Mainstream Renewable Power

Neart Na Gaoithe Wind Farm – Onshore Cable and Grid Connection

Drainage Strategy Plan

Kaya Consulting Limited

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Kaya Consulting Limited Job Number: **KC444**
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1 Introduction

Mainstream Renewable Power is seeking consent to build and operate an offshore wind farm 15.5 km east of Fife in the Firth of Forth, Figure 1. The proposed wind farm is called Neart na Gaoithe. The proposal is that power cable from the offshore wind farm will land close to the village of Thorntonloch south of Dunbar and run underground in a west and south-westerly direction and connect to a new subs-station next to the existing sub-station at the Crystal Rig II wind farm site in East Lothian. The length of the cable running underground between the landing point at Thorntonloch and sub-station is approximately 12.3 km.

LUC has been commissioned to undertake the Environmental Impact Assessment (EIA) for the Onshore Works (comprising cable landfall, cable corridor and sub-station). Kaya Consulting have been sub-contracted to assess the hydrological and flood risk impacts of the proposed development as well as developing an Outline Drainage Strategy.

The purpose of this document is to provide an overview of the proposed drainage strategy which will be used by the contractor to develop a detailed Drainage Management Plan and to inform associated construction method statements during and after construction of the cable connection.

The document outlines various existing drainage features and provides a benchmark for treatment and attenuation mitigation measures based on outline layout and topographical information available at present.

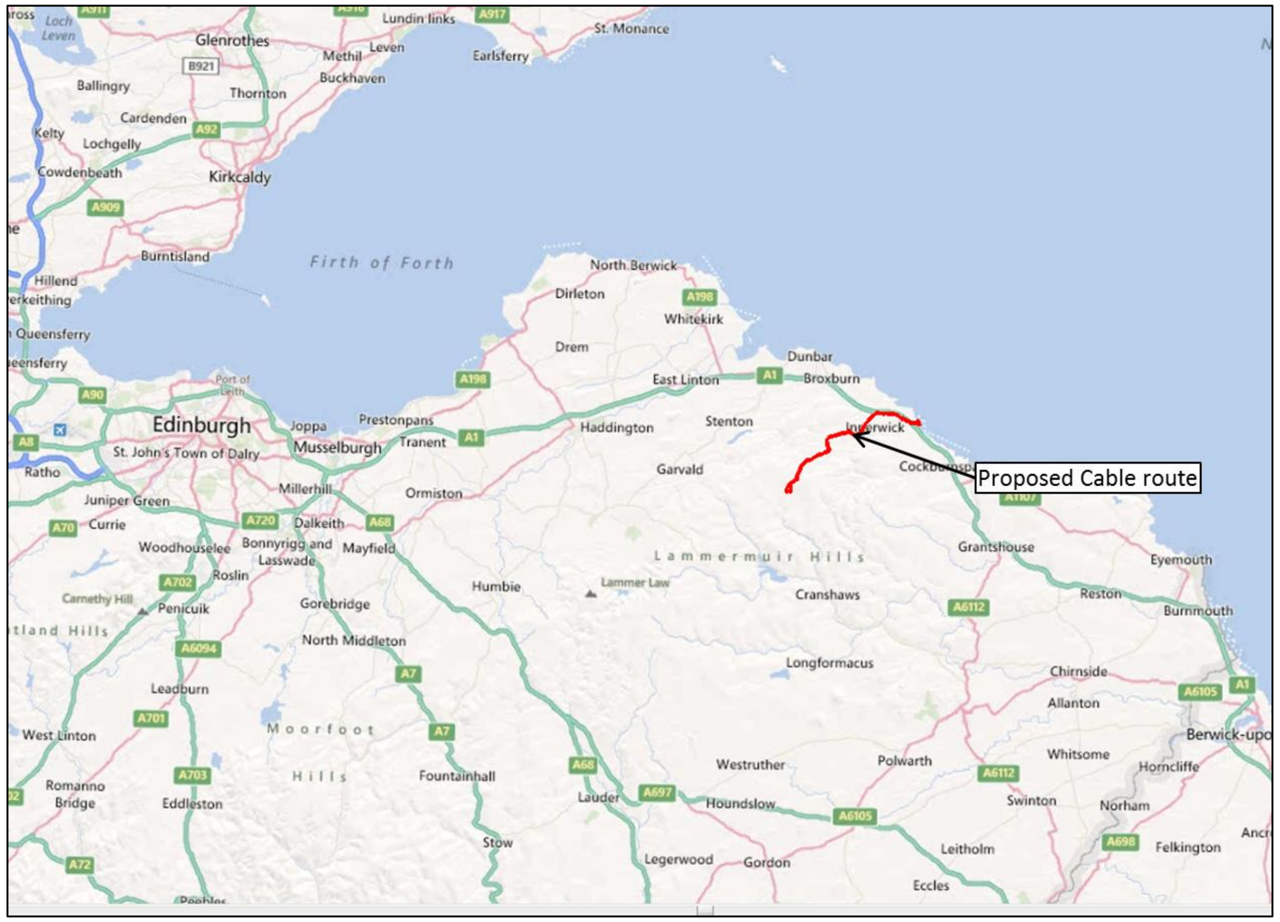
The main aims of the drainage strategy are:

a) To maintain existing overland flow paths during and after construction so that the risk of flooding elsewhere is not increased
b) Make certain that overland elements of the development (such as sub-station) are not at a significant risk of flooding
c) To protect local watercourses from pollution during construction

The following outline drainage strategy has been development with the above aims in mind.

A general location map for the site is shown in Figure 1.

Figure 1: General Location Map



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2 Site Location and Construction Description

The proposed work involves joining the offshore and onshore cables at the landfall point onshore and running the cable along a defined route, underground to the nearest electricity sub-station so that it can be connected to the National Grid.

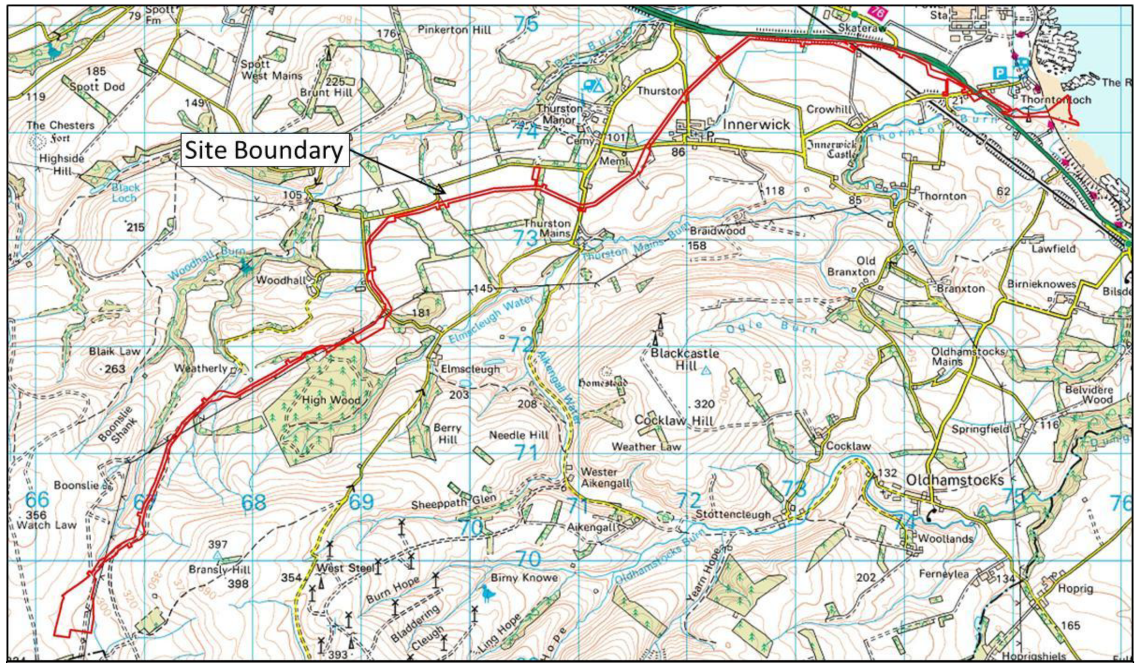
The proposed landing site for the offshore cable is located at Thorntonloch.

It is understood that the cable will approach the beach via an underground trench or through a HDD cable boring. The cable will enter into a transition pit located out with the shoreline, to the west of the beach. From this location the cable will follow an agreed route before connecting to a new sub-station adjacent to the existing the Crystal Rig II wind farm.

A plan of the proposed route is shown in Figure 2. The Application Boundary indicates the proposed construction boundary. Throughout the lower reaches the cable line generally passes through fields and agricultural land. Approximately 8 km west of the landing site, the cable line runs parallel to the Crystal Rig II access track making a connection near the electricity sub-station at the wind farm site. From landing point to the sub-station, the cable will rise approximately 298 m in elevation.

The cable will be encased within approximately a 2 m wide and 2 m deep trench. Cable access points will be installed at several locations throughout the route to allow for access during construction. Construction techniques will vary depending on the above ground conditions however, for road, rail and some watercourse crossings it is possible that the cable may be directionally bored under the obstruction.

Figure 2: Proposed Application Boundary



3 Hydrology

A hydrological analysis has been carried out to estimate overland flows that could be experienced along the route of the cable during construction. The predicted flow rates were then used in the development of the drainage strategy as outlined in the following sections.

The general topography of the study area is varied with undulating hills located within the lower reaches and steep sided moors found close to the Crystal Rig wind farm site. The highest point along the cable line is at 298 m AOD within the existing Crystal Rig wind farm site at Bransly Hill in the Lammermuir Hills.

The Onshore Works lie primarily within the catchment of the Dry Burn, although they cross the catchment of Thornton Burn near to the coast and they enter the headwaters of Bothwell Water near to the proposed sub-station in the Lammermuir Hills.

Catchments in the study area have low runoff rates compared to other catchments in Scotland. Based on data extracted from the Flood Estimation Handbook (FEH) CD-Rom Version 3, the percentage runoff for the Thornton Burn catchment near the coast is around 30% (SPRHOST = 30.4). A similar figure is found for Weatherley Burn catchment in the Lammermuir Hill (SPRHOST = 31.6), and for the Dry Burn catchment (SPRHOST=31.5). These figures indicate that typically around 30% of the rainfall falling on a catchment becomes river and stream flow. The rest is lost to infiltration to groundwater, soil water storage, evaporation or is used by vegetation.

Although there is generally low runoff within the catchments affected by the Onshore Works, there is a high degree of variability in soil conditions. The coastal strip has sandy and very well drained soils which tend to produce limited runoff in response to rainfall (Winter Rain Acceptance Potential (WRAP) Soil Class 1). The farmland between Lammermiur Hills and coast also have well-drained sandy soils (WRAP Soil Class 2), with more silty and poorer drained soils within the lower slopes of the Lammermuir Hills (WRAP Soil Class 3). There is only a small area of very poorly drained peaty soils within the headwaters near the Crystal Rig wind farm (WRAP Soil Class 5).

The cable route crosses approximately eleven watercourses and agricultural drains including Thornton Burn, Weatherly Burn and Thorter Cleugh. There may be other small field drains that are culverted or piped under the road, which could not be identified from a walkover site visit and a review of available topographical maps. These will need to be identified during site investigations or construction. However, these features will be of minor importance and easily replaceable following construction.

Remote from stream crossings, the proposed Onshore Works will cross surface and shallow surface runoff flow pathways on hillslopes along the proposed cable route.

From the coast to the entrance to the access to the Crystal Rig wind farm the Onshore Works pass through farmland with relatively gentle hillslopes (1 - 5 %). The farmland is well drained with sandy and silty soils, field drains and a number of small water courses. For much of the route the cable will follow the line of a C-Class road, which is likely to provide an existing impediment to surface and shallow subsurface flows.

From the entrance to the access to the Crystal Rig wind farm to the headwaters of Dry Burn the cable route follows the access road to the existing wind farm. The route passes across steeper (5 - 20 %) hilllslopes in the Lammermuir Hills. The access road will provide an existing impediment to surface and shallow subsurface flows. There are existing road side swales and ditches that divert unchannelised flow towards stream channels and which focus surface flows through the road at key crossings identified above. Soils within the hills have a higher runoff potential than found further east. Within the headwaters of Dry Burn and Bothwell Burn at the western end of the cable corridor hilllslopes flatten out and the proposed sub-station will be constructed in a broad moorland plateau.

Using the Institute of Hydrology Small Catchment Equation (IH124) see Appendix B, the estimated surface water runoff rates were estimated per hectare of land along the proposed cable route and the results is presented in Section 4 below.

4 Drainage Strategy

The site drainage proposals are given in Appendix A. Plans 1 to 11 provide an overview of the proposed drainage measures including surrounding environmental and key topographical features.

The site is located in a relatively dry area of Scotland and is generally underlain by well drained soils hence it is likely that only minimal surface water runoff and flood risk measures will be required during construction. However, the contractor should address all drainage related considerations arising out of construction of the project such, as;

- Increased flood risk in the downstream environment due to increased run off
- Increase sedimentation of receiving watercourses
- Pollution of surface waters and groundwater from contaminants used during construction
- Damage to downstream environment due to alteration of existing land drainage

It should be noted that the contractor will also be required to ensure that all drainage works affecting the environment will be subject to the relevant statutory requirements as outlined in the Water Environment (Controlled Activities) (Scotland) Regulations 2005. Cognisance of relevant General Binding Rules guidance documents should be made.

Onshore Works

All Onshore Works have the potential to create high volumes of contaminated surface water runoff including;

- Excavation of construction compounds
- Erection of temporary access tracks through agricultural land
- Excavation of cable trenches
- Crossings of watercourse and drainage channels
- Construction of impermeable surfaces
- Stockpiling of materials

Hence, all runoff from site workings should be treated and attenuated. Whilst constructing in areas close to sensitive receptors, and where high volumes of excavation are required, two levels of treatment should be incorporated to attenuate the site runoff and to reduce the risk of contaminants reaching the adjacent watercourses. Treated water should be discharged to the receiving watercourse of the original catchment. Watercourse catchments should not be altered.

Design mitigation measures to be incorporated within the site are described in the following sections and are illustrated in Appendix A.

4.1 Cable Works

- Design of final cable route location within currently proposed red line boundary, to minimise impact on surface water and drainage flow paths
- Selection of cable laying techniques best suited to the adjacent hydrological feature
- Ensure all excavated material is placed away from sensitive hydrological features
- Bedding material should be stored in areas of high ground where washout from surface water runoff is limited

4.2 Hard Standing Areas

- During construction, areas of hardstanding should be limited. Where possible, proposed surfaces should comprise of compacted granular materials which are inherently permeable
- Runoff from areas upslope of hardstanding should be intercepted by drainage measures to reduce washout of aggregate, see Figure 3
- Runoff from hardstanding areas should be treated and attenuated to levels relative to the area of use. Further treatment may be required from areas subject to high pollution risk i.e. fuelling areas etc.
- All runoff from hardstanding should be attenuated to greenfield runoff rates as indicated in Table 1.

Figure 3: Swale interceptor upslope of impermeable area

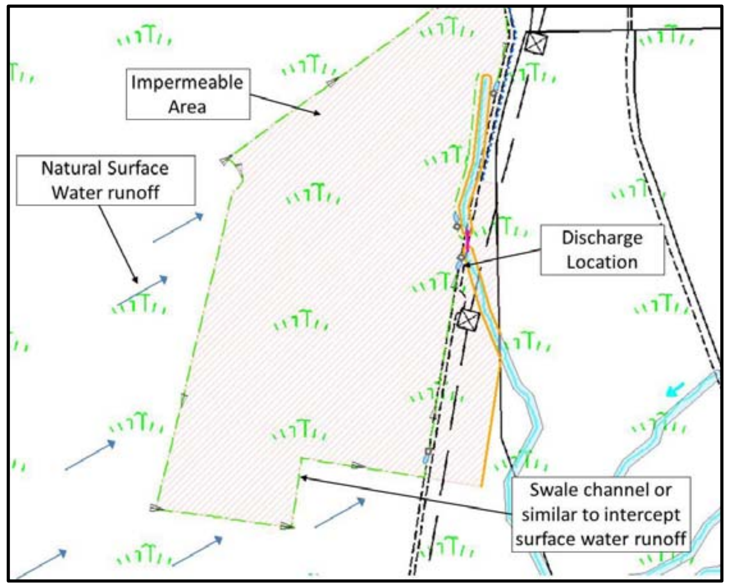


Table 1: Approximate greenfield runoff rates at selected site locations (based on 1 ha areas)

Area	[a]Map Plan	Greenfield runoff rate (l/s/ha)
SOIL TYPE 1	1-3	0.3
SOIL TYPE 2	4-7	1.6
SOIL TYPE 3	8-9	3.7
SOIL TYPE 4	10-11	6.3

a See Appendix A- Outline Drainage Strategy Plans

1. SOIL = 0.15, SAAR = 624 mm
2. SOIL = 0.30, SAAR = 716 mm
3. SOIL = 0.40, SAAR = 862 mm
4. SOIL = 0.50, SAAR = 911 mm

The above summarises likely greenfield runoff rates (1 in 2 years) and can be used to size drainage measures where appropriate. The variations in flow rates are largely due to SOIL type (varying from 1 to 5) as well as Standard Average Annual Runoff.

4.3 Land Drainage

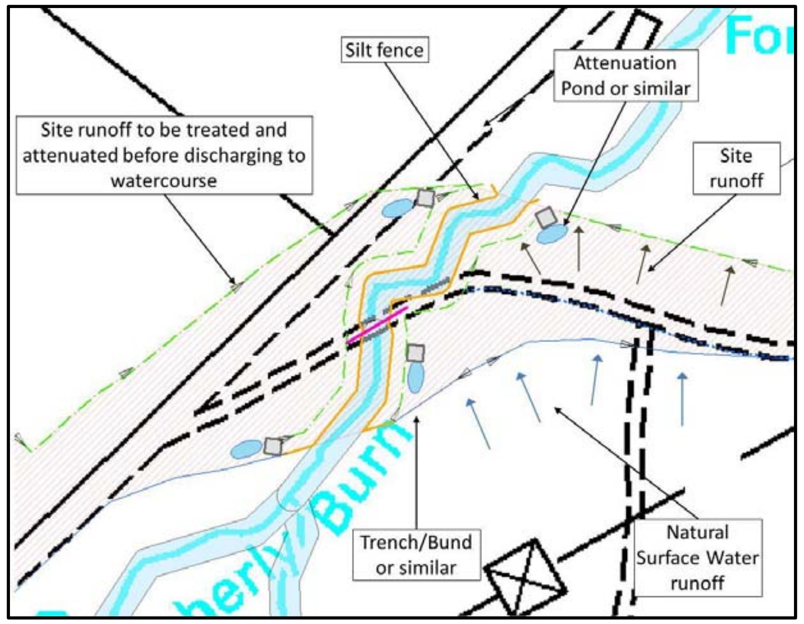
- During construction provision should be made to ensure that the functionality of the existing land drainage is retained
- Where possible intercepted flows should be discharged to the original catchments
- Post construction, land drains damaged or altered in the course of onshore works should be replaced to a similar or better specification which provides a hydraulically similar performance
- Where a number of land drains are anticipated to be broken it is recommended that all flows should be collectively intercepted and, if possible, discharged to an open channel or downstream land drainage. This should be agreed with the land owner.

4.4 Clean Water Separation

- Constructing in areas of sloping land leads to surface water runoff washing out topsoil and excavated material stored within the site boundary. To avoid this, barrier features such a bunds or drains should be employed at the upslope side of the site boundary to prevent surface waters from reaching the site
- As construction moves forward, if practical, such features should be removed and ground levels should be reinstated to pre-construction levels.
- A suitably sized trench or similar structure sufficient to intercept and divert clean water from entering the site should be considered, see Figure 4.
- It is likely that the dimensions of such structures would likely be approximately 0.5 m deep and 0.5 m wide.

- In areas close to woodlands which will be crossed by means of trenchless techniques, bunds or similar features should be used only where construction is above ground and outside root protection zones.
- Where possible intercepted runoff should be diverted towards the original discharge point
- In areas where the drainage feature is remote from a suitable discharge location, efforts should be made to ensure, during an extreme event, any water overtopping the drainage feature is directed away from the construction area.

Figure 4: Drainage feature used to intercept upslope surface water runoff



4.5 Site Drainage

- Constructing in areas of sloping land can lead to silt laden surface water runoff from the construction area. This runoff should be captured and directed within temporary swale structures, or similar, located along the downslope of the construction site boundary
- The drainage feature will used during all types of silt generating construction ensuring that adequate provision is made to serve areas of recently laid cable. In areas where construction has been completed such features should be removed assuming there is no risk of silt laden runoff from the site.
- Where drainage features are expected to extend over a reasonable distance, check dam or silt fence structures should be included within the swale or similar feature to provide attenuation and to encourage settlement of suspended solids. The amount and location of

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such dams will be dependent on a number of factors including; slope, flow and volume of water, see Table 2 as a guide.

Table 2: Suggested check dam spacing

Approximate Gradient %	Approximate Spacing (m)
<3	30
4 - 8	15
9 - 12	10

- Ideally, the chosen structure would treat and attenuate site runoff before discharging directly to a receiving watercourse. In areas remote from discharge points, mitigation options should include on-site storage with direct infiltration. Dimensions of such features should be confirmed following on-site infiltration tests. During extreme events ground levels should be designed so that flood waters will overtop downslope, away from the site.

4.5.1 Woodhall Dean SSSI

Whilst working close to areas upstream of the Woodhall Dean SSSI site, such as the Boonslie Burn and Weatherly Burn, additional measures to reduce potential impacts of the proposed works will be required. These may include;

- Treating and attenuating site runoff discharging into the receiving watercourse. Two levels of treatment are suggested. Runoff entering swales/trenches, etc. should be directed towards a second stage of treatment such as a settlement pond or similar, prior to being discharged into or towards the watercourses.
- Such features should be designed to accommodate attenuated runoff from the site before discharging to the adjacent watercourse. Ground levels adjacent to the site should be arranged so that any treated water overtopping the feature flows directly towards the watercourse without passing through any part of the site.
- As a rough guidance, storage volumes required for the second level of treatment have been estimated using the Wallingford Procedure. For this a 30 minute duration storm with 1 in 10 year return period was assumed. Volumes are calculated based on surface water runoff from an arbitrary 20 m length of a working (construction) corridor assumed to be 30 m wide (construction working corridor is 20 m but 30 m in places). Assuming access track is about 5 m wide; this would indicate 17% impermeable area. Estimated guide volumes are presented in Table 3 (for guidance only).

Table 3: Estimated storage volumes (for guidance only)

Map Plan	Approximate Storage Required (m^3)/20m
8-9	1.7
10-11	2.4

It should be noted that during storms exceeding the assumed design storm of 10 year, proposed treatment and attenuation measures would be overtopped. Such conditions are considered extreme.

4.6 Outfall locations

- Where possible, treated and clean water drainage will be channelled to various discharge locations
- All outfalls should be constructed in such a way to protect against soil erosion and scour at the inlet and outlet of such features

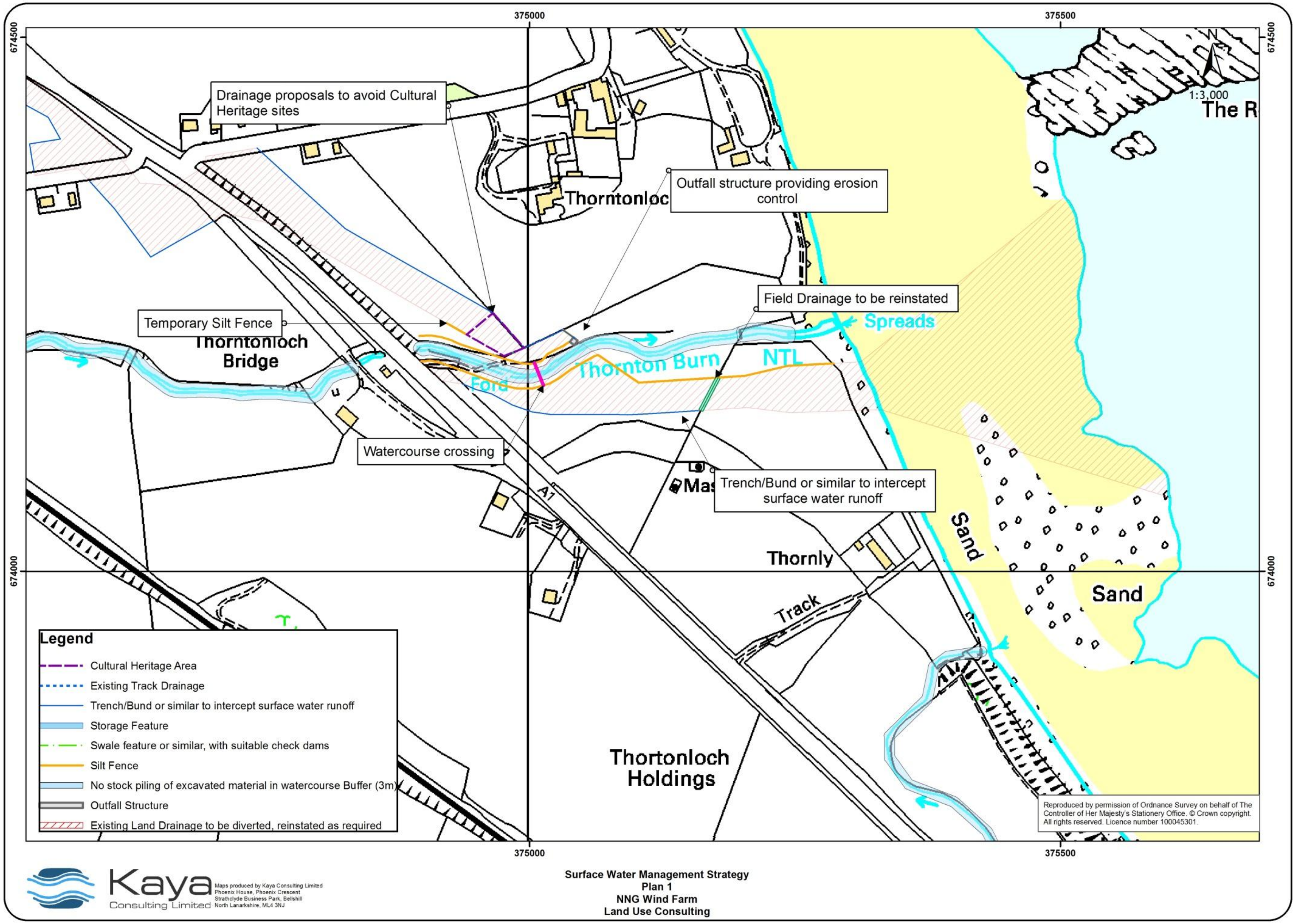
4.7 Crossings

- For major watercourse crossings, it is likely that the cable will be located under the bed of the channel however, most watercourses will be crossed via Open Cut Trenching.
- Where the cable is required to cross smaller drains, measures should be introduced upstream of the crossing to ensure works can be undertaken within a dry channel. Captured flow upstream of the crossing should be redirected through a bypass channel
- The majority of crossing methods have already been chosen however, where the method of crossing has yet to be decided a number of factors will affect the choice including depth of water, available space, duration of works, bed conditions, accessibility and ingress of water
- Authorisation for construction activities within or close to watercourses is managed by SEPA under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (termed CAR). Different levels of authorisation are required for river crossings depending on watercourse conditions and the type/purpose of crossing. In respect of the Onshore Works it is assumed that no CAR licences will be required.

4.8 Silt Fencing and Buffer Zones

- In areas close to natural watercourses and drains, consideration should be given to minimising erosion and run-off from the site. Silt fences should be employed when working close to crossings where the use of swale features is not practical
- Temporary silt fences should also be installed to protect exposed topsoil from within the site
- A buffer zone between the construction boundary and the line of the watercourse should be agreed with SEPA prior to commencement of the works
- All silt fencing close to Birky Bog or the Whittley Strip plantations should be located outside the root protection zones for the adjacent woodlands
- All work should be undertaken using best practice and current guidelines, for example SEPA Pollution Prevention and Environmental Management guidelines.

Appendix A: Outline Drainage Strategy Plans


375000
375500
674500
674000
Drainage proposals to avoid Cultural Heritage sites
Outfall structure providing erosion control
Field Drainage to be reinstated
Temporary Silt Fence
Watercourse crossing
Trench/Bund or similar to intercept surface water runoff
Thorntonloch Bridge
Thorntonloc
Thornton Burn
NTL
Spreads
Ford
A1
Thornly
Track
Sand
Thortonloch Holdings
1:3,000
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
Storage Feature
Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
Outfall Structure
Existing Land Drainage to be diverted, reinstated as required
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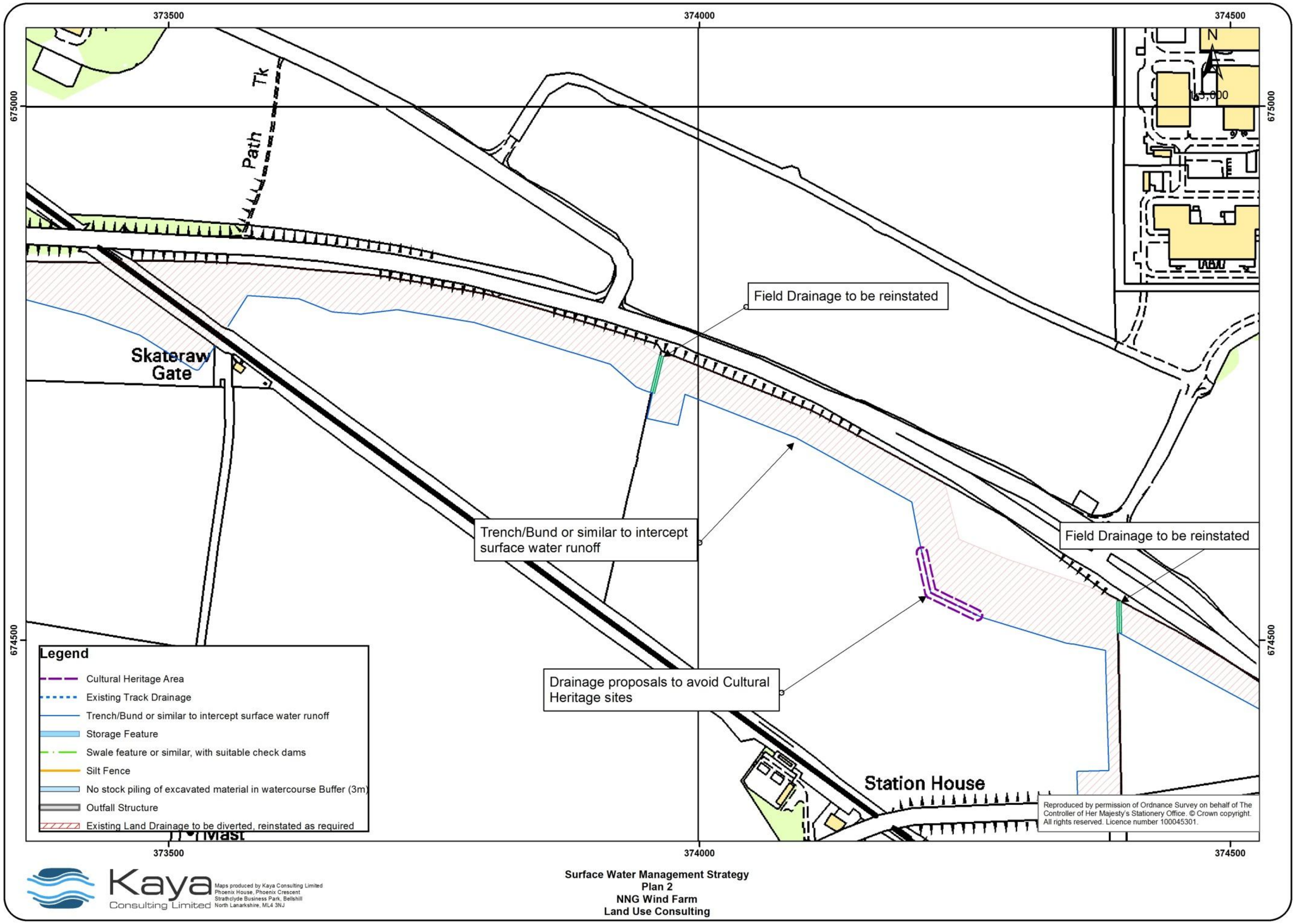
373500
374000
374500
675000
674500
N
Path
Tk
Skateraw Gate
Station House
Mast
Field Drainage to be reinstated
Trench/Bund or similar to intercept surface water runoff
Field Drainage to be reinstated
Drainage proposals to avoid Cultural Heritage sites
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
Storage Feature
Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
Outfall Structure
Existing Land Drainage to be diverted, reinstated as required
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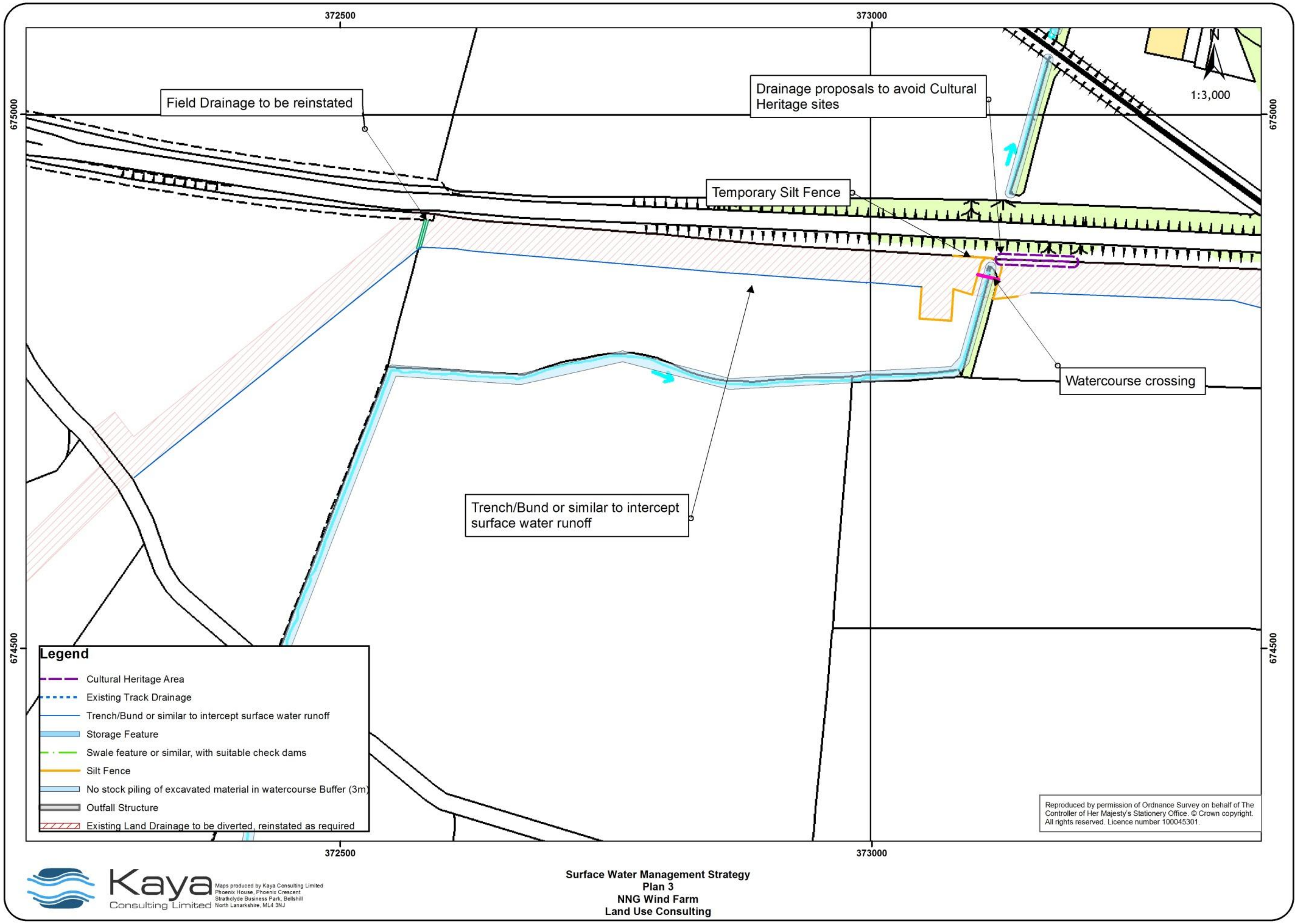

372500
373000
675000
674500
1:3,000
N
Field Drainage to be reinstated
Drainage proposals to avoid Cultural Heritage sites
Temporary Silt Fence
Watercourse crossing
Trench/Bund or similar to intercept surface water runoff
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
Storage Feature
Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
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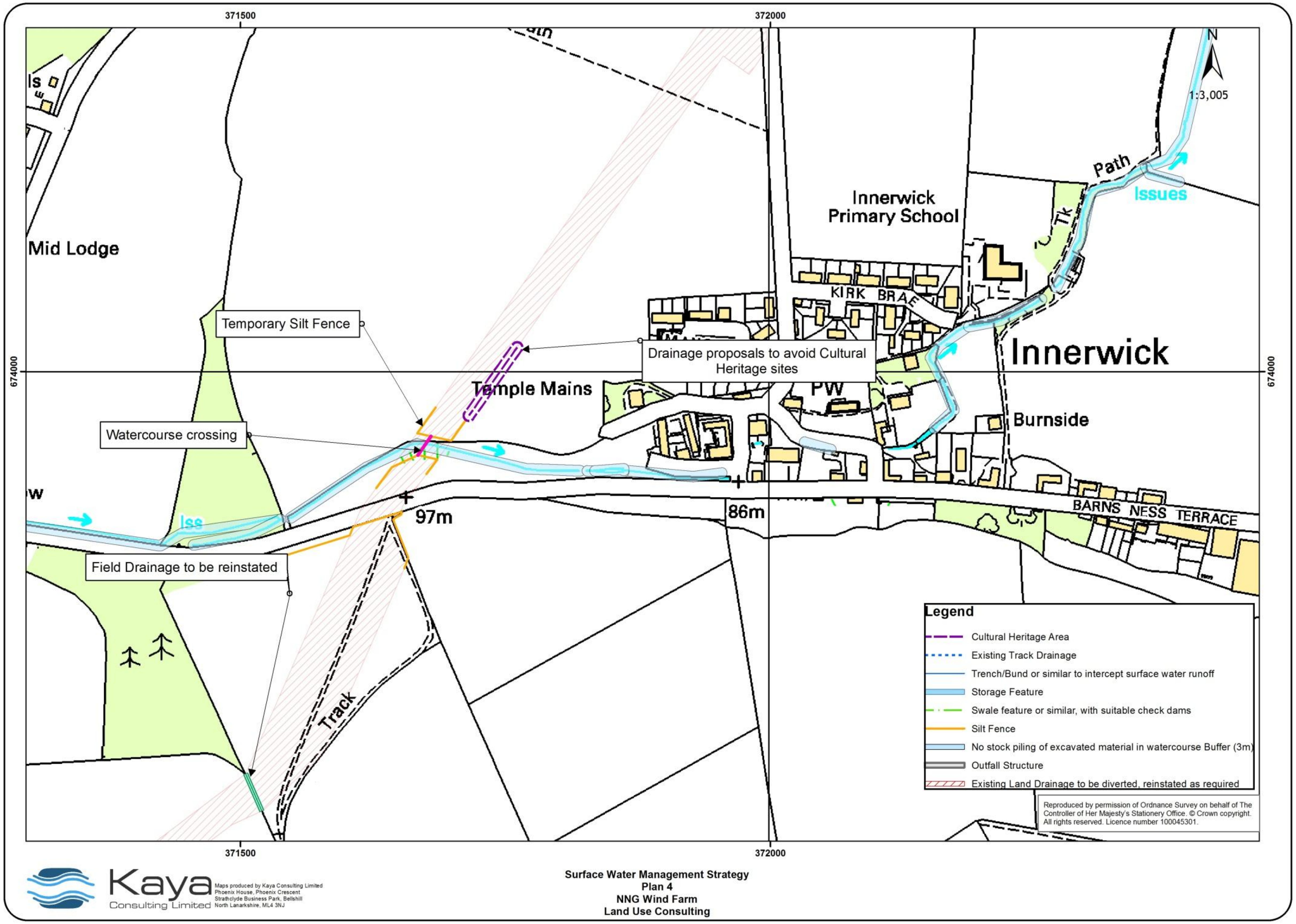

371500
372000
674000
1:3,005
Mid Lodge
Temple Mains
Innerwick Primary School
KIRK BRAE
Innerwick
PW
Burnside
Path
Issues
Iss
Tk
97m
86m
Track
BARNS NESS TERRACE
Temporary Silt Fence
Watercourse crossing
Drainage proposals to avoid Cultural Heritage sites
Field Drainage to be reinstated
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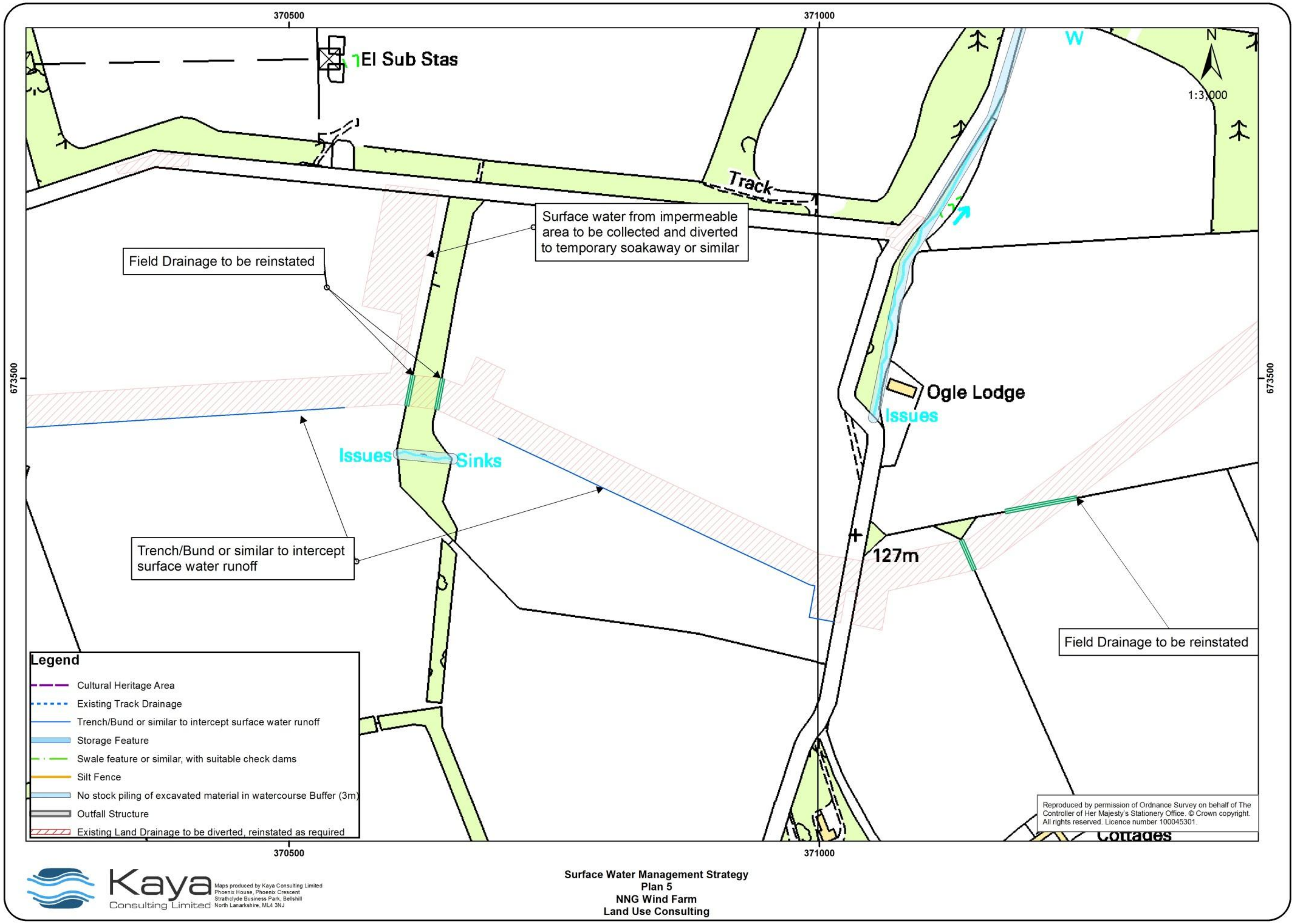

370500
371000
El Sub Stas
Track
W
N
1:3,000
Surface water from impermeable area to be collected and diverted to temporary soakaway or similar
Field Drainage to be reinstated
673500
Ogle Lodge
Issues
Issues
Sinks
Trench/Bund or similar to intercept surface water runoff
127m
Field Drainage to be reinstated
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
Storage Feature
Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
Outfall Structure
Existing Land Drainage to be diverted, reinstated as required
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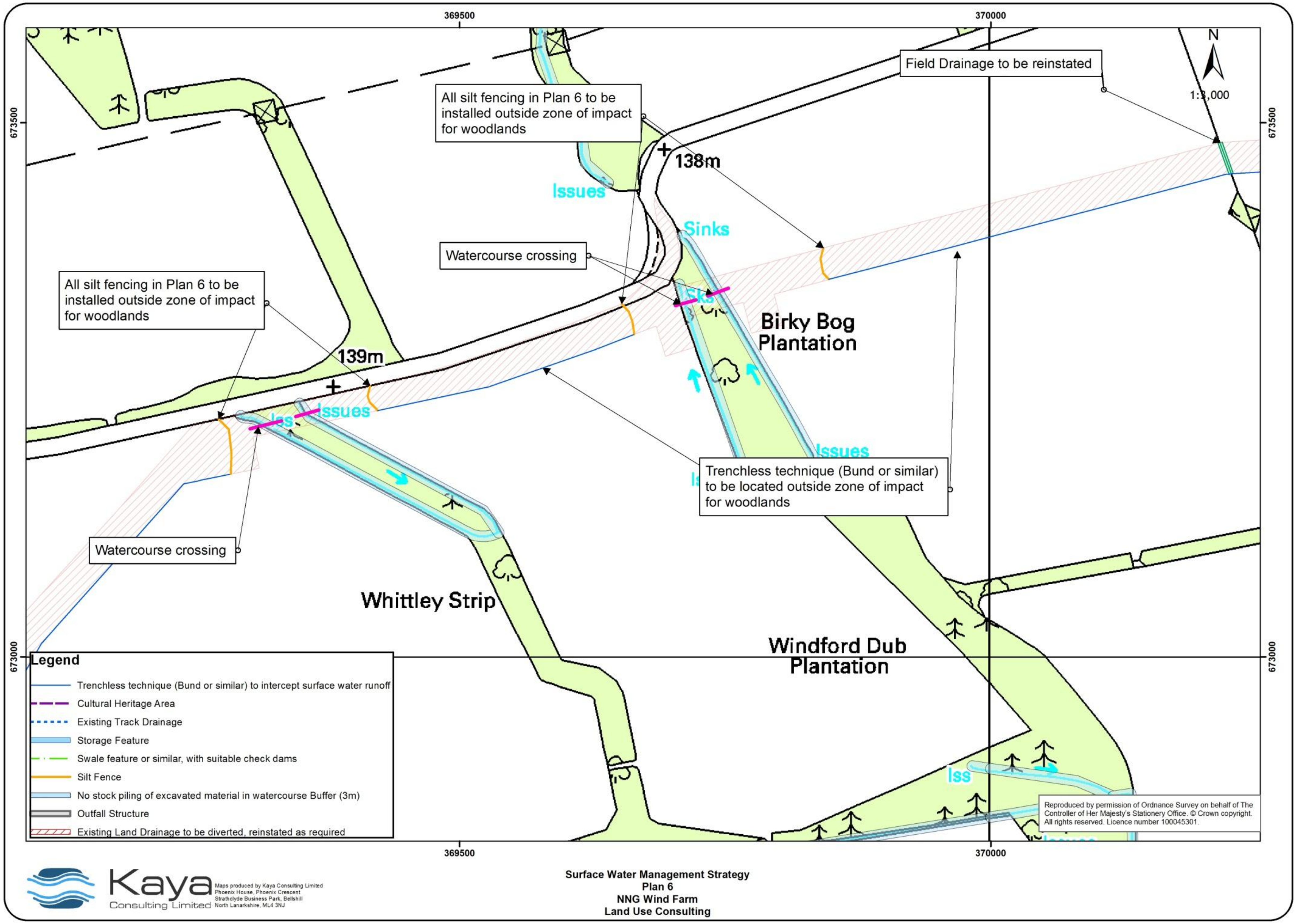

369500
370000
673500
673000
N
1:3,000
Field Drainage to be reinstated
All silt fencing in Plan 6 to be installed outside zone of impact for woodlands
138m
Issues
Sinks
Watercourse crossing
All silt fencing in Plan 6 to be installed outside zone of impact for woodlands
Birky Bog Plantation
139m
Issues
Issues
Trenchless technique (Bund or similar) to be located outside zone of impact for woodlands
Watercourse crossing
Whittley Strip
Windford Dub Plantation
Iss
Legend
Trenchless technique (Bund or similar) to intercept surface water runoff
Cultural Heritage Area
Existing Track Drainage
Storage Feature
Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
Outfall Structure
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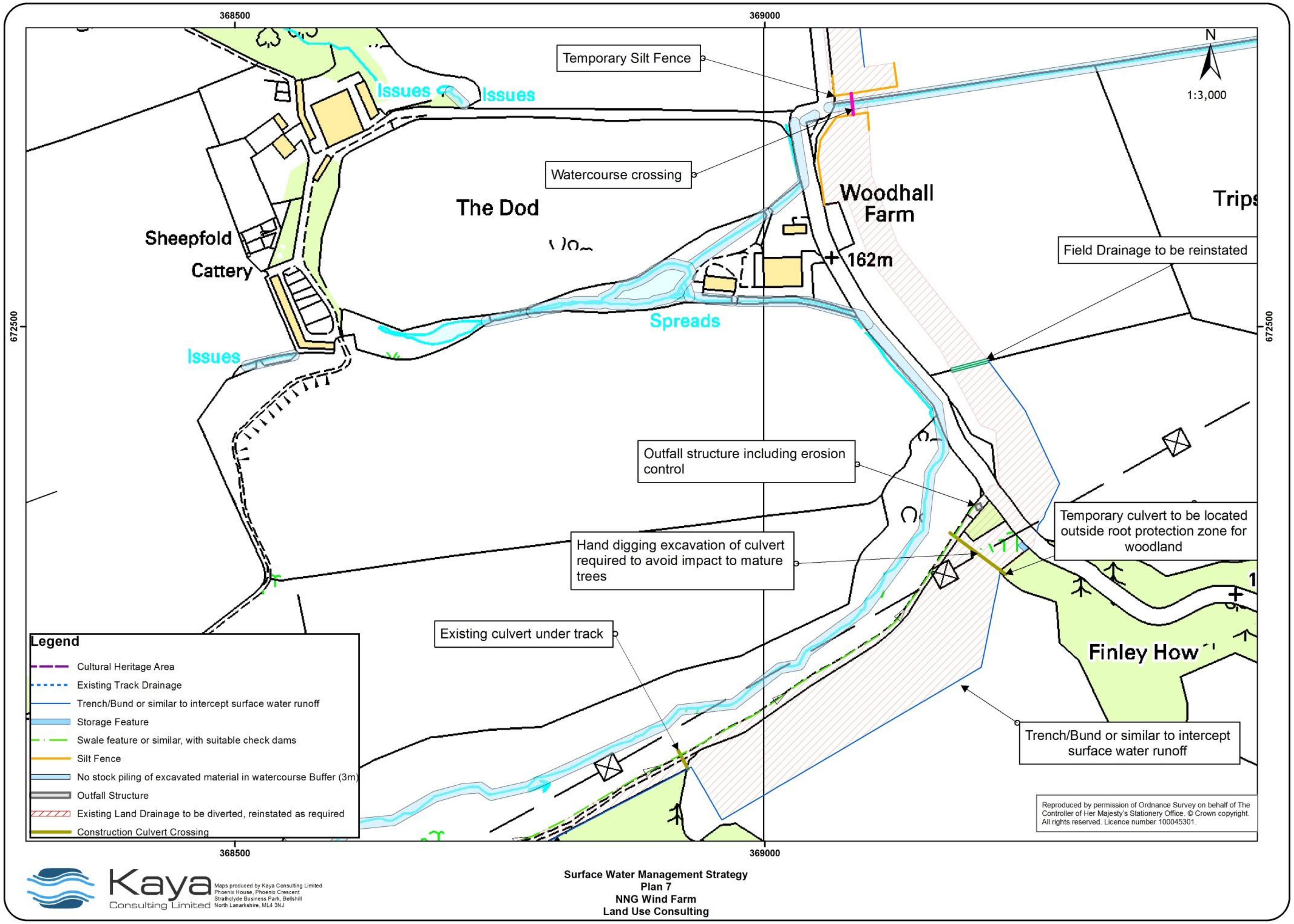
368500
369000
672500
Temporary Silt Fence
Watercourse crossing
Issues
Issues
The Dod
Sheepfold
Cattery
Woodhall
Farm
162m
Trips
Field Drainage to be reinstated
Spreads
Issues
N
1:3,000
Outfall structure including erosion control
Temporary culvert to be located outside root protection zone for woodland
Hand digging excavation of culvert required to avoid impact to mature trees
Existing culvert under track
Finley How
Trench/Bund or similar to intercept surface water runoff
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
Storage Feature
Swale feature or similar, with suitable check dams
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Construction Culvert Crossing
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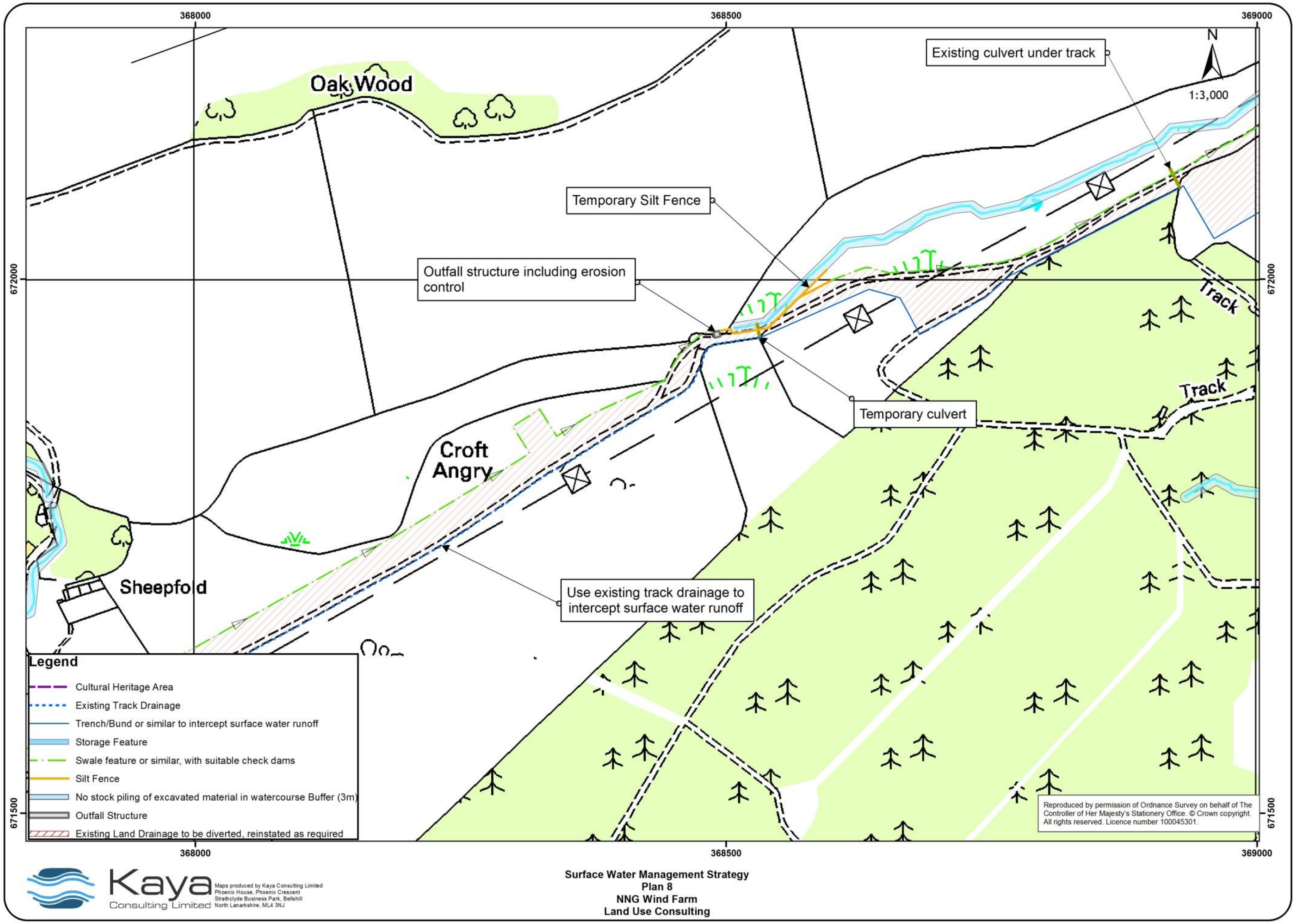
368000
368500
369000
672000
671500
N
1:3,000
Oak Wood
Existing culvert under track
Temporary Silt Fence
Outfall structure including erosion control
Temporary culvert
Track
Track
Croft Angry
Sheepfold
Use existing track drainage to intercept surface water runoff
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
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Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
Outfall Structure
Existing Land Drainage to be diverted, reinstated as required
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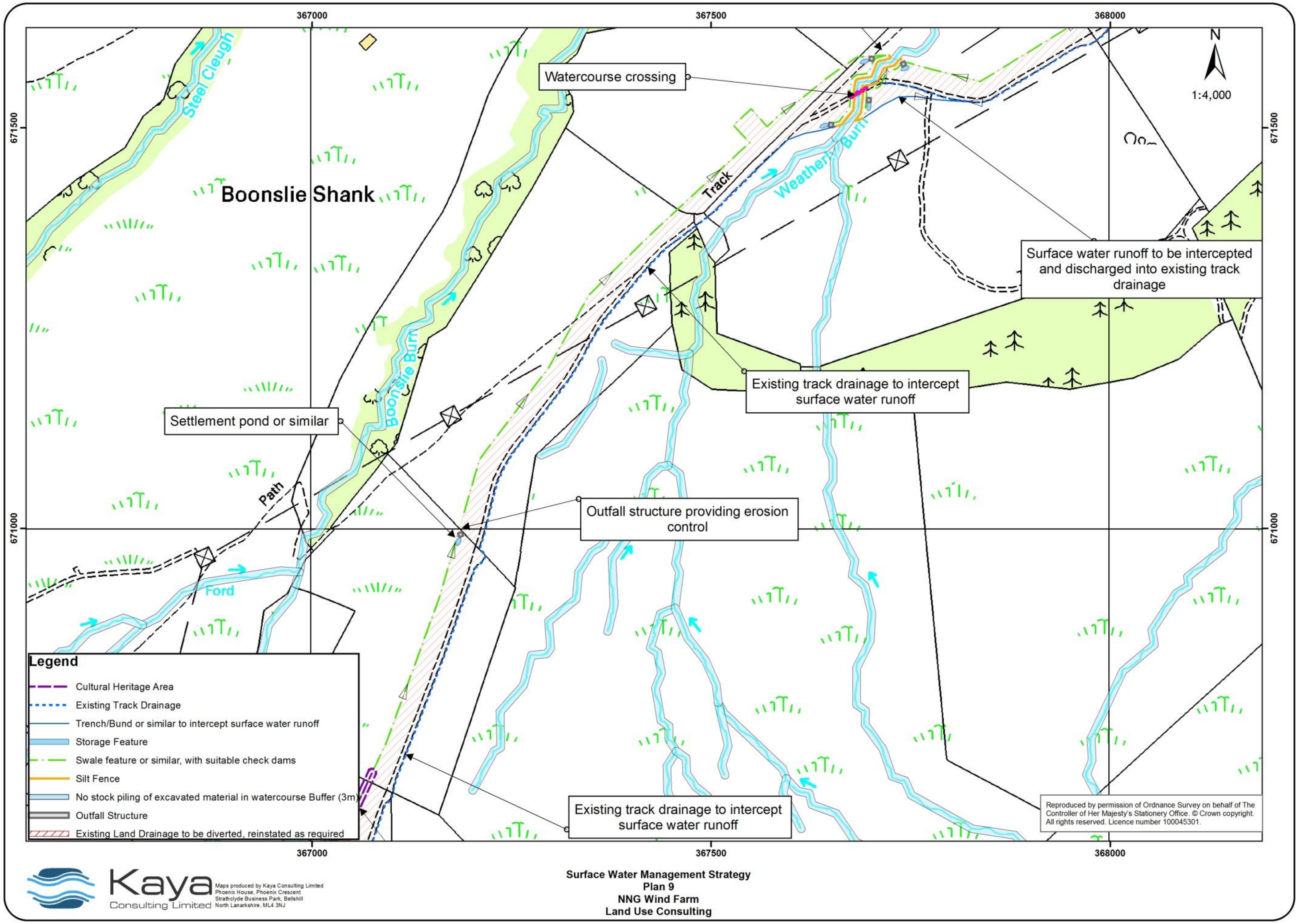
Surface Water Management Strategy
Plan 8
NNG Wind Farm
Land Use Consulting



367000
367500
368000
671500
671000
N
1:4,000
Watercourse crossing
Steel Cleugh
Boonslie Shank
Boonslie Burn
Track
Weatherly Burn
Surface water runoff to be intercepted and discharged into existing track drainage
Existing track drainage to intercept surface water runoff
Settlement pond or similar
Path
Outfall structure providing erosion control
Ford
Existing track drainage to intercept surface water runoff
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
Storage Feature
Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
Outfall Structure
Existing Land Drainage to be diverted, reinstated as required
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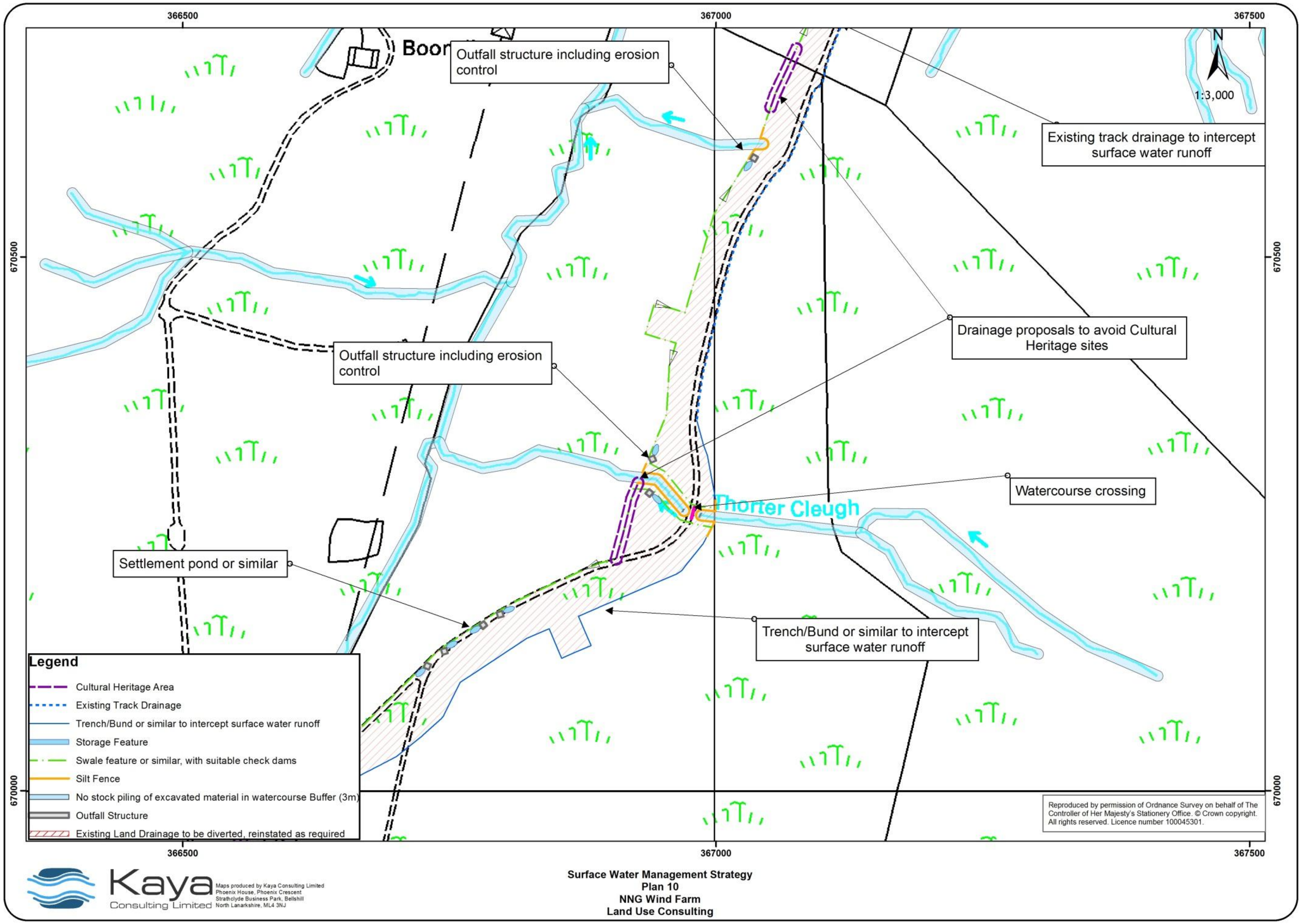
366500
367000
367500
670500
670000
N
1:3,000
Boor
Outfall structure including erosion control
Existing track drainage to intercept surface water runoff
Drainage proposals to avoid Cultural Heritage sites
Outfall structure including erosion control
Watercourse crossing
Thorter Cleugh
Settlement pond or similar
Trench/Bund or similar to intercept surface water runoff
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
Storage Feature
Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
Outfall Structure
Existing Land Drainage to be diverted, reinstated as required
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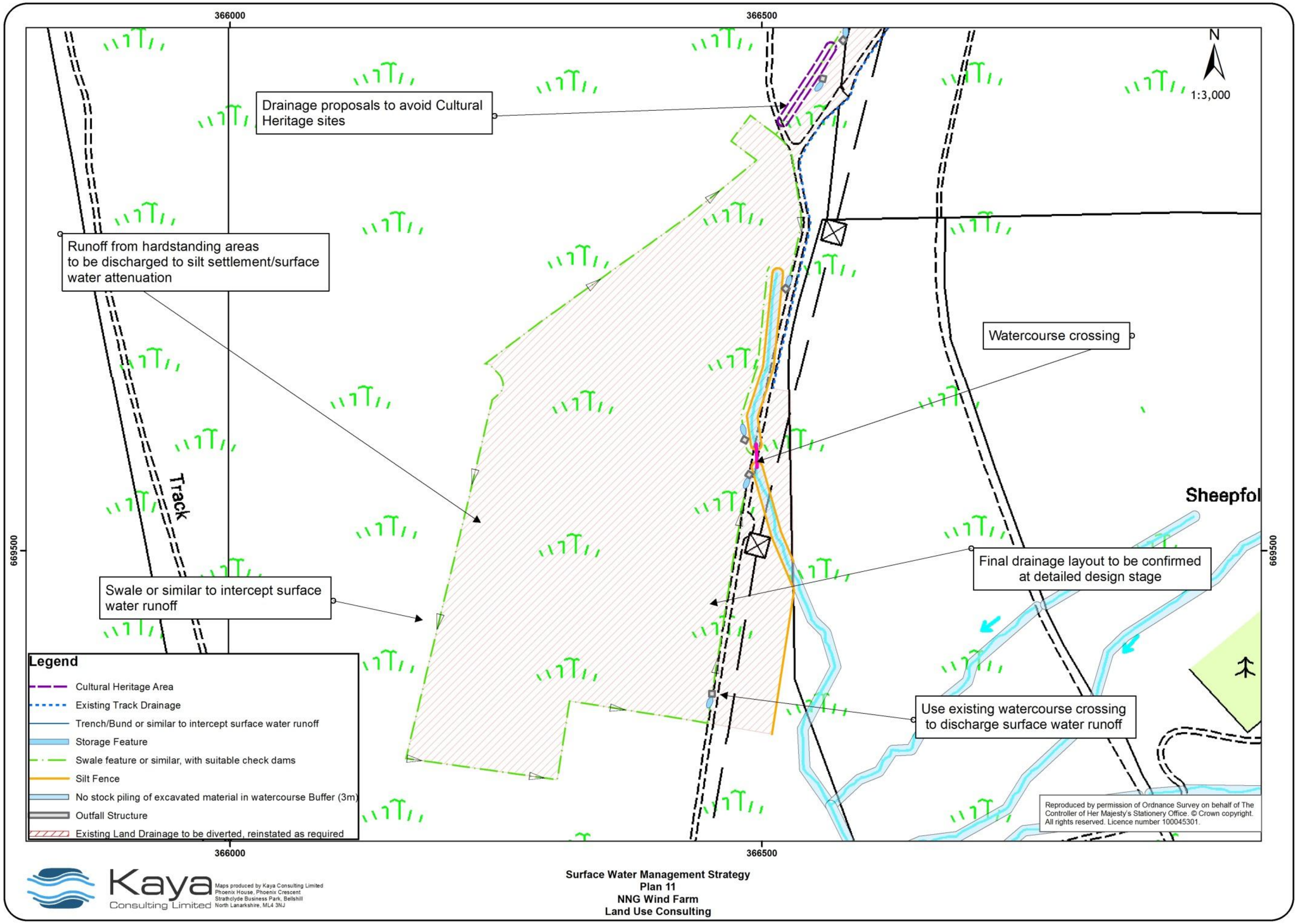

366000
366500
N
1:3,000
Drainage proposals to avoid Cultural Heritage sites
Runoff from hardstanding areas to be discharged to silt settlement/surface water attenuation
Watercourse crossing
Track
Sheepfol
Final drainage layout to be confirmed at detailed design stage
Swale or similar to intercept surface water runoff
669500
Use existing watercourse crossing to discharge surface water runoff
Legend
Cultural Heritage Area
Existing Track Drainage
Trench/Bund or similar to intercept surface water runoff
Storage Feature
Swale feature or similar, with suitable check dams
Silt Fence
No stock piling of excavated material in watercourse Buffer (3m)
Outfall Structure
Existing Land Drainage to be diverted, reinstated as required
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Appendix B: Institute of Hydrology Equation and Calculations (Map Plan 1-3)

This spreadsheet calculates return period peak flow values based on the IH124 Rural Methodolog

Equation;

$$Q_{bar} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$$

where

AREA	Catchment Area in km^2	
SAAR	Standard Annual Average Rainfall in mm	Typically obtained from FEH CD-Rom
SOIL	Soil Type	See Worksheet 'Soil' for Map

The value of Qbar can be converted to return period flows using relevant Growth Factors
The values to be used are based on Regional Growth Curves presented in FSR and summarised in Worksheet 'Growth Factors'

Parameters

AREA	1	km^2
SAAR	624	mm
SOIL	0.15	
Region for Growth Curve	2	
Urban Correction	1.00	

	Proportion of soil type
Type 1 (ISOIL1)	1
Type 2 (ISOIL2)	0
Type 3 (ISOIL3)	0
Type 4 (ISOIL4)	0
Type 5 (ISOIL5)	0

For Urban

NC	0.77
CWI	118
CIND	13.4
URBANEX	0
URBAN	0

Results

Note: If the catchment area < 0.5 km^2, Qbar is estimated assuming the area = 0.5 km^2, then the value of Qbar is scaled by area/0.5

Return Period	Growth Factor	*Flow (m^3/s)*	l/s/ha
Qbar - RURAL	-	*0.03*	0.3
Qbar - URBAN		*0.03*	0.3
2	0.91	*0.03*	0.3