APPENDIX D

Hydrology Study for a Proposed 100MW Wind Energy Project, Kajiado District, Kenya

Report Prepared for

Kipeto Energy Limited

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Prepared for:

Kipeto Energy Limited

14 Riverside, Riverside Drive, Westlands

P. O. Box 8366 – 00200

Nairobi, Kenya

Prepared by:

Eliud Wamwangi, Reg. Geologist
P. O. Box 667 – 00517
NAIROBI

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Compiled by:

Mr. Eliud Wamwangi

Registered Geologist

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

This report is the environmental impact of the proposed wind farm development on the hydrological regime at the proposed project site in Kipeto area of Kajiado County. It aims at assessing sensitivity of the baseline hydrological environment and the potential impacts of the proposed development upon it and proposes mitigation measures in order to ensure that the potential adverse impacts of the proposed wind farm development on the hydrological environment will be slight and neutral.

The proposed wind farm will consist of turbines, substations, anemometer masts, underground cabling and access tracks. The subject site is Kipeto and is currently inhabited by Maasai pastoralists who use the fields for grazing their cattle. The area is mainly covered by grass and shrubs with occasional rocky outcrops projecting onto the surface cover. The soils cover is thin and comprises of rocky surfaces in some places.

The potential impacts on the surface water environment from the proposed wind farm development, in the absence of suitable mitigation measures, are considered to be as follows:

- Direct impacts of the wind farm construction on the hydrological environment for example contamination of surface water (if encountered in excavations) from the spillage/leakage of fuels from vehicles and fuel/chemical/waste storage areas.
- Direct impacts from excavated areas where vegetation has been removed through release of silt laden surface water runoff into local watercourses due to soil erosion and increased volumes of surface water runoff.
- Direct impacts of wind farm operation on the hydrology for example, surface water contamination from minor leakage of oil from maintenance vehicles used on the site and oil storage at the switch room.

2 METHODOLOGY FOR THE STUDY

2.1 Baseline hydrological environment

The description of the baseline hydrological environment at the subject site and in the surrounding area was by means of a desktop study. This was supplemented by a site walkover by the hydrologist to site.

Relevant desktop studies were undertaken to aid in understanding the underlying hydrology of Kipeto area. Supporting information relating to the proposed development was collected for purposes of understanding the wind farm project and to relate development to hydrological characteristics inherent in the area in order to:-

- Assess the sensitivity of the baseline hydrological environment at the subject site and in the surrounding area with respect to the proposed wind farm development.
- Identify any potential impacts on the hydrological environment associated with the proposed development.
- Identify any constraints posed by the existing hydrological environment to the proposed development and to;
- Recommend appropriate mitigation measures in order to ensure that the potential impact of the proposed wind farm is slight and neutral.

2.2 Field Survey Methodology

In order to inform the hydrological impact assessment, a site walkover was carried out by the hydrologist to record observations and features of significance in the project area.

2.2.1 Significance Criteria

Relevant documentation gathered from diverse sources categorize impact into five (5) categories to aid in assessing the potential impacts of the proposed development on the hydrological environment in terms of how significant an impact may be on the overall environment as follows:-

Imperceptible Impact: An impact capable of measurement but without noticeable consequences.

Slight Impact: An impact which causes noticeable changes in the character of the environment without affecting its sensitivities.

Moderate: An impact that alters the character of the environment in a manner that is consistent with existing and emerging trends.

Significant Impact: An impact which, by its character, magnitude, duration or intensity alters a sensitive aspect of the environment.

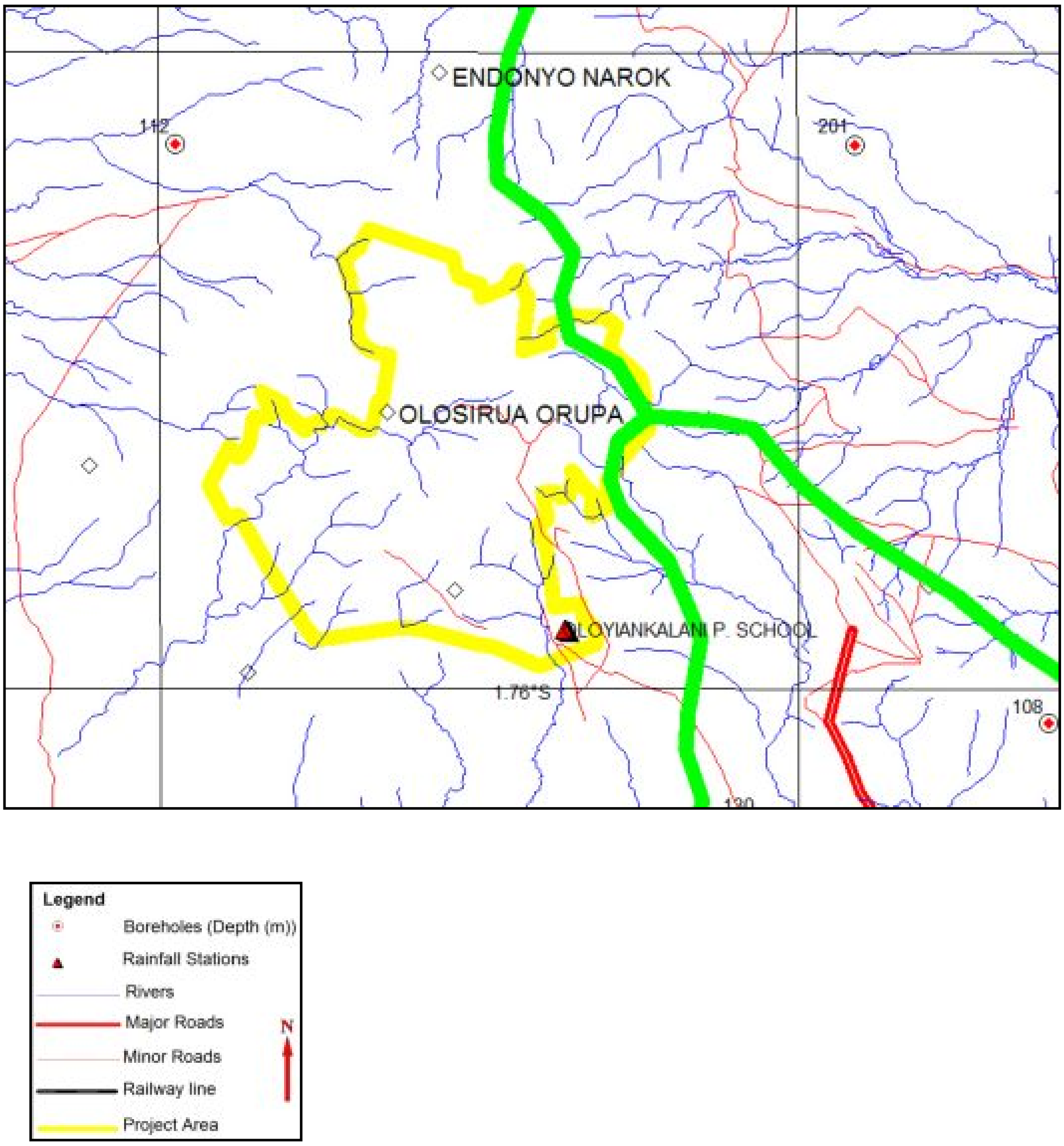
Profound Impact: An impact which obliterates sensitive characteristics.

In this regard, the assessment of the potential impact of the proposed wind farm development on the hydrological environment was carried out according to the criteria and methodology outlined above while being informed by provisions of appropriate Acts such as the Water Act 2002 and Environment Management and Coordination Act 1999 (EMCA) together with prescribed regulations namely Water resource Management Authority (WRMA) Rules and Guidelines, Athi Catchment Management Strategy among others.

3 BASELINE STUDY OF THE HYDROLOGY

The drainage system in the project area can be described as dendritic (see Figure 1 below) consisting of gently sloping valleys from surrounding undulating hills common in Kipeto area of Kajiado County. The slope of land at the proposed turbine locations, anemometer mast and substation seems to be relatively flat to moderately gentle. Hence surface runoff in the project vicinity will consist of mainly overland flow.

Figure 1: Drainage System in Kipeto and Neighboring area



Resulting from observations of local topography, site geology and weather conditions, no noticeable perennial streams could be seen at site. There are however a few water holes at low lying depressions that serve the local population and their livestock.

In addition, there were signs of localized minor flooding at valley bottoms as noted from signs of sand deposition which could only occur due to impeded drainage of excess overland runoff from heavy storms that fall at nearby high ground areas. It is important that the discharge of such flood waters is carefully managed in order to minimize water logging. Water logging may drown some of access tracks and other important installations thereby affecting efficient operation of the facility.

There are no signs of surface water runoff management facilities except for minor impounding works aimed at harvesting storm water for pastoral use. Average annual rainfall is about 700mm. The rainfall season is from March to May and November to December which is governed by the seasonal movement of the Inter-Tropical Convergence Zone (ITCZ). Heavier rainfall occurs between March to May and lighter rainfall in November and December, the so called long rains and short rains respectively. The months in between are hot, dry and windy.

4 POTENTIAL IMPACTS ON THE HYDROLOGY

Major modifications at site for the development of the wind energy facility include excavations of surface, compacting and paving of the land surface with the associated removal of vegetative cover and installation of wind energy facility structures within the precincts of Kipeto area. The proposed wind farm structures include but not limited to turbines, a sub-station, anemometer masts, underground cabling and access tracks. Development of the same has marked influence on the hydrological response for the area in terms of increased runoff, siltation, and risk of water pollution.

Accordingly, this development will involve the following:

- Removal of part of the existing surface vegetation cover and replacement with areas of hard standing, which will increase the amount of surface water runoff to some extent.
- The installation of a drainage system at the location of the proposed turbines and along the access tracks.
- The construction of foundations for each of the turbines, which are unlikely to intercept the underlying bedrock aquifer.
- The construction of the switch room with an associated small oil storage area.

To this end, the assessment of impacts on water is divided into two main phases namely Construction Phase, Commissioning Phase and Operational Phase. The potential impacts associated with the construction phase of the proposed development on the hydrological environment are outlined in the following sections.

5 IMPACT ASSESSMENT ON THE HYDROLOGY

5.1 Criteria for hydrology impact assessment

The potential impacts associated with the proposed development have been assessed using the criteria provided below (Fig 1 and Fig. 2).

Figure 1 Criteria for assessing significance of Impacts

CONSEQUENCE

Magnitude of impact	Rating
Negligible	1
Minor	2
Marginal	3
Significant	4
Catastrophic	5

Geographic Extent of impact	Rating
Activity specific	1
Project specific	2
Local area	3
Regional	4
National	5

Duration of impact	Rating
<1 month	1
1 - 12 months	2
13 - 36 months	3
37 - 72 months	4
>72 months	5

LIKELIHOOD

Frequency/duration of activity	Rating
Annually or less	1
6 monthly/temporary	2
Monthly/infrequent	3
Weekly/life of the operation	4
Daily/permanent	5

Frequency of impact	Rating
Almost impossible	1
Highly unlikely	2
Unlikely	3
Possible	4
Definite	5

Definitions	
Activity:	Distinct process or task undertaken by an organization for which a responsibility can be assigned
Frequency of activity:	Refers to how often the proposed activity will take place
Frequency of impact:	Refers to the frequency with which a stressor (aspect) will impact on the receptor
Magnitude of impact:	Refers to the degree of change to the receptor status in terms of reversibility of the impact
Geographic extent of impact:	Refers to the geographical scale of the impact
Impact duration:	Refers to the length of time over which the stressor will cause a change in the resource or receptor

Figure 2: Significance Ranking Matrix

SIGNIFICANCE

	CONSEQUENCE (Magnitude+Geographic Extent+Duration of impact)														
LIKELIHOOD (Frequency of activity + Frequency of impact)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

POSITIVE/NEGATIVE MITIGATION RATINGS

Significance Rating	Value	Negative impact management recommendation		Positive impact management recommendation
Very High	126-150		Propose mitigation measures	Maintain current management
High	101-125		Propose mitigation measures	Maintain current management
Medium - High	76-100		Propose mitigation measures	Maintain current management
Low - Medium	51-75		Maintain current management	Propose mitigation measures
Low	26-50		Maintain current management	Propose mitigation measures
Very Low	1-25		Maintain current management	Propose mitigation measures

5.2 Predicted Impacts – Construction Phase

During construction there is the potential for increased surface water runoff due to the introduction of impermeable surfaces such as site compounds and roads, and the compaction of soils. This will reduce the overall infiltration capacity of the subject site and increase the rate and volume of direct surface runoff.

The potential environmental impact of this is to increase flow rates, leading to increases in channel erosion, sediment loading reaching watercourses and downstream flood risk. Road crossings, on the other hand, have the potential to locally affect flows and increase erosion.

The open drains along the access tracks will act as preferential flow paths for surface water runoff on the subject site and in the surrounding area. This has a positive impact in that it prevents surface water ponding and land slippage.

In this regard, therefore, the construction phase comprises the following key activities that may have potential adverse impacts on both surface water and groundwater environment, if not appropriately managed:

- Clearance of the surface vegetation cover and the excavation of soils (and possibly gravels and bedrock) during site preparation works, which has the potential to increase surface water runoff and encourage the generation of silt laden surface water.
- Excavation and stockpiling of material at the location of proposed structures and access tracks.
- The pouring of concrete and reinforcing of foundations for the turbines, switch room and crane pads.
- The construction of new access tracks.
- Watercourse crossings.
- Laying of cable ducts.
- The construction of site compounds.
- Oil, fuel, site vehicle and waste storage areas.
- Hanging of gates and constructing fences.

(a) Increased surface water runoff

Increased surface water runoff to some extent will come about because of the following activities:

- Removal of some of the surface vegetation covers to facilitate construction of the compound, access tracks and wind turbines. This activity has potential to reduce infiltration of water into the underlying groundmass and encourage overland flow.
- Compaction of the upper soil layer by heavy machinery further reduces infiltration into the ground.

These impacts are direct, short term, negative and moderate. Increased runoff has potential for increased erosive power on stream/river bed and sediment generation.

(b) Onsite generation of silt laden surface water runoff

During construction there is potential for generation of silt laden runoff due to:

- Removal of the surface vegetation cover and soil stripping to construct roads, temporary crane hard standings, sub-surface cabling, site compounds, turbine foundations and other infrastructure;
- Washed solids especially during heavy storms from excavations, handling, movement and storage of topsoil, subsoil and rocks.
- Dewatering excavations thereby increasing flow rate and consequent increased flooding downstream in receiving waters and drains.

The above potential impacts are considered indirect, short term, negative and moderate. The discharge of silt laden surface water runoff alters the physiochemical composition of receiving waters and may affect both flora and fauna.

(c) Risk of accidental spills and pollution

During construction, there is always the inherent risk of accidental spills and water pollution resulting from the following:

- Spillage or leakage of oils and fuels from chemical and waste storage areas, construction machinery and vehicles, refueling of machinery and vehicles onsite.
- Spillage or leakage from on-site toilet facilities.
- The use of concrete and cement in the construction of turbine foundations. Cement is highly alkaline, any spillage into the surrounding streams/drains changes water quality of receiving waters.

The above potential impacts are considered direct, short term, negative and significant.

5.3 Predicted Impacts - Operational Phase

The operation of the proposed wind farm development is not expected to have a notable impact on the underlying hydrological environment during normal operating conditions. Some of the activities occurring during the operation phase comprise the following:-

(a) Routine Inspection and maintenance visits

During routine inspection and maintenance visits there is likelihood of minor localized contamination in surface water runoff in the unusual event of the leakage of oil/fuel from site maintenance vehicles. In addition, silt laden runoff may be generated from vehicle using project access tracks during such visits. However, these may be considered to be a direct, negative, short term and moderate impacts.

(b) Potential for Oil Spills/Leakage

There is likelihood for leakage of oil/spills from oil storage facilities into the surroundings areas which may subsequently impact surface water of receiving water courses.

5.4 Predicted Impacts - Decommissioning Phase

The potential impacts on the surface water environment during the decommissioning phase will be similar to those described for construction phase.

Consequently the same mitigation, environmental management and monitoring measures will be adopted, subject to advances in approach at the time of decommissioning. If the measures are put in place, there will be a short-term, slight neutral impact on the water environment during the decommissioning phase.

5.5 Summary of Significance of Impacts

The excavation works on site will loosen the soil and make it susceptible to erosion through silt laden runoff during the rainy season and by wind during the dry season. A large amount of excavation will take place during the construction phase of the project due to the large number of turbines to be constructed, the extensive cabling network, and the access tracks to each turbine. This excavated material could end up in the ephemeral streams in the area if proper drainage mechanisms are not put in place.

Accidental spills or leakage of oil/petroleum products could end up into the drainage channels and finally into other water surface bodies if mitigation measures are not put in place.

Construction phase

Unmitigated Impact: Soil erosion and silt laden runoff washing into water bodies	
Magnitude of Impact	4
Geographic extent	3
Duration of impact	2
Frequency of activity	2
Frequency of impact	5
Result	Low to medium (-63)
Comment/mitigation	
Excavation stockpiles will be managed in order to minimize potential for generation of silt laden runoff. Directing surface water runoff from excavated areas to settlement/silt ponds to remove suspended solids prior to discharge to nearby watercourses. Excavations to remain open for very short time before placement of fill to minimize potential for entry of surface water runoff into excavations. Directing surface water runoff away from and around access tracks by implementing a suitably designed drainage system to minimize potential for landslides along the access tracks. Watercourse crossings to comprise culverts of suitable design.	
Mitigated impact: Soil erosion and silt laden runoff washing into water bodies	
Magnitude of Impact	2

Geographic extent	2
Duration of impact	1
Frequency of activity	1
Frequency of impact	3
Result	Very low (-20)

Unmitigated Impact: Contamination of surface water	
Magnitude of Impact	4
Geographic extent	3
Duration of impact	4
Frequency of activity	2
Frequency of impact	4
Result	Low to medium (-66)
Comment/mitigation	
Incorporation of acceptable equipment to arrest oils/fuels arising from accidental spills and/leaks to stop leakage towards surrounding water courses. Regular inspection of dewatering drains to ensure that they work efficiently. Storage of chemicals and hydro-carbon products in bunded areas of sufficient capacity. Refueling only in designated areas under strict protocol.	
Mitigated impact: Contamination of surface water	
Magnitude of Impact	3
Geographic extent	2
Duration of impact	2
Frequency of activity	2
Frequency of impact	2
Result	Low (-28)

6 MITIGATION MEASURES

6.1 Proposed Mitigation Measures – Construction Phase

This section outlines proposals for mitigation measures aimed at ensuring that the construction of the proposed wind farm development does not result in noticeable or significant negative impact on the hydrological environment. The measures should be implemented before, during and after the construction phase.

These measures include but are not limited to the following:-

- Obtaining requisite Permits for Works from Water Resource Management Authority (WRMA) and NEMA.
- In relation to watercourse crossings WRMA approval should be sought for all in-stream structures and bridge crossing including any diversions and a Permit issued for the same. Similarly for discharge of any material NEMA/WRMA approval and Permit should be sought before commencement of works.
- Management of stockpiles to minimize potential for generation of silt laden runoff and the subsequent adverse impact on water quality in surrounding water bodies.
- Directing surface water runoff from excavated areas to settlement/silt ponds to remove suspended solids prior to discharge to nearby watercourses.
- Allowing sufficient retention time in such ponds to enable suspended solids to settle from the surface water collected in the silt pond thereby minimizing potential for release of silt laden surface water into surrounding drains.
- Attenuation of release of surface water runoff from construction site to ensure that it does not result in localized flooding further downstream.

Installation of underground cable runs alongside access tracks to minimize ground disturbance to reduce sediment wash out. These cables connect turbines to transformer/substation for electricity generation.

- When excavating, the trenches need to be open for the shortest practicable time to minimize potential for the generation of silt laden surface water runoff.
- Incorporation of acceptable equipment to arrest oils/fuels arising from accidental spills and/leaks to stop leakage towards surrounding water courses.
- Excavations to remain open for very short time before placement of fill to minimize potential for entry of surface water runoff into excavations.
- Regular inspection of dewatering drains to ensure that they work efficiently.
- Directing surface water runoff away from and around access tracks by implementing a suitably designed drainage system to minimize potential for landslides along the access tracks. Watercourse crossings to comprise culverts of suitable design.

Avoid physical pollution of watercourses in terms of dumping of unsuitable gravel material or other construction debris in or stockpiling such materials near watercourses. This requires special permits from WRMA.

6.2 Proposed Mitigation Measures - Operational Phase

It is recommended that the following measures are implemented before, during and after the operational phase:-

(a) Maintenance of Project Vehicles

Project vehicles have to be maintained to serviceable standards through routine maintenance, inspection and cleaning to safeguard against oil/fuel and spills and leaks.

(b) Construction and Maintenance of Access Tracks

Access tracks used by project vehicles have to be constructed in such a way as to minimize generation of silt laden surface water runoff. Drainage systems of access tracks must be designed with sufficient capacity to accommodate the volume of surface water runoff and be able to attenuate the same to avoid water logging and flooding downstream. Regular maintenance of culverts to avoid localized flooding due to blockages by leaves, sediment and silt.

Implementation of these mitigation measures during the operational phase will result in long-term, slight and neutral impact on the hydrological environment.

6.3 Mitigation Measures - Decommissioning Phase

It is noted that the potential impacts on the surface water environment during the decommissioning phase will be similar to those described for construction phase.

Consequently the same mitigation, environmental management and monitoring measures will be adopted, subject to advances in approach at the time of decommissioning. If the measures are put in place, there will be a short-term, slight neutral impact on the water environment during the decommissioning phase.

7 ENVIRONMENT MANAGEMENT PLAN

The purpose of an EMP is to ensure that social and environmental impacts, risks and liabilities identified during the EIA process are effectively managed during the construction and operation phase of the project. The EMP specifies the mitigation and management measures to which the proponent is committed, and shows how the organizational capacity and resources to implement these measures will be mobilized. The EMP also shows how mitigation and management measures will be scheduled.

The EMP for the hydrology will therefore be a part of the whole project EMP dealing with all the environmental components of the Wind Farm Project. The EMP will highlight the sequence of environmental audit by a qualified person to ensure implementation and compliance of all the mitigation measures recommended in the final Environmental Impact Assessment (EIA) Study report. Other important aspects of the EMP will be the monitoring of the hydrological environment during the construction, operational and decommissioning phases. This activity will be required to adhere to existing legal provisions as spelt out in the EMCA, Water Act 2002 and relevant Rules and Regulations to safeguard national integrity, environmental concerns and security. This will entail monitoring water volumes, quality, as well as flora and fauna.

8 CONCLUSION

The descriptions above have highlighted the possible impacts of wind farm development to the overall hydrological environment of Kipeto area of Kajiado County. Mitigation measures have been prescribed for each of the wind farm development phases during implementation which need implementation in order to minimize adverse impacts of the development to hydrological environment.

Further, it is a requirement that all development must strictly adhere to institutional legal frameworks that are in place. In this regard, requisite approvals and permits for development must be obtained from National Environment Management Authority (NEMA) and Water Resources Management Authority (WRMA) as well as from other key stakeholders before commencement of works.

Works that require Permits and Approval such as water abstractions, stream quality standards, effluent discharge, permanent and temporary river crossing works must be guided and informed by relevant legal provisions. These are spelt out in the Water Act 2002 and specific Athi - Catchment Management Strategy (Athi – CMS), WRMA Rules and EMCA respectively.

Additionally, it is important to state that arising from the above findings; it is recommended as follows:-

- That construction of access tracks should be such that the construction process should minimize the potential for soil erosion via surface water runoff and should entail minimum excavation and disturbance of the underlying soils, which will reduce the potential for soil erosion via surface water runoff.
- That such access track incorporate open drainage channels alongside to facilitate surface water flow around and away from the track in order to minimize potential for water logging and land slippage around the track.
- That earthwork is kept to a minimum to reduce potential for the generation of silt laden surface water runoff.

Following the implementation of the mitigation measures recommended above, the potential impact on the hydrological environment may be considered to be of short term, imperceptible to slight impact and minimal according to the criteria spelt out in Section 3.1 of this report.