higher were taken forward for survey.

9.2.8 Ponds with a HSI score between 0.6 and 0.4, located close (within 500m) to other ponds with a similar score of less than 0.60, were additionally selected for survey.

9.2.9 Professional judgment was used in the selection of ponds for further investigation with a HSI score of less than 0.4.

Presence/Absence Survey

9.2.10 In order to determine the presence/absence of amphibian species within selected ponds, surveys comprising egg searches, bottle trapping and torch searches were undertaken by licensed ecologists following guidelines set out in the Great Crested Newt Mitigation Guidelines (English Nature, 2001) and JNCC's Herpetofauna Workers Manual (Gent & Gibson, 1998).

9.2.11 Each selected pond was surveyed on four separate occasions. In those ponds where great crested newt were identified, a further two surveys were carried out to provide an estimate of population size.

Dates of Survey

9.2.12 The walkover surveys were undertaken from March 2008. Presence/absence surveys were undertaken from April-June 2008.

9.3 Amphibian Habitat Assessment

9.3.1 The information obtained for aquatic and terrestrial habitat for amphibians was used to inform the evaluation and impact assessment in addition to formulating appropriate mitigation for specific sites. The assessment was predominately qualitative, based on known characteristics that are either beneficial or adverse to amphibians.

9.3.2 The quality of the aquatic habitat was assessed for its suitability to hold breeding amphibians, using parameters identified by Oldham et al. (2000) that are of particular value to this stage in their life cycle. This involved walking the perimeter of the pond, noting the presence and amount of marginal vegetation, the percentage of water that was shaded and the presence of fish or wildfowl.

9.3.3 The turbidity (amount of organic/inorganic particles suspended in the water) of the water was estimated based in how clear the water appeared. When the bottom of the pond was clearly visible there was no apparent or very little turbidity, and when the water clarity was such that it was not possible to see into water then the turbidity was high.

9.3.4 The proximity of other ponds was also taken into account, as neighbouring suitable ponds can increase the quality of the site. A combination of the presence, quality and absence of parameters were used to evaluate the aquatic habitat as detailed in Table 9.1.

Table 9.1: Aquatic Habitat Assessment Criteria for Amphibians

Aquatic Habitat Importance	Criteria
High	• Lack of fish or waterfowl with aquatic vegetation. • Clear water with areas of shading and/or areas of shallow and deep water and/or within 300m of a pond suitable for amphibians.
Moderate	• Occasional aquatic vegetation dominated by floating sweet-grass (*Glyceria fluitans*) and lack of shading. • Less than 50% shading and no pond within 300m suitable for amphibians and/or a low population of fish or waterfowl. • In late successional stage.
Low	• High fish, wildfowl or black-headed gull population. • Turbid water with no aquatic vegetation. • Above 75% shading.

9.3.5 Terrestrial habitat suitability for newt requires the area around a breeding pond to provide feeding, dispersal and areas for hibernation. Typically this would include grassland, scrub, woodland, hedgerows, dense ground vegetation, and voids in substrate allowing refuge (English Nature, 2001). The most frequently used area of terrestrial habitat is normally within 250m of a breeding pond, however this can extend to 500m. Table 9.2 shows the values of terrestrial habitat as defined by the presence or absence of these features. Information derived from the Phase 1 habitat survey was used to determine the value of the terrestrial habitat.

Table 9.2: Terrestrial Habitat Assessment Criteria for Amphibians

Terrestrial Habitat Importance	Criteria
High	Presence of substantial woodland and/or large area of scrub or rank grassland or large rock piles or many stone walls.
Moderate	Presence of large area of scrub and/or coarse or area of rank grassland or rock piles or stone walls.
Low	Lack of woodland, scrub, rank grassland and rock piles.

9.4 Limitations to Assessment

9.4.1 There are no identified limitations.

10 Reptiles

10.1 Existing Information

10.1.1 Consultation with statutory and non-statutory consultees was undertaken from March 2008. The purpose of the consultation was to establish the existence of ecological data and, in the case of SNH, to ensure its support for the approach being undertaken. In respect of reptiles, pertinent wildlife groups and organisations consulted include:

- British Herpetological Society;
- Edinburgh Biodiversity Partnership;
- LARG;
- LWIC;

- NBN Gateway;
- SNH;
- SWT; and
- TAPIF EIC.

10.1.2 The ecological assessment reviewed information gathered during these consultations in addition to previous survey data and information gathered as part of the Scottish Transport Appraisal Guidance (STAG) environmental assessment reported in the Forth Replacement Crossing Study Reports 1-5 (Jacobs et al, 2007), and a search of previous studies of the wider area.

10.2 Survey for Reptiles

10.2.1 The DMRB (Highways Agency et al., 1993b) does not provided any specific guidance rating to the size of a study area for reptile surveys. As such, the precautionary principal was adopted whereby a 500m study area was established for the reptile survey which is considered suitable in which to inform as assessment of potential impacts.

10.2.2 Potential reptile habitat within the study area was identified through a review of previous reptile reports and literature and analysis of aerial photographs, OS maps and Phase 1 habitat survey information. Habitats identified as having potential for reptiles were subject to a walkover survey to confirm suitability and to gather specific information on physical attributes. The walkover surveys additionally allowed for the identification of suitable reptile habitat not identified by the desk study.

10.2.3 The design of the survey was discussed and agreed with SNH (M. Cole, SNH,, pers.comm. 20 August 2008).

Reptile Survey

10.2.4 The field survey design was consistent with the technique described in DMRB, Volume 10 Section 4 Part 7 HA 116/05 (Highways Agency et al., 1993b).

10.2.5 Qualified ecologists undertook the surveys using artificial refuges suitable for use on road side verges (i.e. roofing felt of 0.5m^2 squares). The artificial refuges were set in areas most likely to be used by basking and foraging reptiles at a density of no fewer than 10 per hectare, although greater densities were used on large sites exhibiting greater concentrations of key habitat features.

10.2.6 Artificial refuges were left for a period of seven days to become established and allow sufficient time for reptiles to start using them. Artificial refuges were then checked on five separate occasions under suitable weather conditions and at suitable times of day. To maximise the likelihood of finding reptiles, survey visits at each site were structured such that they comprised of both morning and afternoon checks.

10.2.7 All the survey checks were completed in September 2008 which is considered to be one of the optimal months for surveying reptiles. All survey visits were undertaken when ambient air temperatures were between 9-18ºC and when weather conditions were suitable (i.e. in the absence of strong winds and heavy rain).

10.2.8 Numbers for each reptile species observed for each survey visit were recorded, as well as the prevailing weather conditions, air temperatures and temperature under the felts. Naturally occurring refuges such as log piles were also checked for reptiles, and any additional incidental sightings were recorded.

Dates of Survey

10.2.9 The walkover surveys were undertaken between 07-09 July 2008. Artificial refuges surveys were undertaken between 27-29 August 2008 and 08-25 September 2008.

10.3 Habitat Assessment

10.3.1 To fully assess the potential impacts of the proposed scheme on reptiles it was necessary to identify the key attributes of the landscape that reptiles rely upon and their ecological function. Although reptiles have relatively broad habitat requirements, at a landscape scale their distribution will largely be dependent on the availability of places of rest and shelter, basking opportunities, foraging habitat and habitat connectivity.

10.3.2 Favourable habitat for reptiles is typically characterised by a mosaic of habitat types with a high degree of structural heterogeneity. A list of key habitats present within the study area and a summary of their key attributes are shown in Table 10.1. Although not exhaustive, Table 10.1 also indicates the reliance of reptiles on these key habitats.

Table 10.1: Summary of Key Habitats/Attributes for Reptiles

Habitat	Attributes/Quality	Reliance
Woodland	Shaded by closed canopy overhead resulting in very little opportunity for basking reptiles. Some areas of woodland, particularly the edges, may be good for reptiles, particularly where sunlight reaches the ground and where the herb layer is thick. Fallen trees, deadwood habitat may be used for hibernation.	Potential basking and foraging sites on woodland edge and where sunlight reaches the woodland floor, otherwise sub-optimal. Hibernation sites.
Heathland	Open heathland is dominated by low growing shrubs and provides a favourable mix of cover and abundant food supply, as well as free draining sites for hibernation. An open sunny aspect and sandy soils produce warm and productive conditions.	Foraging, basking and breeding habitat for all four species of common reptile. Hibernation sites.
Scrub and Hedgerows	If located adjacent to grassland habitat, used for shelter and hibernation. Features such as rabbit burrows, exposed tree roots and deadwood are important.	Foraging and hibernating sites. Basking habitat associated with interface to adjoining habitats.
Grassland (unmanaged)	Unmanaged, un-grazed grassland develops tussocky structure and thick litter layer affording cover and protection for reptiles, particularly favoured by slow worms. This type of habitat also supports good populations of invertebrates, and amphibians and small mammals, prey to slow worm and adder respectively. Areas of shorter grass (e.g. mammal pathways) are used for basking. Reptile populations take time to reach carrying capacity and generally the older, more established sites hold the highest populations	Foraging, basking and breeding habitat for all common reptile species.
Highway verges and embankments	A mosaic of the above habitats on and adjacent to road verges maximises the boundaries between habitat types within a small area, providing all the requirements for reptiles and allowing large populations to develop.	All aspects of the life cycle, all species to varied degrees.
Arable land	The field margins and boundary features around arable fields provide a mosaic of the above habitats, and similar to road verges can support reptiles. Arable land itself is generally inhospitable and avoided.	Foraging, hibernating and basking sites restricted to margins.
Wetland habitats including standing and running water, fens, and marshy grassland	These types of habitat support good populations of invertebrates, amphibians and small mammals, prey items for all common species of reptile. Complex sites will offer diverse habitat structure.	Foraging and basking habitat for all common reptile species.

10.3.3 The criteria used to assess the potential of habitats to support reptiles, measured by the availability of key attributes are shown in Table 10.2.

Table 10.2: Habitat Assessment Criteria for Reptiles

Habitat Importance	Criteria
High	Habitats considered to offer a mosaic of structurally diverse vegetation ranging from dense growth to more open, exposed substrates; good connectivity to other areas of suitable reptile habitat; aspect and topographic variation including well-drained south-facing slopes; availability of natural refuges and hibernation sites; high prey densities; a lack of, or minimal human disturbance. Structurally diverse habitats may support one or more of the following habitat types: broad-leaved/coniferous woodland, scrub, semi-improved grassland, wet and dry heathland, bracken, standing water and boundary features.
Medium	Habitats considered to offer some, but not all of the features which characterise high quality habitats and those which exhibit restricted connectivity to other suitable reptile habitats.
Low	Habitats considered to offer few of the features that characterise high quality habitats and those which exhibit limited/isolated connectivity to other suitable reptile habitats. Habitats include open fields of arable and improved grassland, amenity grassland and habitats isolated by barriers which restrict the dispersal of reptile species.

10.4 Limitations to Assessment

Weather

10.4.1 All survey visits were undertaken during optimal weather conditions. However, during the survey period there was frequent rain which although not a limiting factor for individual visits, it did contribute to damp ground conditions throughout the survey period at many of the sites. Indeed, according to Meteorological Office (Met Office) statistics, the total summer rainfall for 2008 in Scotland exceeded the long term average of 1971-2000. This may have resulted in slightly less reptile activity and an associated reduction in the likelihood of reptile observations.

11 Terrestrial Invertebrates

11.1 Existing Information

11.1.1 Consultation was undertaken with a variety of statutory and non-statutory organisations including;

- Buglife Scotland;
- LWIC;
- SNH; and
- TAPIF EIC.

11.1.2 The NBN Gateway and the Butterfly Conservation website were used to provide additional details of protected species in the study area.

11.1.3 A data search of records of terrestrial invertebrates with statutory and notable designations was carried out on 10km squares through which the study area passed and included:

- North-NT 08, NT 18, NT 19; and
- South-NT 07 and NT 17.

11.2 Survey of Terrestrial Invertebrates

11.2.1 Due to the large numbers of individuals and species of this group in the study area, systematic surveying for terrestrial invertebrates was not considered practical. Consultation was undertaken

with a range of statutory and non-statutory organisations, the results of which and in conjunction with a literature review, were used to inform the final scope and focus of the field surveys.

11.2.2 A walkover survey was undertaken throughout the study area to assess the potential of sites to support terrestrial invertebrates. Eight sites were then chosen to be assessed by an entomologist to confirm their invertebrate status (shown in Table 11.1). The assessment focused on habitats suitable for important species, which had been identified from local biodiversity records, previous surveys, Biodiversity Action Plans, the Scottish Biodiversity List, Species of Conservation Concern Lists (JNCC, 2008) and the NBN Gateway.

11.2.3 Phase 1 habitat survey maps and target notes were also used to assess nature conservation potential of sites for invertebrates. Habitats were generally assessed for potential suitability with a prior knowledge of the habitat requirements of invertebrates in general and in particular invertebrates of local importance.

Table 11.1: Terrestrial Invertebrate Survey Sites

Site Number	Site Name/Designation	National Grid Reference (NGR)
1	St. Margaret's Hope Wood and St. Margaret's Marsh SSSI	NT 124 815
2	Ferry Hills SSSI	NT 128 811
3	Dundas Wood North	NT 128 769
4	Dolphington Burn Wood	NT 134 764
5	Ross's Plantation	NT 105 747
6	Lindsay's Craigs	NT 114 743
7	Parkland West Kirkliston	NT 118 743
8	River Almond South Kirkliston	NT 127 744

Dates of Survey

11.2.4 The habitat quality assessment surveys were conducted over a two week period in August-September 2008, which is at the limit of the ideal survey period, although additional information was derived from Phase 1 habitat survey which was carried out from May-September 2008.

11.3 Terrestrial Invertebrate Habitat Assessment

11.3.1 Factors that determine the maintenance of terrestrial invertebrate populations are judged as the most crucial points when evaluating habitat importance. Invertebrates require a mosaic of habitats which provide a range of suitable conditions which can accommodate the various life stages and over-wintering habitats. Invertebrates also require abundant food sources and suitable egg laying opportunities, which are of principal importance in defining habitat value. Details of how values of importance for survival of the local invertebrate populations were derived are given below and shown in Table 11.2.

11.3.2 A combination of both species and habitat assessment was employed to assess habitat value including the following factors:

- site contains records of notable species;
- proximity of site to a range of habitats to form the mosaic required for different invertebrate life stages;
- likelihood of a species being present in the area following existing data searches; and
- site contains some of the following features: suitable herbaceous food plant availability; varying stages of succession of habitats; suitability of woodlands for saprophytic invertebrates including deadwood; the presence of long grassland, tall ruderals, scrub, hedgerows; walls as potential sites for over wintering; and bare ground.

Table 11.2: Habitat Assessment Criteria for Terrestrial Invertebrates

Habitat Importance	Criteria
High	The area provides a mosaic of habitats in close proximity, with a varied age structure. Habitats provide suitable abundant food plants, egg laying habitats and shelter.
Medium	Despite suitable range of habitats, the location is considered sub-optimal due to habitat fragmentation and/or lack of appropriate management.
Low	The area offers limited food resources and/or poor habitat/cover and/or suffers from either substantial disturbance or lack of appropriate management.

11.4 Limitations to Assessment

11.4.1 As set out above, the habitat quality assessment surveys were undertaken over a two week period at the limit of the optimal survey period. Ideally terrestrial invertebrate surveys should be undertaken throughout one full field season as a minimum in order to establish the range of fauna present. However, the shorter survey period associated as part of the current study was compensated by additional consultation data and from information obtained by the Phase 1 habitat surveys.

12 River Habitat

12.1 Introduction

12.1.1 River Habitat Survey (RHS) is a nationally standardised system to measure, classify and report the physical structure of rivers (Environment Agency, 2003b) which was originally developed in 1994 by the Environment Agency and SEPA. RHS is extensively used across the UK and central Europe to describe and compare physical habitat structure and habitat quality. Through assessing the presence of functional habitat types, RHS can be used to assess biotic diversity potential. RHS has been accepted as a key ecological method under the Water Framework Directive (WFD) (EC, 2006).

12.2 Existing Information

12.2.1 No previous survey data were available from SEPA (John Clayton, SEPA, pers.comm. 08 June 2008). Data on watercourse designations for water quality and provisional WFD classifications were gathered from the SEPA website, utilising the most recent data available (SEPA, 2006).

12.3 River Habitat Survey

12.3.1 RHS sites were chosen in the vicinity of the proposed scheme (within 500m of the proposed crossing point of each watercourse) based on health and safety grounds, site accessibility and proximity to the aquatic macroinvertebrate and freshwater macrophyte studies (Sections 13 and 14). These sample sites provide a reliable representation of the watercourse that would be at risk from potential impacts of the proposed scheme. The locations of the RHS sites are detailed in Table 12.1and shown on Figure 10.11.

Table 12.1: RHS Site Locations

Watercourse	Site Reference	Description	Upstream NGR	Downstream NGR
JA08	Swine Burn	Downstream of Humbie Reservoir	NT 10908 74806	NT 10815 75339
JA09	Swine Burn	Adjacent to M9 Junction 1A	NT 10984 74755	NT 11509 74526
JA12	Niddry Burn	South of Lindsay's Craigs	NT 11323 74105	NT 11814 74021
JA14	River Almond	Downstream of Maitland Bridge	NT 12356 73851	NT 12610 74241

Survey Method

12.3.2 RHS was carried out over a 500m section of watercourse. Observations were made at 10 spot checks at 50m intervals along the channel. Surveys were undertaken from the bank, with the use of a ranging pole to assess bed/bank material, and a range finder to determine channel width. Global Positioning System (GPS) was used to record the start, mid and end point of the survey, as well as features of particular interest.

12.3.3 At each spot check a range of parameters were recorded in the field such as bank and substrate materials, marginal, bank and channel features, flow types, riparian vegetation and structure. Information on valley form, adjacent land use and artificial features provided additional context.

12.3.4 On completion of the ten spot checks a 'sweep up' assessment of the surveyed reach was made, recording any feature, flow types and substrates not represented in any of the preceding spot checks. Land use, tree cover and bank modifications were also recorded at this point.

12.3.5 Standard forms were used to enable a consistent approach for collection of baseline information which was then used to assess the degree of channel modification or nature conservation.

12.3.6 On completed of the field surveys, two indices were calculated for each site-the Habitat Quality Assessment (HQA) and Habitat Modification Score (HMS). The HQA is a measure of the structural diversity of the river where increasing scores are associated with increasingly complex habitat diversity. HMS assesses the degree of anthropogenic modification to the channel, with larger scores indicating a higher degree of modification.

Dates of Survey

12.3.7 The RHS of the four watercourses was conducted between 29-30 July and on 01 August 2008.

12.4 Habitat Assessment

Habitat Importance

12.4.1 Forms were checked on completion to ensure all field data had been recorded and photographs taken of unusual features of interest. Prior to analysis a second accredited RHS surveyor ensured the form and all relevant fields were completed and reviewed all photographs taken. The data was then used to calculate HQA/HMS (Environment Agency, 2003b).

12.4.2 The HMS was calculated using information on channel modification from each of the ten spot checks along the reach together with records of any artificial features such as weirs and culverts to give an index of habitat modification.

12.4.3 The importance of the habitat of each site was primarily determined by HMS (Table 12.2) derived from field observations. However, water quality (including aesthetics) and WFD classifications for the watercourses were also considered together with area designations to ascertain the overall significance of the habitat modification.

Table 12.2: Habitat Assessment Criteria for RHS

Habitat Importance	Criteria
High	RHS reach classed as Pristine or Semi Natural (HMS of 0-16), Predominantly Unmodified (HMS 17-199). No or very few channel modifications (e.g. planform alterations or bed/bank reinforcements); natural and diverse flow types; natural or semi-natural marginal and riparian vegetation.
Medium	RHS reach classed as Obviously Modified (HMS 200-499), Evidence of resectioning or revetment works; moderate morphological and habitat diversity.
Low	RHS reach classed as Significantly Modified (HMS 500-1399) or Severely Modified (HMS 1400+) Significant modifications limiting morphological adjustment; uniform channel characteristics and flow.

12.5 Limitations to Assessment

12.5.1 There were no limitations associated with the survey methods.

13 Aquatic Macroinvertebrates

13.1 Previous Survey Information

13.1.1 Consultation was undertaken with the following statutory and non-statutory organisations:

- Fife Nature Records Centre;
- LWIC;
- SEPA;
- SNH; and
- TAPIF EIC.

13.2 Survey of Aquatic Macroinvertebrates

13.2.1 All watercourses within the study area (Figure 10.11) were examined during initial visits in April 2008. Sample sites were then chosen to provide a reliable representation of each watercourse and, in particular, the section of watercourse that would be at risk from potential impacts of the proposed scheme (Figure 10.11). Sites which were recorded as dry, inaccessible or unsuitable on health and safety grounds were excluded from the site selection.

Survey Method

13.2.2 Macroinvertebrates were collected using the standard sampling method (BSI, 1994) to suit the monitoring criteria for the WFD waterbody characterisation process. This method incorporates components of survey methodology BT001 (Murray-Bligh, 1999), which sets out procedures for collecting, examining and analysing macroinvertebrate samples so as to be compatible with the River InVertebrate Prediction And Classification System (RIVPACS), developed by the Institute of Freshwater Ecology (IFE) and used by regulatory organisations within the UK and Northern Ireland.

13.2.3 A three-minute kick sample using a standard Freshwater Biological Association (FBA) net (with a 1mm mesh size, net depth of 50cm and handle of approximately 1.5m in length), followed by a one-minute manual search was conducted at each site. Invertebrate samples were stored in formalin (4%) and transported to the laboratory for processing and identification to species level.

13.2.4 Prior to processing, preserved samples were placed in graduated sieves (mesh size 2mm, 1mm and 0.5mm) and washed clean of preservative. Each fraction was then spread evenly across a white tray and all invertebrates picked out and identified using standard identification keys. With the exception of Oligochaeta (aquatic worms), Hydracarina (water mites) and some Dipteran (fly larvae) groups, all intact specimens were identified to species level.

13.2.5 The identification of invertebrate specimens makes it possible to assign conservation value to the individuals and the communities they form and to indicate biological water quality based on known sensitivities to organic pollution. The biotic indices calculated were Biological Monitoring Working Party score (BMWP), Average Score Per Taxon (ASPT) and Community Conservation Index (CCI), as described below.

13.2.6 The BMWP index is based on the tolerance of different freshwater macroinvertebrates to organic pollution. Each invertebrate family is assigned a score from 1 to 10, depending on their tolerance to pollution. Low scores are given to pollution-tolerant taxa, whilst the pollution-intolerant taxa score highly. Scores are assigned based on the presence of a scoring family in the sample and

abundance within families is not considered. The BMWP score is the total of all the scoring families present in a given sample.

13.2.7 BMWP is widely used by ecologists to determine the ecological quality of running waters and has been used in the UK since 1989. Although capable of highlighting additional water quality pressures, the system was specifically designed for the detection of organic pollution and, as such, any interpretation of additional pressures beyond this should be undertaken with caution.

13.2.8 The ASPT is used in conjunction with the BMWP index. By dividing the total BMWP score by the number of scoring taxa present the average taxon BMWP score can be found. This result is more easily comparable with other sites and permits an indication of biological water quality that is less influenced by the presence of a greater proportion of low scoring taxa or sampling effort. ASPT is often therefore seen as a more resilient method of assigning ecological quality. In both the case of BMWP and ASPT, higher scores indicate better ecological quality.

13.2.9 The preceding indices (BMWP and ASPT) all examine the invertebrate community composition in relation to water quality or environmental conditions. However, the diversity and conservation importance of an invertebrate community at each site can be represented by analysing species level data through the CCI. The CCI incorporates elements of taxon rarity and richness in an attempt to summarise the conservation value of invertebrate communities (Chadd & Extence, 2004). Scores defined within Chadd & Extence (2004) are assigned to species within the sample to derive a total sample conservation score which infers a conservation value from the criteria shown in Table 13.1.

Table 13.1: CCI Score Classifications (Chadd & Extence, 2004)

Conservation Score	Classification	Description
0≤5	Low conservation value	Sites supporting only common species and/or a community of low taxon richness.
5≤10	Moderate conservation value	Sites supporting at least one species of restricted distribution and/or a community of moderate taxon richness.
10≤15	Fairly high conservation value	Sites supporting at least one uncommon species, or several species of restricted distribution and/or a community of high taxon richness.
15≤20	High conservation value	Sites supporting several uncommon species, at least one of which may be nationally rare and/or a community of high taxon richness.
>20	Very high conservation value	Sites supporting several rarities, including species of national importance, or at least one extreme rarity (e.g. taxa included in the British Red Data Books) and/or a community of very high taxon richness (potentially of national significance and may merit statutory protection).

Dates of Survey

13.2.10 The reconnaissance surveys were undertaken in April 2008. Sampling surveys were undertaken in the week commencing 28 April 2008 for spring and the week commencing 15 September 2008 for autumn.

13.3 Aquatic Macroinvertebrate Habitat Assessment

13.3.1 Environmental characteristics that support species rich assemblages of aquatic invertebrates are those that provide a variety of substrate and flow characteristics (such as riffles and pools), good food supply and consistently good water quality. Freshwater flows may be dramatically different between seasons, which may lead to notable variation in the species and age composition of a freshwater habitat, reflected in altered BMWP, ASPT and CCI scores. Similarly, species of notable conservation value may be present in only specific habitat conditions. Protecting a variety of habitat features is a recognized way to provide suitable habitat conditions for a larger number of species.

13.3.2 Habitat importance for aquatic macroinvertebrates can therefore be determined using a combination of specific physical features (substrate type, flow features and water quality) and habitat quality (shown in Table 13.2).

Table 13.2: Habitat Assessment Criteria for Aquatic Macroinvertebrates

Habitat Importance	Criteria
High	Habitats considered to offer: • A good variety of substrate and flow features. • At least 'good' water quality.
Medium	Habitats considered to offer: • Some variety of substrate and flow features. • At least 'fair' water quality.
Low	Habitats considered to offer: • Poor variety of substrate and flow features. • Less than 'fair' water quality.

14 Freshwater Macrophytes

14.1 Existing Information

14.1.1 Consultation was undertaken with the following statutory and non-statutory organisations:

- Fife Nature Records Centre;
- LWIC;
- SEPA;
- SNH; and
- TAPIF EIC.

14.2 Survey of Macrophytes

14.2.1 The results of consultation with statutory and non-statutory organisations detailed in Appendix A10.4 (Section 13.1) were analysed in conjunction with an extensive literature review and used to inform the scope of appropriate field surveys. A walkover survey was conducted in April 2008 to identify freshwater sites that may support aquatic macrophytes. The purpose of the survey was to assess the importance of the aquatic macrophyte communities within the proposed scheme, with particular reference to taxa of conservation importance.

14.2.2 Ten sites within 500m of the proposed scheme were identified for survey and included watercourses crossed by the proposed scheme (shown on Figure 10.11). Sites were assessed by a botanist for their potential to support important macrophyte species (shown in Table 14.1). The assessment encompassed all groups of macrophyte; algae, bryophyte and angiosperm.

Table 14.1: Macrophyte Survey Sites

Site	Site Name	NGR
JA01	Brankholm Burn	NT 12180 83770
JA04	Linn Mill Burn	NT 11440 78720
JA06	Dolphington Burn	NT 12810 76570
JA07	Humbie Reservoir	NT 10530 75580
JA08	Swine Burn (downstream of Humbie Reservoir)	NT 10530 75580
JA09	Swine Burn (adjacent to M9 Junction 1A)	NT 09340 75770
JA10	Niddry Burn (Ross's Plantation)	NT 10830 75340

Site	Site Name	NGR
JA12	Swine Burn (adjacent to M9 Junction 1A)	NT 11130 74670
JA13	Niddry Burn	NT 10680 74670
JA14	River Almond	NT 11400 47070

14.2.3 The aquatic macrophyte surveys were undertaken by two ecologists following Mean Trophic Rank (MTR) methodology in running waters (Holmes et al., 1999), Predictive System for Multimetrics (PSYM) in still-waters and Environment Agency operational instruction guidelines (Environment Agency, 2007).

14.2.4 The PSYM methodology has not been extensively tested in Scottish still waters. Following discussion with the Ponds Conservation Trust: Policy and Research (PCTPR), who designed PSYM, in collaboration with the Environment Agency this method was considered to be the most appropriate technique available.

14.2.5 For running watercourses (Brankholm Burn, Linn Mill Burn, Dolphington Burn Swine Burn, Niddry Burn and River Almond) a single 100m stretch was surveyed using standard MTR survey forms. The macrophyte fauna and physical character of each stretch was surveyed from the bank. All macrophytes, algae and moss species present were recorded, with an estimated percentage cover of each species (SCV) and total macrophytes cover (CVS) of the site made. Every species was assigned a Species Trophic Rank (STR) which was used to determine the nutrient status of the watercourse and forms, along with the SCV/CVS the mean trophic rank for the site.

14.2.6 For the standing waterbody (Humbie Reservoir), the standard Predictive System for Multi-metrics (PSYM) survey methodology was adopted (PSYM, 2002). Basic hydrological and chemical data, along with macrophyte and invertebrate data was combined within PSYM methodology to classify the ecological status of still-waters. Wetland plants were assessed by walking the perimeter of the lake, recording all specimens encountered. Macrophyte data was then used to create three plant metrics (number of submerged and emergent species, trophic ranking score (TRS) and uncommon species index) and described in relation to the invertebrate samples collected.

14.2.7 Quality and consistent identification of specimens was maintained through the use of two experienced botanists in the field. A sample of any difficult or unusual specimens was returned to the laboratory for further identification where necessary.

Dates of Survey

14.2.8 The aquatic macrophyte surveys were undertaken in July and September 2008.

14.3 Habitat Assessment

Habitat Importance

14.3.1 The results of the data review were combined with survey results to characterise the aquatic flora at each survey site. The importance of the habitat available in these watercourses is determined by both physical and chemical parameters.

14.3.2 Physical environmental factors were recorded as part of the aquatic macrophyte surveys, collecting information on the following parameters:

- channel width;
- channel depth;
- substrate composition;
- fluvial habitat composition;

- shading of site;
- water clarity; and
- bed stability.

14.3.3 Based on the survey findings, the importance of habitat at each site was assessed in line with the criteria shown in Table 14.2.

Table 14.2: Habitat Assessment Criteria for Freshwater Macrophytes

Habitat Importance	Criteria
High	• Wide species diversity, good representation of pollution sensitive taxa and flow habitats. • MTR score 65+.
Medium	• Reasonable species diversity, some pollution sensitive taxa present. • MTR score 30-64.
Low	• Low species diversity, the community is dominated by a few pollution tolerant species. • MTR score 0-29.

14.4 Limitations to Assessment

External Data Sources

14.4.1 The assessment of habitat value was principally based on the habitat assessment conducted in 2008 and further informed by the limited data gained through consultation with the organisations mentioned above.

Survey Restrictions

14.4.2 Macrophyte surveys were undertaken during the optimum period stated within the standard methods (Holmes et al., 1999). However, it should be noted that heavy rain was experienced throughout the survey period and may have affected the community present and in-channel visibility.

14.4.3 Wider plant communities beyond the survey stretches can be inferred from the survey results. However, it is possible that numerically scarce species may be overlooked if they fall outside one of the surveyed stretches. To ensure macrophyte communities are fully and accurately represented, MTR methodology recommends the minimum data set analysed is three surveys undertaken over a three year period. In consequence, this single year dataset may under represent the rare macrophyte species present in each watercourse.

15 Freshwater Fish

15.1 Aims of Survey

15.1.1 The aims of the survey were to identify and quantify fish species present in freshwater habitats within 500m of the proposed scheme and to assess these sites for habitat quality and importance to the fish species found there.

15.2 Previous Survey Information

15.2.1 Consultation was undertaken with a variety of statutory and non-statutory organisations (as described below). Through consultation, information was requested/sourced for freshwater fish populations and their distribution within the Forth catchment and watercourses of interest.

- Association of Scottish River and Fishery Management Trusts;

- Biological Records Centre (BRC);
- Federation of Fly Fishers;
- Forth District Salmon Fisheries Board (FDSFB);
- LWIC;
- Natural History Museum;
- NBN Gateway;
- SEPA;
- SNH; and
- TAPIF EIC.

15.3 Survey of Fisheries Habitat and Freshwater Fish

15.3.1 At the outset a walkover survey and desk study were undertaken of the standing and running waters that lie within the footprint of the proposed development. The results were used to refine a list of watercourses that warranted further survey. Targeted surveys of fish communities and species abundance were then undertaken using standardised electrofishing techniques.

Fisheries Habitat Survey

15.3.2 A fisheries habitat survey was carried out at four sites, two on the Swine Burn, one on the Niddry Burn and one on the River Almond. These watercourses met one or more of the following criteria:

- designated under the EC Freshwater Fish Directive (2006/44/EC) and the Surface Waters (Fishlife) (Classification) (Scotland) Amendment Regulations 2007 (water quality standards and fish class (salmonid and cyprinid));
- classified under the original SEPA Classification Scheme 2006 (overall water quality);
- categorised under the WFD (risk based categorisation risk of not meeting WFD target of good ecological status by 2015);
- protected under the Water Environment (Controlled Activities) (Scotland) Regulations (2005) (CAR); and
- likely to host protected fish species/fish species of conservation concern.

15.3.3 The approved habitat survey method is drawn from the Scottish Fisheries Co-ordination Centre (SFCC) guidelines for fisheries habitat survey with specific reference to Atlantic salmon and brown/sea trout (SFCC, 2007a). The SFCC habitat survey is a method used to record detailed information relating to salmonid habitat in a standardised format. Salmonid habitat requirements are recorded in terms of water quality, shelter, food and availability of spawning habitat. The SFCC habitat survey protocol records in-channel features (e.g. instream vegetation, substrate type, proportion of cover for fish, flow features) and physical attributes (e.g. width, depth, land use) of a 100m length of river representative of the general character of the watercourse. The output from the habitat survey is not a standardized index or quantitative (SFCC, 2007a) and is therefore interpreted using professional judgement based on the criteria shown in Table 15.1.

Electrofishing Survey

15.3.4 Permission was sought from the FDSFB and proprietors and tenants of any fishing rights (including riparian landowners) to undertake electrofishing operations. The FDSFB are responsible for managing and improving salmonid fisheries in the Forth catchment and are empowered under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act (2003) to regulate and licence methods of fishing in inland waters other than by rod and line.

15.3.5 Consent to use electrofishing equipment to catch salmon or freshwater fish was granted by the Scottish Government under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act (2003).

15.3.6 Electrofishing surveys were conducted using standard electrofishing techniques, following guidelines developed by the SFCC (SFCC, 2007b) and the British Standard for sampling fishing with electricity (BSI, 2003). Equipment was manufactured in accordance with Appendix A of the Environment Agency specifications, maintained in accordance with Appendix B of the same specifications and inspected for electrical continuity before each use (Environment Agency, 2001).

15.3.7 Prior to commencing the fisheries survey conductivity (µS/cm) and temperature (°C) readings were taken at each site using a calibrated hand held meter (Hach meter). This was used to inform the set up of the electrofishing equipment.

15.3.8 Smaller running water sites on the Swine Burn (Site JA08) and Niddry Burn were sampled using an Electracatch International ELBP2 back pack unit (battery powered), using a single anode (250mm diameter) and standard braid cathode compatible with the unit. This unit was operated using smooth direct current (DC), with an output voltage of between 100-250volts, and at 1.0-1.5amps.

15.3.9 A quantitative survey was undertaken on the Swine and Niddry Burn sites, using multiple-run catch depletion electrofishing. As all fish could not conceivably be caught at any site, catch depletion involves repeatedly fishing a stretch until only a small proportion (statistically estimated) of the population remain. This method allowed a catch efficiency to be determined and thereby a statistical estimate of the density of fish for a given area to be calculated A survey length of at least 50m was delineated using stop-nets (10mm mesh size) upstream and downstream to enclose the survey reach and to stop the movement of fish in and out of the survey site. NGR were recorded (Appendix A10.4: Baseline, Section 13.2, Table 13.1) at both the downstream and upstream stop nets using a Garmin Etrex GPS (accuracy ~2-3m) unit.

15.3.10 Electrofishing was carried out by progressing upstream through the stretch and sampling all habitats representatively. Stunned fish were collected using pole nets (5mm mesh size) and placed in tanks of oxygenated water to recover. Recovery tanks were situated at the mid-point within each survey reach. Each survey stretch was fished through three times allowing abundance, species assemblage, density estimates and catch efficiency to be determined. Catch depletion was observed over three runs on the Swine Burn, but not the Niddry Burn, where four electrofishing runs were completed.

15.3.11 A qualitative survey was conducted on the River Almond as the size and flow of the watercourse made a quantitative approach impractical due to the errors which would be associated with the method used (such as reduced catch efficiency) in these conditions. Stop nets were placed at either end of the survey reach and the river was fished using the method listed above.

15.3.12 On the River Almond and Swine Burn (Site JA09) sites, an Electracatch International WFC4 control box and compatible Honda Eu20i generator unit was used (maximum power 2000W). This was configured to employ a twin anode (350mm diameter) arrangement that could be extended 50m from the control box and a standard braid cathode compatible with the unit. This unit was operated using smooth DC at 50Hz with an output voltage of between 100-250 volts, and at 1.0-1.5 amps.

15.3.13 All captured fish were retained separately per run before processing. All native species that are threatened or of conservation concern (e.g. migratory trout) were anaesthetised using a dilute solution of benzocaine, and subsequently weighed (to the nearest 0.5g) and measured to the nearest millimetre (fork length). All other fish species were processed without using anaesthetic and only abundance of each species was recorded. After processing, all fish were transferred to separate, oxygenated recovery tanks. When all fish had completely recovered (showing signs of normal activity such as the ability to maintain their position and orientation consistently in the holding facility), they were returned to the watercourse.

15.3.14 No areas of suitable lamprey habitat were identified during these surveys and consequently specific lamprey surveys did not take place.

Dates of Survey

15.3.15 The fisheries habitat surveys were conducted between 26 March-18 April 2008. Electrofishing surveys were conducted between 21-24 April and 25-26 June 2008.

15.4 Habitat Assessment

Habitat Importance

15.4.1 Waterbodies identified as being suitable for further investigation were assessed for fish habitat quality and the potential for utilisation by fish. This was accomplished using a combination of professional judgement and guidelines provided by the SFCC for conducting fisheries habitat survey (SFCC, 2007a). A habitat value was assigned to each watercourse based on the criteria listed in Table 15.1.

Table 15.1: Habitat Assessment Criteria for Freshwater Fisheries

Habitat Importance	Criteria
Good	Habitats considered to offer a series of flow types to include pools, runs, riffles and glides. Complex substrate diversity must also be exhibited throughout the survey reach. Ample cover on both banks to provide refuge for both juvenile and adult fish, incorporating both in-stream and marginal vegetation. Substrate present for spawning salmonids. No obvious signs of pollution/marginal poaching. No obvious barriers to upstream migration.
Moderate	Habitats considered to offer a number of flow types throughout the survey reach. Limited substrate diversity present. Sparse patches of cover present on either bank, providing refuge for both juvenile and adult fish. Low in-stream and marginal vegetation diversity. Limited substrate present for spawning salmonids. No obvious signs of pollution, marginal poaching may be present. Potential barriers to upstream migration present.
Poor	Habitats considered to offer minimal flow types throughout the survey reach. Substrate diversity absent. No bankside/marginal cover for fish on either bank. In-stream and marginal (where present) limited to a single dominating species. No substrate available for spawning salmonids. Watercourse may receive diffuse land based pollution (run off) and exhibit a high degree of poaching. Barriers to upstream migration (debris/man-made dams) present.

15.5 Limitations to Assessment

Environmental Conditions

15.5.1 All surveys were subject to suitable weather conditions and flow conditions (dry, calm, moderate temperature and moderate water levels and flows). The exception to this was the River Almond where, due to the river being above moderate level and flow, windows of opportunity for surveys were restricted. As a consequence, surveys took place in less than ideal conditions and this led to a reduced sampling efficiency due to elevated turbidity, reduced visibility and consequently reduced sampling efficiency. Data for this site were therefore likely to under represent the fish numbers present and were treated as qualitative.

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