A83 Rest and Be Thankful

LTS EIAR VOLUME 4, APPENDIX 12.4 - CUTTINGS ASSESSMENT

Transport Scotland

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A12-4.Cuttings Assessment

A12-4.1. Introduction

A12-4.1.1. This assessment considers the impact of the cuttings associated with the Proposed Scheme on groundwater aquifers and groundwater dependent receptors, including private water supplies, Groundwater Dependent Terrestrial Ecosystems (GWDTEs) and surface waters.

A12-4.1.2. The primary mechanism of impact is through the excavation of road cuttings. Road cuttings have the potential to affect both groundwater flow and groundwater levels while also increasing the vulnerability of local aquifers to contaminants as overlying material is removed. Where road cuttings penetrate the groundwater table this may result in permanent change to local groundwater levels and flow patterns, directly impacting the aquifer and indirectly affecting the local groundwater dependent receptors. Groundwater levels can change seasonally and cuttings that penetrate close to the groundwater table may have seasonal impact i.e. during wet periods when the groundwater table rises above the base of the cutting.

A12-4.1.3. This appendix provides details on and for each separate assessment for private water supplies and GWTDEs, which are considered as receptors within Chapter 12: Geology, Soils and Groundwater, of the Environmental Impact Assessment (EIA) Report.

A12-4.1.4. The Study Area for the assessment is as defined in Chapter 12: Geology, Soils and Groundwater and the assessment considers the impacts from the Proposed Scheme.

A12-4.2. Approach and Methods

Groundwater Assessment

A12-4.2.1. An assessment has been undertaken on each cutting along the Proposed Scheme to assess the potential impacts on the groundwater resources within the underlying aquifer(s).

A12-4.2.2. The location of each road cutting along the Proposed Scheme was identified and the maximum depth of each cutting was calculated using QGIS and information from 3D design models. Several cuttings were identified to be present along the Proposed Scheme alignment, however not all of the cuttings designated as an embankment cut feature in the QGIS shapefile for the Proposed Scheme are shown to be present on the 3D design Models and Proposed Scheme cross-sections as a change in ground level.

A12-4.2.3. Where a shapefile is present within the QGIS model, but no change in ground level is demonstrated on the cross-section for the Proposed Scheme, the cutting is not taken further in the assessment. These nominal changes in ground level (less than 0.01m) have been identified as cuttings in the Proposed Scheme's GIS database, however many are associated with the 'tailing off' of the larger embankment cutting features to the north-east of the road, and are largely associated with nominal changes in the road surface elevation.

A12-4.2.4. For the purposes of the assessment, a cutting is considered to be a feature which demonstrates a clear change in the profile of the ground surface following the Proposed Scheme, as such features held within the QGIS database which do not demonstrate a change in the profile of the ground surface level following the Proposed Scheme are removed from the assessment at the initial stages.

A12-4.2.5. The geology was identified using the results from historical ground investigation (GI) logs and the British Geological Survey (BGS) online geological data .

A12-4.2.6. The depth to groundwater at each of the cuttings was calculated using a combination of available groundwater level readings and groundwater contour plots which were modelled by AtkinsRéalis on QGIS using groundwater

monitoring data available at the time of authoring, only boreholes located within 25m of the cutting were used. Boreholes in which groundwater level data was available but were installed in a different geology were not used due to the potential differences in groundwater level resulting from different geologies permeabilities. Limitations to this technique are discussed below in paragraphs A12-4.3.13 and A12-4.3.16. Where no groundwater level data was available, a conservative groundwater level was applied to the cutting.

A12-4.2.7. Where the base of the cutting, as defined by the ground surface models, was found to not intercept groundwater, where groundwater level data is available, the cutting has been removed from any further assessment.

A12-4.2.8. Hydraulic conductivity values have been derived for each unit based on rising / falling head test results from historical GI, or from literature values in the 2006 British Geological Survey's Guide to Permeability Indices.

A12-4.2.9. The base elevation of the aquifers was determined using available GI data. Regarding the superficial aquifers, geological strata information from the nearest borehole to each cutting was used to find the base of the superficial aquifer. For the bedrock aquifers, the deepest GI borehole reach a depth of 50m into the bedrock, where frequent fracturing indicates a fracture permeability, groundwater within the bedrock aquifer is likely to be present at this depth.

A12-4.2.10. For the groundwater impact assessment, the aquifer thickness is not applicable for the relevant equations to define flow rates or zone of influence. As such, the total depth of bedrock aquifer is immaterial and has not been considered further within this specific assessment.

A12-4.2.11. To determine the likely impact of the road cuttings on groundwater flows and groundwater levels, the drawdown and the distance / area of influence has been calculated for each cutting.

A12-4.2.12. The method for estimating the distance of influence of individual road cuttings has been based on the widely used empirical formula for calculating the radius of influence of point groundwater abstractions, as presented in 2016 CIRIA report

C750 Groundwater Control: Design and Practice. This method is considered appropriate to this level of assessment and the available data. Limitations to this technique are discussed below in paragraphs A12-4.3.13 and A12-4.3.18.

A12-4.2.13. The radius of influence for a given drawdown and hydraulic conductivity is given by the Sichardt equation:

$$R0 = Ch\sqrt{k}$$

- Where R0 = distance / radius of influence (m);
- k = hydraulic conductivity (m/sec);
- h = drawdown in groundwater level (m) i.e. penetration of the cutting beneath the water table; and,
- C = 2000 for linear flow, where C is a constant.

A12-4.2.14. The Sichardt equation method has inherent uncertainties. The calculations depend on an empirical constant (C = 2000 for linear flow) for which a conservative value has been used, which may result in an overestimation of the flow as this is likely to be representative of a permanent flow rate, which is considered unlikely to be the case. It also relies upon the assumptions that the aquifer is unconfined, has an infinite areal extent and that the aquifer is homogenous, isotrophic and of uniform thickness. However, it is considered a reasonable estimate of likely zone of influence.

A12-4.2.15. The flow discharge rates were also calculated for each of the cuttings using the following equation:

$$Q_W = \left[0.73 + 0.27\frac{P}{H}\right]\frac{kx(H^2 - h_w^2)}{L_0}$$

Where:

- Q_w = calculated flow discharge rate

- P = the penetration below the original water table (m)
- H = initial piezometric head (m)
- x = linear length of the cut (m)
- h_w = drawdown head (m) and
- L_0 = distance of influence (m).

A12-4.2.16. The following assumptions have been applied to the use of the above equation:

- the aquifer is unconfined, homogenous, isotrophic and of uniform thickness
- the initial water table is horizontal and
- L_0 is obtained using Sichardts equation, with the use of C as 2000;

A12-4.2.17. The following limitations have been identified for the use of the flow discharge rate equation:

- cuttings are only partially penetrating the unconfined aquifer below the original water table
- the calculation assumes the cut area is completely dewatered
- the recorded groundwater level (where available) is assumed to be the original water table
- the true aquifer thickness may not have been proven during the ground investigation, therefore a value that best represents the on-site conditions may have been used in the assessment
- the equation assumes that the impact from dewatering impacts the full aquifer thickness when in reality a minor cut (i.e. 5 m into a 30 m thick aquifer) will not impact the saturation zone beneath the base of the cut and
- permeability may vary across the cut i.e. variable lithologies and variations in measured values may be because of limitations in test techniques undertaken during the GI and results may not reflect the properties of the ground across the cut.

A12-4.2.18. Following the estimation of the radii of influence, a qualitative assessment has been undertaken of the impact on the aquifer(s) affected by each cutting, based on the criteria set out in A12-4.2.29 below.

A12-4.2.19. At this stage there is limited groundwater level data available for the Proposed Scheme and therefore the assessment has been undertaken using conservative worst-case scenario levels where there is an absence of data.

A12-4.2.20. A qualitative risk assessment of the magnitude and significance has been carried out for identified cuttings, based on the criteria set out in A12-4.2.29 of this report.

Private and Public Water Supply Assessment

A12-4.2.21. Groundwater dependent water supplies, operations and abstractions have not been identified within 250m of the Proposed Scheme. Whilst there are private water supplies within 250m of the Proposed Scheme (serving High Glen Croe property) this is understood to be fed by a stream and therefore are not groundwater dependent. This supply is discussed in Chapter 19: Road Drainage and Water Environment.

A12-4.2.22. No further assessment of the impacts from the cuttings on private and / or public water supplies are therefore required.

Surface Water Assessment

A12-4.2.23. Surface water features have been identified within 250m of the Proposed Scheme's cuttings (as per Scottish Environment Protection Agency (SEPA) Guidance Note 31) including:

- rivers
- streams (named or unnamed)
- land drains and
- waterbodies.

A12-4.2.24. The locations of these surface water features were then compared with the estimated radii / area of influence associated with each cutting as calculated through the methodology discussed in paragraph A12-4.3.11. Any features which

have been found to be within the calculated zone of influence are potentially at risk of being impacted by the cutting.

A12-4.2.25. A qualitative risk assessment of the magnitude and significance has been carried out for each affected feature, based on the criteria presented in Section A12-4.3.28 of this report.

GWTDE Assessment

A12-4.2.26. Potential GWDTE have been identified from National Vegetation Classification (NVC) survey, with survey zone extending 250m from the Proposed Scheme extent. The survey method, outcomes and associated figures are provided within Chapter 11: Biodiversity.

A12-4.2.27. The NVC survey identified a number of habitats which correlate to potentially moderate or high groundwater dependency from SEPA LUPS-GU31; Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems.

A12-4.2.28. Post-NVC survey, these potential GWDTE locations have been considered in the context of local characteristics and available data, to establish likely level of groundwater dependency and establish sensitivity, magnitude and significance values.

Impact Assessment Criteria

A12-4.2.29. The assessment of significance of impacts in relation to groundwater and groundwater dependent features has been based on the guidance provided in the LA 113 Road Drainage and the Water Environment standard.

A12-4.2.30. Application of the DMRB / EIA guidance has involved consideration of the importance / sensitivity of relevant attributes of the groundwater receptors and evaluation of the magnitude of the impact. Importance / sensitivity has been evaluated considering quality, rarity, scale and substitutability in keeping with the DMRB guidance and using the criteria shown in Volume 4, Appendix 12.2 Geology, Soils and Groundwater Methodology.

A12-4.3. Groundwater Assessment

Background

A12-4.3.1. A total of 73 cuttings have been identified along the main A83 upgrade alignment including the Rest and Be Thankful Car Park. Individual IDs were assigned numerically to each cutting from south to north. The same was repeated for the 34 cuttings identified relating to the improvements to the Old Military Road (OMR).

A12-4.3.2. The minimum elevation for each cutting was extracted using GIS and from 3D design models of the alignment and checked against 25m interval cross sections of the alignment.

Groundwater Levels

A12-4.3.3. Where groundwater level information is available, the deepest penetration of the cutting into the groundwater table has been taken to provide a worst-case estimate of the impact for the cuttings located along the Proposed Scheme.

A12-4.3.4. For the cuttings the following criteria have been utilised:

- Where there is a groundwater monitoring point at the location, or immediately nearby (within 25m of the cutting), the recorded depth to groundwater has been used in the assessment. However, where a groundwater monitoring point is located within 25m of the cutting but the geology of the installation is not the same as that of the cutting, this data has not been utilised.
- Where no groundwater level data is available, or a suitable monitoring point, and no significant surface water features are present, a conservative groundwater level estimate of 0.0m below ground level (bgl) has been utilised in the assessment. This value was selected due to the presence of very shallow groundwater recorded across the Proposed Scheme.

A12-4.3.5. Limited groundwater monitoring data has been provided from the 2022 historical GI. This data is presented in Table 12.4.1 for the main A83 alignment upgrades and in Table 12.4.2 for the improvements to the OMR. Further groundwater monitoring and investigation is recommended to infill the data gaps present.

Table 12.4.1 – Groundwater Levels Along the LTS Proposed Scheme

Borehole ID	Easting	Northing	Average Groundwater Levels (m AOD*)	Maximum Groundwater Levels (m AOD)	Minimum Groundwater Levels (m AOD)
AAB-BH1016	223943.5	706640.1	195.51	196.53	195.05
AAB-BH1020	224187.3	706241.5	173.57	173.91	173.34
AAB-BH1023	223944.2	706639.3	191.24	191.27	191.19
AAB-BH1025A	224267.6	705999.9	160.44	163.08	159.08
AAB-BH1037	223044.4	707964.3	250.2	250.44	249.84

Table 12.4.2 - Groundwater Levels along the MTS Proposed Scheme

Borehole ID	Easting	Northing	Average Groundwater Levels (m AOD*)	Maximum Groundwater Levels (m AOD)	Minimum Groundwater Levels (m AOD)
AAB-BH1026	223739.2	706538.9	124.64	125.12	124.24
AAB-BH1027A	223691.1	706705.0	141.44	141.68	141.06
AAB-BH1041	224634.8	704763.9	90.54	90.79	90.35

Note: *AOD – Above Ordnance Datum

Drawdown

A12-4.3.6. Estimations of drawdown have been produced by subtracting the estimated maximum groundwater levels (m AOD) from the cutting base elevations. Cuttings where the groundwater level is considered likely to be deeper than 1m below the base of the cutting were considered to pose no significant risk of affecting groundwater and were screened out from further assessment.

A12-4.3.7. For cuttings in which nominal changes in the ground surface level are demonstrated on the design models these cuttings have been screened out of further assessment. Numerous of these nominal cutting features were identified in the QGIS shapefiles for the Proposed Scheme and allocated an individual cutting reference. These are primarily associated with nominal changes to the road surface level, and the tailing out across the road surface of the main embankment cutting (which has separate cutting identification) to the north-east of the existing road network.

Hydraulic Conductivity

A12-4.3.8. Hydraulic conductivity of the ground, defined by the nature of the geology in the area, is highly variable. This has been confirmed by the on-site in-situ permeability testing.

A12-4.3.9. Where data is available, aquifer hydraulic conductivity has been estimated from GI infiltration tests carried out in the course of the 2022 GI for each of the geological formations (Table 12.4.3). For the rest of the cutting locations where no site-specific permeability data is available, generic and relatively conservative hydraulic conductivity values have been used based on the geological formation shown to be present at the location from the values presented in the BGS report, these were used for three formations which were not tested in the 2022 GI and were based on ranges presented in the 2006 British Geological Survey's Guide to Permeability Indices.

Table 12.4.3 - Hydraulic Conductivity of on-site Geological Formations

Geology	Hydraulic Conductivity* (m/s)	Exploratory Hole Number
Hummocky (Moundy) Glacial Deposits	1.36x10-07 9.21x10-8 8.10x10-8 Average: 1.03x10-7	AAB-BH1037 (3 tests)
Till, Devensian	6.53x10-7	AAB-BH1032 (1 test)
South Of Scotland Granitic Suite - Intrusion-Breccia and Tuffisite	9.96x10-7 1.27x10-7 7.64x10-8 Average: 4.00x10-7	AAB-BH1020 (3 tests)
Beinn Bheula Schist Formation - Psammite and Pelite	1.47x10-7	AAB-BH1036 (1 test)
Alluvium - Clay, Silt, Sand and Gravel	1.81x10-07	AAB-BH1026 (1 test)
River Terrace Deposits, 1 - Gravel, Sand, Silt and Clay	1.00x10-03	BGS Literature value
South Of Scotland Granitic Suite - Diorite, Pyroxene-Mica	1.15x10-10	BGS Literature value
South Of Scotland Granitic Suite - Tonalite	1.15x10-10	BGS Literature value

A12-4.4. Results

Main A83 Alignment

A12-4.4.1. Following completion of the assessment it was found that 39 cuttings along the Proposed Scheme for the main A83 alignment works would potentially intercept the groundwater table, due to the absence of groundwater level data along the Proposed Scheme and a conservative level being used of 0.0 m bgl. The remaining 34 of the identified 73 cuttings were considered to have no impact on groundwater flows and have been screened out of the assessment at an earlier stage.

A12-4.4.2. The 34 cuttings which have been discounted prior to the assessment have been removed due to the absence in a change in ground level according to the cross-section models for the Proposed Scheme. Whilst a polygon is present along the route indicating there to be a cutting, these 34 have been proven from the cross-section models to not be a true cutting (i.e. no change in ground level or a nominal change of less than 0.01 m) and hence would not impact upon the groundwater level as a result of the Proposed Scheme.

A12-4.4.3. It is anticipated that groundwater may be intercepted at 39 locations shown in Table 12.4.4. Details are provided of the estimated drawdown and calculated radius of influence for each of the cutting locations. The impact of each cutting is also provided, with the sensitivity of the aquifer based on the sensitivity assigned in the Baseline Section of Chapter 12: Geology, Soils and Groundwater. The magnitude and significance of each impact has been derived using the criteria set out in the Volume 4, Appendix 12.2 Geology, Soils and Groundwater Methodology.

A12-4.4.4. For many of the cuttings, the availability of accurate groundwater level readings and the presence of site-specific hydraulic conductivity values, has likely over-estimated the impact of the cuttings on the groundwater at that location.

Table 12.4.4 - Main A83 Alignment Cuttings Assessment Results

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
1	224245, 706056	Ch00. To Ch15.	1.38	$6.53x10^{-7}$	2.23	0.02	TILL	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer at this location, the calculated drawdown, radius of influence and the flow discharge rates are all minimal, and there are no nearby groundwater receptors other than the superficial aquifer, hence the magnitude of impact on the aquifer is considered as No change and significance is Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
2	224244, 706068	Ch15. To Ch35.	1.38	$6.53x10^{-7}$	2.23	0.03	TILL	High	Negligible	Slight	See discussion for cutting 1.
4	224267, 706128	Ch35. To Ch120.	1.38	$6.53x10^{-7}$	2.23	0.19	TILL	High	Negligible	Slight	See discussion for cutting 1.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
3	224224, 706067	Ch10. To Ch.50	0.05	$6.53x10^{-7}$	0.08	0.04	TILL	High	No change	Neutral	As the change in ground level from the cutting is minimal this has been classed as a no change magnitude. A high sensitivity is assigned to the superficial aquifer at this location. The calculated drawdown, radius of influence and the flow discharge rates are all minimal, and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact on the aquifer is considered as No Change and significance is Neutral. The conservative groundwater level estimate has likely resulted in the identification of a cutting that is not likely to have any impact on the aquifer.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
5	224245, 706107	Ch50. To Ch70.	13.59	$4.00x10^{-7}$	17.19	0.29	SSGS	High	Negligible/ Minor	Slight / Moderate	A conservative groundwater level of 0.0 m bgl has been used for this cutting. A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 13.59 m and radius of influence of 17.19 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels, and the radius of influence being greater than 5 m. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight. however with accurate groundwater levels this impact may be reduced further to be neutral / slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
6	224240, 706132	Ch70. to Ch110.	9.56	$4.00x10^{-7}$	12.09	0.52	SSGS	High	Minor	Slight / Moderate	A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 9.56 m and radius of influence of 12.09 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.
7	224198, 706137	Ch75. To Ch120.	9.56	$4.00x10^{-7}$	12.09	0.61	SSGS	High	Minor	Slight / Moderate	See discussion for Cutting 6.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
8	224217, 706179	Ch130. To Ch150.	7.88	$4.00x10^{-7}$	9.97	0.35	SSGS	High	Minor	Slight / Moderate	A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 7.88 m and radius of influence of 9.97 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
9	224228, 706164	Ch120. To Ch130.	9.56	$4.00x10^{-7}$	12.09	0.31	SSGS	High	Minor	Slight / Moderate	A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 9.56 m and radius of influence of 12.09 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
10	224198, 706238	Ch190. To Ch200.	0.44	$4.00x10^{-7}$	0.56	0.00	SSGS – IB&T	High	Negligible	Slight	One borehole with groundwater monitoring data (AAB-BH1023) is located within the vicinity of the cutting demonstrating the minimum depth to groundwater at 1.68m bgl. A high sensitivity has been assigned for this cutting due to the presence of a high vulnerability aquifer. The negligible magnitude is associated with the calculated radius of influence which is less than 5m, at 0.56 m. This cutting are also relatively small in size and there is the potential that the cutting base at this location does not intercept the water table. The calculated flow discharge rate for the cutting is also modelled to be 0.00 L/sec and therefore considering the absence of any other groundwater receptors, other than the aquifer itself, the cutting is likely to have no impact upon groundwater at this location. Availability of site-specific groundwater levels may further reduce the significance of the impact.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
11	223979, 706631	Ch230. To Ch920	6.18	$1.1.5x10^{-10}$	39.09	36.80	SSGS - D	High	Negligible	Slight	One borehole with groundwater monitoring data (AAB-BH1023) is located within the vicinity of the cutting demonstrating the minimum depth to groundwater at 2.18m bgl (worst-case scenario). With a relatively large drawdown of 6.18 m and radius of influence of 39.09 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With more accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
12	224061, 706542	Ch480. To Ch570.	7.3	$1.47x10^{-7}$	46.17	5.10	SSGS -T	High	Negligible	Slight	One borehole with groundwater monitoring data (AAB-BH1023) is located within the vicinity of the cutting demonstrating the minimum depth to groundwater at 2.18 m bgl. With a relatively large drawdown of 7.3 m and radius of influence of 46.17 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, and the flow discharge rate is small, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With more accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
13	223877, 706756	Ch810. To Ch815.	6.12	$1.15x10^{-10}$	38.71	0.17	SSGS - D	High	Negligible	Slight	A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 6.12 m and radius of influence of 38.71 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
14	223870, 706767	Ch820. To Ch825.	10.57	$1.47x10^{-7}$	8.11	0.02	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	One borehole with groundwater monitoring data (AAB-BH1016) is located within the vicinity of the cutting demonstrating the minimum depth to groundwater at 2.18m bgl. A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 10.57 m and radius of influence of 8.11 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, and the flow discharge rate is minimal, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With more accurate groundwater levels this impact may be reduced further to be Neutral/Slight. With more accurate groundwater levels this slight / moderate impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
15	223663, 707034	Ch925. To Ch1430.	0.65	$6.53x10^{-7}$	1.05	1.75	TILL	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer at this location, The calculated drawdown, radius of influence and the flow discharge rates are all minimal, and there are no nearby groundwater receptors other than the superficial aquifer, hence the magnitude of impact on the aquifer is considered as Negligible and significance is Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 mbgl was used. With more accurate groundwater levels this impact may be reduced further to be Neutral.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
16	223467, 707262	Ch1430 To Ch1480.	10.26	$1.47x10^{-7}$	7.87	0.41	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 10.26 m and radius of influence of 7.87 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
17	223419, 707322	Ch1480 To Ch1590.	0.66	$6.53x10^{-7}$	1.07	0.39	TILL	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer at this location, The calculated drawdown, radius of influence and the flow discharge rates are all minimal, and there are no nearby groundwater receptors other than the superficial aquifer, hence the magnitude of impact on the aquifer is considered as Negligible and significance is Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 mbgl was used. With more accurate groundwater levels this impact may be reduced further to be Neutral.
18	223308, 707344	Ch1620 to Ch1570.	0.59	$6.53x10^{-7}$	0.95	0.17	TILL	High	Negligible	Slight	See discussion for cutting 17.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
20	223298, 707369	Ch1630 to Ch1710.	10.04	$1.47x10^{-7}$	7.7	0.64	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 10.04 m and radius of influence of 7.7 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight/Moderate. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
21	223239, 707363	Ch1710 to Ch1720.	2.73	$1.47x10^{-7}$	2.09	0.07	BBSF – P&P	High	Negligible / Minor	Slight/Moderate	A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 2.73 m and radius of influence of 2.09 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
22	223203, 707363	Ch1720 to Ch1790.	9.96	$1.47x10^{-7}$	7.64	1.04	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown of 9.96 m and radius of influence of 7.64 m, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible, with significance of Slight. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
23	223205, 707372	Ch1720 to Ch1790.	1.11	$6.53x10^{-7}$	1.79	0.96	TILL	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer at this location, The calculated drawdown, radius of influence and the flow discharge rates are all minimal, and there are no nearby groundwater receptors other than the superficial aquifer, hence the magnitude of impact on the aquifer is considered as Negligible and significance is Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 mbgl was used. With more accurate groundwater levels this impact may be reduced further to be Neutral.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
24	223150, 707372	Ch1790 to Ch1850.	11.23	$1.47x10^{-7}$	8.61	0.49	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	A conservative estimate of groundwater has been used for this cutting (0.0 m bgl). A high sensitivity is assigned to the bedrock aquifer at this location. With a relatively large drawdown and radius of influence, the magnitude of impact has been given as Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible, with significance of Slight. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight.
25	223091, 707389	Ch1860 to Ch1890.	16.13	$1.47x10^{-7}$	12.37	0.26	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	See discussion for cutting 24.
26	223070, 707396	Ch1890 to Ch1910.	10.81	$1.47x10^{-7}$	8.29	0.22	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	See discussion for cutting 24.
27	223011, 707460	Ch1930 to Ch2075.	7.63	$1.47x10^{-7}$	5.85	1.06	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	See discussion for cutting 24.
28	222986, 707622	Ch2125 to Ch2205.	7.13	$1.47x10^{-7}$	5.47	0.62	BBSF – P&P	High	Negligible / Minor	Slight / Moderate	See discussion for cutting 24.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
29	222990, 707662	Ch2205 to Ch2230.	4.72	$1.47x10^{-7}$	3.62	0.20	BBSF – P&P	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer at this location, The calculated drawdown, radius of influence and the flow discharge rates are all minimal, and there are no nearby groundwater receptors other than the superficial aquifer, hence the magnitude of impact on the aquifer is considered as No Change and significance is Neutral. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
30	222970, 707635	Ch2060 to Ch2200.	4.01	$1.47x10^{-7}$	3.07	0.29	BBSF – P&P	High	Negligible	Slight	See discussion for cutting 29.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
31	223005, 707328	RABT Car Park	0.03	$1.03x10^{-7}$	0.02	0.07	HGD	High	No change	Neutral	This cutting is associated with the upgrades to the Rest and Be Thankful (RABT) car park and is a small cutting with a small drawdown value, with the absence of groundwater level data this has likely further overestimated the potential radius of influence for the cutting. A high sensitivity is assigned to the superficial aquifer at this location, The calculated drawdown, radius of influence and the flow discharge rates are all minimal, and there are no nearby groundwater receptors other than the superficial aquifer, hence the magnitude of impact on the aquifer is considered as No Change and significance is Neutral. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
32	223024, 707328	RABT Car Park	1.316	$1.03x10^{-7}$	0.84	0.05	HGD	High	Negligible	Slight	See discussion for cutting 31.
33	223031, 707346	RABT Car Park	0.043	$1.03x10^{-7}$	0.03	0.04	HGD	High	No change	Neutral	See discussion for cutting 31.
34	223015, 707327	RABT Car Park	0.656	$1.03x10^{-7}$	0.42	0.01	HGD	High	Negligible	Slight	See discussion for cutting 31.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Flow Discharge Rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
37	223058, 707372	RABT Car Park	0.118	$1.03x10^{-7}$	0.08	0.02	HGD	High	No change	Neutral	See discussion for cutting 31.
38	223009, 707363	RABT Car Park	0.133	$1.03x10^{-7}$	0.09	0.05	HGD	High	No change	Neutral	See discussion for cutting 31.
39	223058, 707380	RABT Car Park	0.118	$1.03x10^{-7}$	0.08	0.01	HGD	High	No change	Neutral	See discussion for cutting 31.
40	222968, 707362	RABT Car Park	3.282	$1.03x10^{-7}$	2.11	0.16	HGD	High	Negligible	Slight	See discussion for cutting 31.
41	223030, 707385	RABT Car Park	0.058	$1.03x10^{-7}$	0.04	0.03	HGD	High	No change	Neutral	See discussion for cutting 31.
42	223005, 707388	RABT Car Park	0.211	$1.03x10^{-7}$	0.14	0.32	HGD	High	Negligible	Slight	See discussion for cutting 31.

A12-4.4.5. At this stage, further GI, groundwater monitoring and assessment would enable the refinement for the estimation of groundwater drawdown and zone of influence and confirm the significance of the impact for the main A83 alignment upgrade cuttings. This data will also be required to assess the groundwater volumes seeping into the cuttings, which will inform the cutting drainage design.

A12-4.4.6. The assessment undertaken indicates that at worst, the potential impacts from the cuttings along the main A83 alignment have been given a magnitude of impact of Minor due to potentially having minor effects on the aquifer's groundwater levels. However, given that there are no nearby groundwater receptors other than the bedrock aquifer, the flow discharge rate is minimal, and that the drawdown is likely to be overestimated due to using a conservative groundwater level, the magnitude of impact can be reduced to Negligible/Minor, with significance of Slight. With accurate groundwater levels this impact may be reduced further to be Neutral/Slight. Therefore, no additional mitigation is required.

Improvements to the OMR

A12-4.4.7. Following completion of the assessment it was found that 17 cuttings relating to the improvements to the OMR would intercept the groundwater table, due to the intermittent presence of groundwater level data along the Proposed Scheme and a conservative level being used of 0.0m bgl where no groundwater level data is available. The remaining 17 of the identified 34 cuttings were considered to have no impact on groundwater flows and have been screened out of the assessment as they were modelled to not intercept groundwater or to have only nominally cut into existing surface.

A12-4.4.8. As per the main A83 alignment, several cuttings were presented in the QGIS shapefile for the OMR Proposed Scheme, however these do not appear to demonstrate a change in ground level in the cross-sections for the Proposed Scheme and have been discounted from the assessment for the OMR cuttings as they are not 'true cuttings'.

A12-4.4.9. It has been anticipated that groundwater would be intercepted at the following 17 locations, shown in Table 12.4.5. Details are provided of the estimated drawdown

and calculated radius of influence for each of the cutting locations. The impact of each cutting is also provided, with the sensitivity of the aquifer based on the sensitivity assigned in Volume 4, Appendix 12.3 Geology, Soils and Groundwater Baseline. The magnitude and significance of each impact has been derived using the criteria set out in Volume 4, Appendix 12.2 Geology, Soils and Groundwater Methodology.

Table 12.4.5 – Improvements to the OMR Cuttings Assessment Results

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Discharge flow rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
9	224332,705457	Ch1080. to Ch1190.	0.06	6.53x10-7	0.10	0.12	Till	High	No change	Neutral	A high sensitivity is assigned to the superficial aquifer at this location, The calculated drawdown, radius of influence and the flow discharge rates are all minimal, and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact on the aquifer is considered as No change and significance is Neutral. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
10	224350,705417	Ch1090. to Ch1095.	0.52	6.53x10-7	0.84	0.01	Till	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer. The calculated drawdown is minimal and both the radius of influence and the flow discharge rate are insignificant. There are also no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as Negligible and significance of Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Discharge flow rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
11	224318,705542	Ch1100. to Ch1320.	1.96	1.47x10-7	1.51	0.22	BBSF – P&P	High	Negligible	Slight	A high sensitivity is assigned to the bedrock aquifer. Despite the moderate drawdown of 1.96 m, both the calculated radius of influence and the flow discharge rate are insignificant and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as Negligible and significance of Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
12	224304,705542	Ch1220. to Ch1240.	0.18	6.53x10-7	0.29	0.02	Till	High	No change	Neutral	A high sensitivity is assigned to the superficial aquifer at this location. The calculated drawdown, radius of influence and the flow discharge rates are all insignificant, and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as Negligible and significance of Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Discharge flow rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
13	224286,705573	Ch1250. to Ch1275.	0.04	6.53x10-7	0.06	0.03	Till	High	No change	Neutral	See discussion for cutting 12.
15	224226,705706	Ch1320. to Ch1470.	1.16	6.53x10-7	1.88	0.20	Till	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer. Despite the relatively large drawdown of 1.88 m, both the calculated radius of influence and the flow discharge rate are insignificant and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as Negligible and significance of Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Discharge flow rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
16	224241,705650	Ch1350. to Ch1355.	0.01	6.53x10-7	0.01	0.01	Till	High	No change	Neutral	A high sensitivity is assigned to the superficial aquifer at this location. The calculated drawdown, radius of influence and the flow discharge rates are all insignificant, and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as No change and significance of Neutral. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used..
17	224231,705667	Ch1360. to Ch1380.	0.13	6.53x10-7	0.2	0.02	Till	High	No change	Neutral	See discussion for cutting 17.
18	224186,705740	Ch1455. to Ch1460.	0.05	6.53x10-7	0.09	0.01	Till	High	No change	Neutral	See discussion for cutting 17.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Discharge flow rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
19	224194,705757	Ch1470. to Ch1480.	1.07	6.53x10-7	1.72	0.01	Till	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer. Despite the relatively large drawdown of 1.07 m, both the calculated radius of influence and the flow discharge rates are minimal and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as Negligible and significance of Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
21	224144,705839	Ch1480. to Ch1650.	2.20	1.47x10-7	1.68	1.26	BBSF – P&P	High	Negligible	Slight	A high sensitivity is assigned to the bedrock aquifer. Despite the relatively large drawdown of 2.2 m, both the calculated radius of influence and the flow discharge rates are minimal and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as Negligible and significance of Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Discharge flow rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
22	224153,705795	Ch1490. to Ch.1550.	0.04	6.53x10-7	0.06	0.06	Till	High	No change	Neutral	A high sensitivity is assigned to the superficial aquifer at this location. The calculated drawdown, radius of influence and the flow discharge rates are all insignificant, and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as No change and significance of Neutral. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
23	224092,705898	Ch1630. to Ch1650.	0.09	6.53x10-7	0.15	0.02	Till	High	No change	Neutral	See discussion for cutting 22.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Discharge flow rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
24	224093,705954	Ch1660. to Ch1725.	0.95	6.53x10-7	1.53	0.09	Till	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer. Despite the relatively large drawdown of 0.95 m, both the calculated radius of influence and the flow discharge rates are minimal and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as Negligible and significance of Slight. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
25	224083,705928	Ch1670. to Ch1675.	0.07	6.53x10-7	0.11	0.01	Till	High	No change	Neutral	A high sensitivity is assigned to the superficial aquifer at this location. The calculated drawdown, radius of influence and the flow discharge rates are all insignificant, and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as No change and significance of Neutral. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.

Cutting ID	NGR (centre of cutting)	Chainage	Drawdown (m)	Permeability value (m/sec)	Radius of Influence (m)	Discharge flow rate (L/sec)	Groundwater Body	Sensitivity	Magnitude	Significance	Discussion
26	224072,706034	Ch1765. to Ch1800.	0.23	6.53x10-7	0.37	0.05	Till	High	Negligible	Slight	A high sensitivity is assigned to the superficial aquifer. The calculated drawdown, radius of influence and the flow discharge rates are all insignificant, and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as No change and significance of Neutral. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.
27	224054,706038	Ch1775. to Ch1795.	0.07	6.53x10-7	0.11	0.02	Till	High	No change	Neutral	A high sensitivity is assigned to the superficial aquifer at this location. The calculated drawdown, radius of influence and the flow discharge rates are all insignificant, and there are no nearby groundwater receptors other than the aquifers themselves, hence the magnitude of impact is considered as No change and significance of Neutral. In addition, the drawdown value is likely to be overestimated because, due to the lack of nearby groundwater monitoring points, a conservative groundwater level of 0.0 m bgl was used.

A12-4.4.10. The assessment of the available data for the OMR alignment cuttings shows the potential impacts on groundwater to be slight to neutral. Therefore, at this stage no additional mitigation measures would be likely for the OMR cuttings.

A12-4.5. Surface Water Assessment

Main A83 Alignment

A12-4.5.1. Surface water features such as rivers and burns, which interact with groundwater via a baseflow component, may be impacted by changes in groundwater levels as a result of dewatering activities during the construction phase, and steady-state drawdown during operation of the Proposed Scheme.

A12-4.5.2. Of the 39 cuttings along the main alignment of the A83 which are expected to have an impact on groundwater, six have been found to have watercourses, all tributaries of the Croe Water, within the associated zones of influence. The intersecting watercourses are presented in Table 12.4.6 below.

Table 12.4.6 - Watercourses found to be within zone of influence of cuttings of the main A83

Cutting No	Watercourse	Grid Reference	Sensitivity	Magnitude	Significance
11	Tributary of Croe Water 1	223817, 706843	Low	Negligible	Neutral
15	Tributary of Croe Water 2	223718, 706965	Low	Negligible	Neutral
15	Tributary of Croe Water 3	223680, 707017	Low	Negligible	Neutral
15	Tributary of Croe Water 4	223598, 707114	Low	Negligible	Neutral
15	Tributary of Croe Water 5	223506, 707213	Low	Negligible	Neutral

Cutting No	Watercourse	Grid Reference	Sensitivity	Magnitude	Significance
20	Tributary of Croe Water 6	223258, 707361	Low	Negligible	Neutral

A12-4.5.3. For each watercourse the magnitude of the impact is anticipated to be Negligible due to the small proportion of base flow that may be lost and the watercourses classification according to assigned sensitivity and magnitude determined from the criteria presented in the methodology Volume 4, Appendix 12.2 Geology, Soils and Groundwater Methodology. The subsequent impact significance would be Neutral.

Improvements to the OMR

A12-4.5.4. Of the 17 cuttings along the alignment of the OMR which are expected to have an impact on groundwater, three have been found to have watercourses, all are tributaries of the Croe Water, within the associated zones of influence. The intersecting watercourses are presented in Table 12.4.7.

Table 12.4.7 - Watercourses found to be within zone of influence of cuttings for the OMR

Cutting No	Watercourse	Grid Reference	Sensitivity	Magnitude	Significance
11 and 14	Tributary of Croe Water 7	224271,705624	Low	Negligible	Neutral
32	Tributary of Croe Water 1	223710,706751	Low	Negligible	Neutral

A12-4.5.5. For each watercourse the magnitude of the impact from the Medium-Term Solution is anticipated to be Negligible due to the small proportion of base flow that may be lost and the watercourses classification assigned in the assessment

from the criteria presented in Appendix 12.2 Geology, Soils and Groundwater Methodology. The subsequent impact significance would be Neutral.

A12-4.6. Waterbodies

Main A83 Alignment

A12-4.6.1. Loch Restil is located to the north-west of the Proposed Scheme and is approximately 15m west of cuttings 28, 29 and 30. The calculated radius of influence for these cuttings are not currently modelled to intersect Loch Restil, even with worst-case scenario groundwater levels used.

A12-4.6.2. It is considered to be likely that Loch Restil is not solely fed through groundwater baseflow, and is present due to a combination of factors, including low permeability strata.

Improvements to the OMR

A12-4.6.3. There are no waterbody features located within or adjacent to the OMR alignment. Therefore, the assumed magnitude of the impact is considered to be Negligible due to the lack of intersection of the cuttings and the loch. The impact of the cuttings is considered to be Neutral.

A12-4.7. GWTDE

A12-4.7.1. Potential GWDTE habitats, typical characteristics, known groundwater levels and current influences on groundwater conditions are reported in Volume 4, Appendix 12.3, Geology, Soils and Groundwater Baseline.

A12-4.7.2. Following baseline review, the majority of locations initially identified as potential GWDTE (based on SEPA LUPS-GU31) are not considered groundwater dependent (low dependency), with the primary inputs of water onto the Study Area considered to be surface flows and direct precipitation, with groundwater providing a minor contribution, which may exhibit some seasonal variation.

A12-4.7.3. However, M10 habitat was noted with greater potential for dependency (moderate dependency) by the Ecology survey team and has typical settings which indicate

a greater degree of groundwater input. Applying a risk-based approach, the GWDTE assessment targeted this habitat for further consideration.

M10 Community

A12-4.7.4. M10 habitat (or mosaic habitats including M10); Carex dioica - Pinguicula vulgaris mire, are base-rich mires which typically occupy sloping flush zones, often below a springhead or more diffuse groundwater emergence. The three M10 polygons in the Study Area are all located near High Glen Croe property, displayed on Volume 3, Figure 12.7, Groundwater Dependent Terrestrial Ecosystems.

A12-4.7.5. The M10 habitats in the Study Area occupy steep slopes, located between the A83 and OMR, plus below the OMR. All locations are subject to existing groundwater modification from both the OMR and A83, from which diffuse road drainage may be contributing to the wet slope conditions. These polygons are also in close proximity to surface channels and observed flush zones. Plate 12.4-1 shows a typical M10 location.

A12-4.7.6. Their moderate dependency (medium sensitivity) value takes account of uncertain groundwater conditions, including potential for deeper flowpaths that could be contributing (with varying seasonality) to water inputs on M10 habitats. Ongoing Ground Investigations may reduce uncertainty over groundwater levels and aid understanding of flowpaths that could be intercepted.

A12-4.7.7. Without GI data being available, local groundwater flows are anticipated to be shallow and follow surface gradients, flowing towards the base of Glen Croe. The existing A83 and OMR baseline features, including associated drainage ditches, run across the eastern slope of Glen Croe, perpendicular to likely groundwater flow paths. These features shall act as barriers, with shallow groundwater flows likely to be intercepted, transferring into surface water system and discharged downslope, currently. Where underlying geology allows, deeper flows may pass below.

A12-4.7.8. Ongoing Ground Investigations may reduce uncertainty over local groundwater levels and aid understanding of likely shallow flowpaths in relation to M10 habitats. This is further discussed in Volume 2, Chapter 12.

Plate 12.4-1 M10 Community, taken above OMR at NGR 223467 707084, looking north east towards A83. A83 vehicle restraint barrier and embankment visible in mid-ground, immediately above the steep M10 area, with evidence of local surface water flow paths near to a small channel.

Main A83 Alignment

A12-4.7.9. There is an anticipated increase in groundwater intercepted by the A83 cuttings, due to the deeper and wider excavations than currently present from installation of an extended catch pit, with such flows transferred into surface channels.

A12-4.7.10. However, the radii of influence values for cuttings, presented in Table 12.4.4, generally indicates limited influence beyond cutting extent. These typically extend less than 10 m from the A83 cuttings, with the maximum extent estimated as 46 m.

A12-4.7.11. The cutting areas with greatest radii of influence values (over 10 m) are not coincident with the M10 habitats, with centrepoints/polygons of these cutting areas provided on Volume 3, Figure 12.7: Groundwater Dependent Terrestrial Ecosystems. The nearest of which are cuttings 13 and 25, approximately 400m south and 200m north, respectively, of the nearest M10 habitats.

A12-4.7.12. For the combined M10 GWDTE habitats the magnitude of the impact from the A83 is anticipated to be Minor due to the small radii of influence from local excavations and considered a medium sensitivity receptor due to existing groundwater barriers and likely dominance of other water sources on these slopes, determined from the criteria presented in Appendix 12.2 Geology, Soils and Groundwater Methodology. The subsequent impact significance would be Slight, for both construction and operation.

Improvements to the OMR

A12-4.7.13. In comparison to the main A83 alignment, the OMR improvements involve shallower excavations of reduced extent, with associated reduction in radii of influence, as presented in Table 12.4.5, with lateral distance values very limited; all OMR cuttings being estimated as less than 2m.

A12-4.7.14. The M10 areas in the northern part of the OMR corridor have no adjacent lane widening proposed, with the Proposed Scheme extending into some M10 habitats to achieve improvements to stability and scour conditions adjacent to local watercourses.

A12-4.7.15. Consequently, the magnitude of impact from the OMR is anticipated to be Negligible on this medium sensitivity M10 receptor, with subsequent impact significance of Slight, for both construction and operation.