Appendix 8.1

Revised ES Chapter 12 Flood Risk and Effect on Water Resources.

Proposed extension to Linhay Hill Quarry Environmental Statement

Updated water resources chapter

E&JW Glendinning Ltd

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12. Water Resources, Drainage and Flood Risk

Introduction

12.1. This is a revised version of the Chapter of the ES that assesses the likely significant effects of the extension to Linhay Hill Quarry with regard to water resources, drainage and flood risk. The Chapter describes the methods used to assess the effects, the baseline conditions currently existing at the Site and surrounding area, the mitigation measures required to prevent, reduce or offset any significant negative effects; and the likely residual effects after these measures have been adopted. The revisions have been made in response to the Reg 22 Request issued by the DNPA in December 2016 and incorporates additional information as requested by the Environment Agency in the consultation responses dated 2 August 2016 and 8 September 2016. It also responds to points made in Highway England's consultation response dated 25 July 2016.

12.2. The chapter is based on Hydrogeological Impact Assessments which form Appendix 12A (produced in 2016) and Appendix 12B (produced in 2018), and a Flood Risk Assessment which is a separate document within the Planning Application. The Hydrogeological Impact Assessment produced in 2018 now largely supersedes the 2016 assessment.

Policy Context

National Planning Policy Framework 2012 and 2018

12.3. The general thrust of the National Planning Policy Framework in relation to water resources is the avoidance of pollution, and wherever possible to improve water quality. It also requires that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe for its lifetime without increasing flood risk elsewhere.

12.4. The Planning Practice Guidance section on Flood Risk and Coastal Change (https://www.gov.uk/guidance/flood-risk-and-coastal-change) sets how that policy should be implemented. That includes the requirement for Local Plans to be supported by Strategic Flood Risk Assessment and to develop policies to manage flood risk from all sources, and that Local Plans "should apply a sequential, risk-based approach to the location of development – taking account of the impacts of climate change – so as to avoid, where possible flood risk to people and property (NPPF 2018). The approach to managing residual risk is also outlined.

Dartmoor National Park Policy

12.5. Flood risk and drainage are addressed in Core Strategy Policy COR9 Flooding - protection and prevention, and COR 24 Water Resources. Policy COR9 is concerned with application of the Sequential Test to reduce the risk of flooding and requires appropriate flood protection and resistance and sustainable drainage systems to be incorporated into development proposals. Policy COR24 seeks to protect the quality and yield of water resources, including abstraction sites, groundwater, rivers, streams and still waters.

12.6. The Dartmoor National Park Authority has prepared Strategic Flood Risk Assessments (SFRA) to define the strategic drivers for implementation of its policy COR9. Those identify Ashburton as a local centre with a history of flooding and include a detailed SFRA for the Chuley Road Masterplan area of Ashburton. The aim of that study was to provide a detailed understanding of flood risk and hazard from flooding from the River Ashburn and Balland Stream to inform future planning decisions in Ashburton.

12.7. Core Strategy Policies COR1 Sustainable development, and COR8 regarding sustainable and efficient use of natural resources, also make reference to flood risk and drainage. Policy COR1 seeks:

- *"the conservation of the quality and quantity of natural resources including water, …;*
- *allowance for the natural drainage of surface water;*
- *the avoidance of new development and a reduction in vulnerability of redevelopment carried out within medium to high risk flood zones."*

12.8. Policy COR8 looks for development to use natural resources in efficient and sustainable ways including the following aims:

"(iii) incorporating sustainable drainage and water conservation systems;
(iv) having no adverse effects on drainage patterns or flood storage capacity".

12.9. The Development Management and Delivery DPD (the 'DMD') document refers to the SFRA and has requirements regarding surface water, drainage and flood in several of its potentially relevant policies:

- Policy DMD3: Sustaining the quality of places in Dartmoor National Park includes reference to surface water and flooding: *"Development proposals should help to sustain good quality places in Dartmoor National Park by:….disposing of surface water in accordance with sustainable methods that minimise the risk of flooding of property and land or the pollution of watercourses".*
- Policy DMD34: *"Agricultural, forestry and rural business related development Agricultural, forestry and other rural enterprise related non-residential development will be permitted where the proposal complies with the following criteria:…….(v) it will not cause unacceptable harm to biodiversity, geodiversity and archaeological and cultural heritage assets, natural drainage or soil stability".*

12.10. In Part 3.2 'Local Centres – Ashburton' only refers to surface water, drainage and flood risk in relation to requirements under its proposal ASH2 concerning 3.5 ha of land at Chuley Road, identified for redevelopment for mixed use.

Devon County Council Policy

12.11. The Devon County Council Minerals and Waste Development Framework Strategic Flood Risk Assessment (SFRA) March 2013 provides an overview of flood risk in Devon and accompanying guidance.

12.12. Devon County Council is the Lead Local Flood Authority under the Flood and Water Management Act and is responsible for managing local flood risk in Devon from surface water, groundwater and consenting and enforcement on Ordinary Watercourses. Devon County Council's 'Devon Local Flood Risk Management Strategy 2014-2020' is a statutory document to which Risk Management Authorities must adhere to.

12.13. Also of relevance to the quarry extension and associated infrastructure drainage design and flood risk mitigation is Devon County Council's requirement to ensure that SuDS are included on new developments. The Council has produced Sustainable Drainage Systems (SUDS) guidance, May 2014, to be adhered to and which broadly aligns with the requirements of the DEFRA / Environment Agency publication Rainfall runoff management for developments, Report – SC030219, October 2013 and the comprehensive CIRIA C753 The SuDs Manual 2015.

Teignbridge District Council Policy

12.14. Linhay Hill Quarry and surrounding land lies within the Ashburton and Buckfastleigh ward of Teignbridge District Council. Teignbridge District Council's Strategic Flood Risk mapping available online shows flood risk areas.

Assessment Methodology and Significance Criteria

Methodology

12.15. The assessment methodology has been to prepare a Hydrogeological Impact Assessment and a Flood Risk Assessment to understand in detail the potential for effects on the water environment associated with the proposed quarry extension. There were common aspects to those studies including desktop research, site visits and investigations to obtain baseline, local and historical information. The findings of those studies have been utilised to identify which aspects of the water environment are likely to be significantly affected, and how the effects can be mitigated.

12.16. The Hydrogeological Impact Assessment follows the approach outlined in the Environment Agency's Science Report – SC040020/SR1 Hydrogeological impact appraisal for dewatering abstractions, 2007, which details both a standard sequential fourteen step methodology for appraising potential dewatering effects and an approach specifically for karst groundwater systems where the heterogeneity of the groundwater system means there are difficulties in the reliable prediction of hydrogeological effects. The karst groundwater system entails an eight step 'monitor and mitigate' approach which has the following relationship with the fourteen step methodology. The first two steps of both approaches entail establishing the regional water resource status and developing a conceptual model; steps 3 to 12 of the fourteen step approach relate to predictions but become step K3 'identify sensitive sites', and steps 13 to 14 of the fourteen step approach are subdivided to become:

- Step K4: Commence preliminary monitoring at those sites.
- Step K5: Design and demonstrate effective mitigation measures for the sensitive sites.
- Step K6: Specify trigger levels for the mitigation measures.
- Step K7: Continue surveillance monitoring at the sensitive sites.
- Step K8: If necessary, implement mitigation measures when trigger levels have been passed[1].

12.17. Both methodologies are iterated until the required level of confidence is achieved. The Hydrogeological Impact Assessment 2018 concludes that the karst characteristics of the limestone environment of the Chercombe Bridge Limestone Formation in which the Linhay Hill Quarry lies mean that the eight step approach is the most appropriate methodology to follow.

12.18. As required by the EA's consultation responses dated 2 August 2016 and 8 September 2016, the Hydrogeological Impact Assessment 2018 (HIA 2018) covers steps K1 to K3 and includes step K4, though the preliminary monitoring will continue to gather data, and the assessment outlines envisaged mitigation measures (Step K5). Steps K5 to K8 are to be iterated as necessary and flexibly as part of a tiered risk-based approach informed by continued monitoring, the overall aims of the eight step approach and main fourteen step methodology being the same.

12.19. The Flood Risk Assessment, which is presented as a separate document submitted with the planning application for the application, was carried out in general accordance with the DEFRA flood risk standing advice for local planning (www.gov.uk/planning-applications-assessing-flood-risk) and the guidance listed below:

- BS 8533:2011 Assessing and managing flood risk in development – Code of practice.
- BS 8582:2013 Code of practice for surface water management for development sites.
- Environment Agency report SC030219 Rainfall runoff managements for developments, October 2013.
- CIRIA C753 The SuDs Manual, 2015.

The study is also broadly in line with a Level 2 Flood Risk Assessment as described in CIRIA publication C624 Development and Flood Risk, 2004.

12.20. The Flood Risk Assessment provides a site specific study which identifies and assess the risks of flooding to and from the proposed quarry extension and associated infrastructure works. The study

[1] See page 95 of Environment Agency's Science Report – SC040020/SR1.

outlines how those flood risks will be managed so that flood risk is mitigated throughout the lifetime of the development proposal, taking climate change into account, to ensure that flood risk off-site will not be adversely affected. The findings of the Hydrogeological Impact Assessment 2018 have not affected the Flood Risk Assessment as submitted in July 2016.

Significance Criteria

12.21. The relative terms described in the following tables have been used to classify the importance of the water resources which may be affected by the quarry extension and the magnitude of a potential effect. The descriptive criteria are mainly based on guidance within the Department for Transport's TAG Unit A3 Environmental Impact Assessment December 2015, Chapter 10 Impacts on the Water Environment, and specifically the following tables therein: Table 13 Water Resources, Their Features and Indicators of Quality, Table 14 Guidance on Estimating the Importance of Water Environment Features and Table 15 Criteria for Determining Impact Magnitude.

Table 12-1 Water Feature Importance

Importance	Criteria
High	Feature with a high quality and rarity, regional or national scale and limited potential for substitution. For example: - Water body classified as 'high' ecological status under the Water Framework Directive. - Principal aquifer covered by soils with leaching potential, or aquifer providing potable water to a large population. - Within Source Protection Zone 1 or 2 of a groundwater abstraction point. - Watercourse widely used for recreation, directly related to watercourse quality (e.g. swimming, salmon fishery, etc.). - Active floodplain area (important in relation to flood defence).
Medium	Feature with high quality and rarity, local scale and limited potential for substitution, or feature with a medium quality and rarity, regional or national scale and limited potential for substitution. For example: - Water body classified as 'good' ecological status or potential under the WFD; - Secondary aquifer covered by soils with leaching potential, or aquifer providing potable water to a small population. - Within Source Protection Zone 3 of a groundwater abstraction point. - Watercourse used for recreation, directly related to watercourse quality (e.g. swimming, salmon fishery etc.). - Active floodplain area of some importance to flood defence.
Low	Feature with medium quality and rarity, local scale and limited potential for substitution, or feature with a low quality and rarity, regional or national scale and limited potential for substitution. For example: - Water body classified as 'moderate' ecological status or potential under the WFD. - Principal Aquifer covered by soils with low leaching potential or Secondary Aquifer covered by soils with high leaching potential, not within a Source Protection Zone of a groundwater abstraction point but may provide abstraction water for agricultural or industrial use, or a private water supply. - Watercourse not widely used for recreation, or recreation use not directly related to watercourse quality. - Area at low flood risk.
Minimal	Feature with a low quality and rarity, local scale and limited potential for substitution. Environmental equilibrium is stable and resilient to changes that are greater than natural fluctuations, without detriment to its present character. For example: - Water body classified as 'poor' or 'bad' ecological status or potential under the WFD. - Secondary aquifer covered by soils with low leaching potential; unproductive strata so no abstraction for use with no drinking water supplies in area. - Receptor heavily engineered, artificially modified or dries up during summer months. - Area not at risk of flooding.

Table 12-2 Magnitude of Impacts on the Water Environment

Magnitude of Impact (Change)	Criteria	Description and Examples
Major	Results in total loss or major / substantial alteration of feature.	Wide spread changes affecting an essential part of the water environment. For example: - Extensive changes to watercourse channel, route, hydrology or hydrodynamics; groundwater flow regime or water levels. - Loss or enhancement of designated species/habitats. - Change in water quality status, or major changes to the water chemistry or hydro-ecology. - Substantial change in flood storage or flood risk affecting important infrastructure or inhabited properties. - Pollution or clean-up of public or private drinking water source.
Moderate	Results in effect on integrity of key elements or attributes of feature, or loss of part of feature.	Material effect but not affecting an essential part of the water environment, not system wide but of greater than local significance. For example: - Some distinct changes to watercourses, hydrology or hydrodynamics. - Distinct changes to site resulting in an increase in runoff within system capacity. - Distinct changes to groundwater recharge, flow mechanisms or water levels. - Distinct changes to erosion and sedimentation patterns. - Change to a proportion of the effluent in the receiving water, but insufficient to change to its water quality status. - Distinct change to flood storage or flood risk affecting infrastructure or a small number of inhabited properties.
Minor	Results in minor effect on feature or its attributes.	Measurable but slight non-material change to the water environment at a local scale. For example: - Discernible change to a watercourse, hydrology or hydrodynamics. - Discernible increase in runoff well within the drainage system capacity. - Discernible changes to groundwater recharge, flow mechanisms or water levels. - Discernible measurable change in water quality, but of limited size and over limited geographical scale. - Minor change to flood storage or flood risk with few effects on people or property.
Negligible	Results in an effect on feature but of insufficient magnitude to affect the use, integrity or quality.	No perceptible changes to the water environment. For example: - No alteration or very minor changes with no discernible effect to watercourses, hydrology, hydrodynamics, erosion or sedimentation patterns. - Discharges to watercourse but no change in quality, fisheries productivity or biodiversity. - No change in flood risk. - No change to the quality of private or public drinking water resources.

12.22. In addition the magnitude of an effect more than negligible is either adverse or beneficial, and a qualitative description of the effect duration is given as follows:

- Temporary: lasting for the duration of construction works (e.g. Stage 0)
- Short-term: within the first year of quarry operation in the extension area (e.g. within Stage 1a).
- Medium-term: extending over 1-10 years from the start of operation (e.g. Stage 1a).
- Long-term: extending beyond 10 years from the start of operation (e.g. to Stage 5).

- Permanent: lasting for the duration of development i.e. post restoration.

12.23. Based on the criteria in Tables 12.1 and 12.2 the overall significance of the resulting effects is determined as per the criteria in the following Table 12.3.

Table 12-3 Criteria for Estimating the Significance of Potential Effects on the Water Environment

Magnitude of potential effect (Change)	Importance of water feature			
	Minimal	Low	Medium	High
Negligible	Not significant	Not significant or low significance	Not significant or low significance	Low significance
Minor	Not significant or low significance	Not significant or low significance	Low significance	Low or moderate significance
Moderate	Not significant or low significance	Low significance	Moderate significance	Moderate or highly significant
Major	Low significance	Low or moderate significance	Moderate or highly significant	Highly or very highly significant

12.24. In this ES, the effects which are of moderate significance or above are considered to be significant in relation to the EIA Regulations.

Baseline Conditions and Receptors

Geology

12.25. In general, superficial deposits are absent from the area, except where shown by the British Geological Survey maps as narrow ribbons of Alluvium associated with watercourses, namely the River Ashburn and its tributaries, the Kestor Brook, and the River Lemon. The BGS mapping also shows one area of Made Ground where the A38 crosses Chuley Road south west of the quarry. In addition, there is the existing partially restored spoil tip to the north of the quarry, and locally the A38 is on embankment fill. These latter instances of Made Ground are not shown on BGS mapping.

12.26. Linhay Hill Quarry is working the Chercombe Bridge Limestone Formation (CBLF) which is medium to dark grey, strong to very strong, with medium to widely spaced bedding which has been tilted to dip at 22º to 50º to the south east. The British Geological Survey 1:50,000 geology viewer shows the geological sequence from north west to south east across Linhay Hill Quarry to be as follows:

Geological Age	Formation
Carboniferous	St Mellion Formation (sandstone, siltstone and mudstone) locally capped with Codden Hill Chert Formation (chert), though shown north of Caton and Goodstone as the Crackington Formation, metamorphosed shale and sandstone, locally capped with the Teign Chert Formation.
Devonian:	Tavy Formation slate and hornfelsed metamorphic bedrock, previously known as the Kate Brook Slate Formation. North of Caton and Goodstone this is not present between the Crackington Formation and the Chercombe Bridge Limestone Formation (CBLF).
Devonian limestone.	Chercombe Bridge Limestone Formation (CBLF), medium to dark grey
Devonian	Foxley Tuff Formation, basic tuff, agglomerate.

Lower Carboniferous Gurrington Slate Formation, slate, lava and tuff.

12.27. The Devon County Council 'Geodiversity Audit of Active Aggregate Quarries Project Overview Report, January 2004 2237/30 PO, records the limestone sequence across the quarry as totalling about 250 metres (measured perpendicular to the bedding) with generally little variation in limestone type throughout. There is however a light brown diagenetic calcite fracture feature approximately 2-5m wide exposed in the quarry's north east face, which the Geodiversity Audit described as being a replacement rather than infill feature, and which cross cuts the bedding sub-vertically and is believed to extend to the north east.

12.28. The outcrop of the CBLF covers an area of more than 300 hectares extending from Ashburton to Bickington and has been subject to karst weathering (dissolution) processes, forming a variety of solution features. Several sub-vertical karst features are exposed in the quarry, particularly on the south east side of the quarry above the Level 4 bench. Groundwater inflow to the quarry from those exposed karst features has not been observed, and the features are infilled with brown clay sediment which suggests they ceased to be important for groundwater flow before they were exposed by the quarry. Within the central area of the quarry is a zone of brown poorer quality rock which has karst features.

12.29. Following the development of the CBLF karst it was covered by claying superficial deposits, probably originating from periglacial and post glacial weathering of the hill slopes to the north west, though it is not known how many phases of superficial deposition occurred, nor the spatial and temporal relationship between phases of deposition and the development of the karst.

12.30. Reference to karst features occurring locally is made in the paper 'Limestone weathering: its engineering significance and a proposed classification scheme, P.G. Fookes and A.B. Hawkins, Quarterly Journal of Engineering Geology, 1988, Vol. 21, pp 7-31, which includes a 'Case History' section on the ground conditions encountered during construction of the Caton Cross Overbridge i.e. the A38 at the Goodstone Junction. With reference to the classification outlined in that paper, the limestone karst features encountered were classed as III to IV; class III being described as 'Karst' with major solution along many joints above the ground water level, and class IV being described as 'Doline Karst' which has the development of dolines above the groundwater level. Indeed a doline (sinkhole) is shown on OS maps from 1842 onwards, located in the back garden of Caton farmhouse, and previously surface water which flowed south east down Caton Road drained around the farmhouse to that doline, as shown on the OS maps.

12.31. To the north west of the limestone deposit being quarried is the less permeable Tavy Formation (previously known as Kate Brook Slate Formation) overlain by the St Mellion Formation / Crackington Formation (sandstones, siltstones, mudstones) further north west. The Tavy Formation forms the north west boundary to the limestone almost to Caton Road where the geological maps show a fault north north west to south south east, east of which the boundary is formed by the Crackington Formation. The limestone extends south west under Ashburton and north east under Alston, Caton, Goodstone, and beyond to Bickington. South east of the existing Linhay Hill Quarry and from the quarry to Caton, the limestone underlies the land south of the A38 for approximately 300-450metres from the A38, with the Foxley Tuff Formation and then the Gurrington Slate Formation to the south of the limestone. The Foxley Tuff Formation also surrounds the south west extent of the limestone west of the where it underlies Ashburton.

Hydrogeology

12.32. The CBLF is classified as a Principal Aquifer whereas the surrounding strata are classified as Secondary A aquifers. There are no superficial deposits which have an aquifer designation other than along the River Lemon river bed where alluvial deposits are classified as 'Secondary A'. The geological map shows some superficial deposits in the form of alluvium along the base of the Kestor Brook valley at Higher Mead Farm and eastwards. The limestone groundwater vulnerability is mainly classified as 'Major Aquifer Intermediate', except for a localised area north of the junction of the minor road from Caton to Gale Road where it is classified as 'Major Aquifer High'. Groundwater vulnerability for the Tavy Formation, St Mellion Formation and Foxley Tuff Formation is classified as 'Minor Aquifer Intermediate', whereas the Gurrington Slate Formation groundwater vulnerability is classified as 'Minor Aquifer High'.

12.33. Groundwater flow in a karst limestone is controlled by a network of fractures and conduits. There is evidence based on observation that the fracture network in the CBLF has a low overall permeability. A network of open fractures is not visible on the quarry face and during periods of low rainfall a seepage face across the face of the pit walls has not been observed. Moreover, during drilling operations, drill cuttings were dry for up to 50 m below the piezometric surface, when the first conduits were encountered.

12.34. There is evidence of conduit groundwater flow within the CBLF and four main groundwater inflows to the quarry from the surrounding limestone. The main inflow above the sump is from a conduit in the limestone which is located on the northeast face of the quarry at an elevation of 85-86mOD to an elevation of approximately 127mOD, which is ground surface. The conduit (referred to as NE face) is a light brown diagenetic calcite fracture feature, approximately 2 to 5 m in width. The conduit cross cuts the bedding sub-vertically. The feature is believed to extend to the northeast. The conduit was exposed during quarrying and may have originally been infilled with sediment, although that cannot be confirmed. The main inflow is located at an elevation of approximately 103mOD within the Level 3 face (approximately 97-110 mOD), though some flow occurs from the Level 2 and Level 4 faces above and below the observed main inflow. During periods of high rainfall, typically in the winter, the inflow is sufficient to form a steady stream of water. During dry periods, typically in the summer, the inflow reduces to a trickle. This indicates that the inflow from the conduit is dependent on rainfall and that the storage within the conduit system is low.

12.35. Smaller inflows to the quarry have been observed at two locations on the southeast face at respective elevations of approximately 88 and 90 mOD, one being a spring referred to as the SE face conduit, and the other seepage. No flow was observed in these features during the majority of site visits made during the preparation of the ES and this revised chapter. Some minor seepage has also been recorded in isolated parts of the quarry at lower levels, and during excavation to Level 7 in late 2017 / early 2018 in the central area of the quarry where there is a distinct zone of brown poorer quality rock, a conduit was encountered which inflows to the sump. Several sediment infilled conduits have been exposed by the quarrying in other parts of the pit, which are predominantly located on the southeast face of the quarry. The frequency of the infilled conduits decreases with depth.

12.36. The quarry sump is now in Level 8 and captures inflows at the base of the quarry. Based on a water balance for the period June 2017 to May 2018, deep groundwater constitutes the largest contribution to water inflows into the quarry.

12.37. Thrust faults located between the Tavy Formation and CBLF, and the Foxley Tuff and CBLF, may be an area of recharge to the limestone. Groundwater may be flowing across the faults from the Tavy and Crackington Formations, and the Foxley Tuff, to the limestone.

12.38. Aquifer tests were undertaken in six deep boreholes within the extension area to assess the hydraulic conductivity of the CBLF and Tavy Formation. The results are consistent with observations during or post drilling, with two boreholes in the limestone showing relatively high flows and hydraulic conductivity, whereas the other tested boreholes in the limestone and the two boreholes in the Tavy Formation display hydraulic conductivity values that are one to two orders of magnitude lower.

Water Resources

12.39. The Environment Agency’s online maps indicate there is no groundwater source protection zone within four kilometres of Linhay Hill Quarry and the proposed quarry extension, the nearest groundwater source protection zones being to the north at Lewthorn Cross at Ilsington, and to the south at Lower Combe and near Baddaford just east of the A38 and Buckfastleigh.

12.40. From the Environment Agency’s South Devon WFD Management Area Abstraction Licensing Strategy, December 2012, states there is ‘water available’ (surface water and groundwater) in the Ashburn catchment (within which Linhay Hill Quarry is located), during the spring, autumn, and winter (Q30, Q50 and Q70) periods. In summer (Q95) water is not available for licensing in the Ashburn catchment. Water is available in the River Lemon catchment all year round (Q30 to Q95).

12.41. The Environment Agency's response to an enquiry regarding licensed groundwater abstractions confirmed there are none located within two kilometres of Linhay Hill Quarry and the proposed quarry extension, and its online maps do not show a groundwater abstraction nearby.

12.42. Teignbridge District Council Environmental Control Team provided a map and list of nineteen private water supplies in the vicinity of Linhay Hill Quarry and the proposed extension. There is also a private borehole water supply at Little Barton Farm to the north north east of the proposed extension. The nearest private water supply is a spring located in Alston Wood which provides water to Alston Farm and Alston Cottage. There are also spring water supplies at Lower Mead south east of the existing quarry and at Lower Brownswell north west of the existing quarry. Those supplies are from the Secondary A aquifer bedrock the Tavy Formation, surrounding the limestone.

Surface Water Features and Drainage

12.43. Linhay Hill Quarry lies within catchment of the River Ashburn which sits within the Dart, Start Bay and Torbay WFD Operational Catchment, the closest point of the River Ashburn to the quarry being approximately 1km west at Cuddyford Cross. The River Ashburn flows through alluvial deposits and the CBLF in the southern part of Ashburton, but in places is also in open concrete lined channel or culverted. The River Ashburn level is gauged in Ashburton by the Environment Agency just upstream of the town centre at elevation of approximately 72mOD, and shown online by the Government's flood information service, though direct monitoring of the, though flows within the River Ashburn in Ashburton has not been undertaken by the Environment Agency.

12.44. Several springs discharge mostly during the winter months at the contact of the St. Mellion and Tavy Formations, and directly from the St. Mellion Formation. The St Mellion Formation pinches out above the Tavy Formation to the northwest of the quarry. Groundwater comes to the surface as springs at the contact between the two units as the Tavy Formation is less permeable than the St Mellion Formation. Springs also emerge directly from the multi-layered St. Mellion Formation aquifer, possibly a consequence of sandstone emerging to the surface above a mudstone unit. The springs are seasonal and do not flow during periods of low rainfall, which may be due to seasonal water table fluctuations in the St. Mellion Formation. The springs located to the north of Linhay Hill Quarry generally drain into the Balland Stream. During periods of heavy rainfall, overland flow from the quarry's spoil tip to the northwest also discharges directly into the quarry.

12.45. The catchment for the Balland Stream lies to the north and west of the quarry and is fed by a number of springs, surface runoff and periodic pumped discharge from the Balland Pit. The Balland Pit provides attenuation storage and acts as a settlement pond to remove suspended solids before the water is recycled in the quarry for various manufacturing uses, washing and dust suppression. On a catchment scale it is estimated the quarry utilises very little water, and the quarry's water usage is not expected to change with the proposed extension. Excess water is pumped from the Balland Pit to discharge to the Balland Stream.

12.46. The lower Balland Stream is dry during extended periods of low rainfall. The Balland Stream flows over the Tavy Formation approximately along the north and northeast boundary of the quarry. It is partly culverted and in places runs in an open concrete block lined channel. The stream flows through the west side of the quarry property, and then southwest, roughly parallel to the A38, joining the River Ashburn in the town of Ashburton. The Balland Stream flows in an open concrete channel and culvert in Ashburton. The Balland Stream was 'enmained' by the Environment Agency in April 2006 to become a main river, and the Environment Agency's flood maps imply the main river classification begins from the workshops area of Linhay Hill Quarry.

12.47. The quarry extension will expand into the Teign WFD Operational Catchment, which is a subdivision of the South Devon Management Catchment. The River Lemon is a sub-catchment of the Teign catchment, and the closest point of the River Lemon to the quarry is approximately 2.3 km to the northeast, roughly where the river crosses under the A38 at Bickington. The River Lemon flows through a zone of the CBLF for approximately 500m in Bickington and the river leve is gauged in Bickington by the Environment Agency and shown online by the Government's flood information service, however direct monitoring of the flows within the River Lemon in Bickington has not been undertaken by the Environment Agency.

12.48. Spring areas located in Alston Wood (much of which is within the 6.7ha Little Barton Fields Unconfirmed Wildlife Site) to the north of the Alston Farm, flow during periods of high rainfall overland to the south, past Alston Farm and form the Alston stream. One source of water flow is from an adit driven into the Tavy Formation north of Alston Farm and is currently used as a private water supply for Alston Farm and Alston Cottage. There are also springs near the adit. The Alston stream provides recharge to the CBLF as it flows overland and flows over a swallow hole located approximately 150 m southwest of the Alston Farm. The seasonal Alston stream flows south past this swallow hole during periods of high flows, via a network of ditches, some of which may be sinking streams, to a small culvert which flows under the A38. The culvert discharges to the 1ha Mead Cross Unconfirmed Wildlife Site (a habitat of broadleaved woodland which lies approximately 165m south of the proposed quarry extension) where, if the flows are very high (drainage lines within the Mead Cross Unconfirmed Wildlife site are typically dry, even during winter), overland flow may reach the upper reach of the Kester Brook. A conservative assumption is that when flows are high the Alston stream connects with the Kester Brook, via the overland ditch network. The Kester Brook flows into the River Lemon.

12.49. There are also springs located outside (east) of the proposed quarry extension approximately 350m northeast of the Alston Farm in the field east of Little Barton, and emerging behind the property ‘Samastar’. The water from these springs flows overland (south) across the CBLF and may recharge the limestone. The spring east of Little Barton and runoff from the catchment above forms a stream which flows south towards Caton (referred to locally as the Caton stream), whereas the spring behind ‘Samastar’ flows southeast. The stream at Caton has been diverted around the hamlet of Caton. Prior to its diversion, the stream flowed to a swallow hole behind Caton Farm house. The Caton stream either goes to ground south of Caton before a cattle creep underbridge to the A38, or when flow is sufficient, the stream flows through the underbridge. Approximately 100 m to the southeast of the underbridge the watercourse ceases and the water can pond in an area which is typically dry except in winter. In high flow periods, water can flow overland from that area across a field to the southwest, though there is no watercourse. That water can then flow down the road to eventually join the Kester Brook. Localised subsidence appeared in February 2014 within an existing doline depression north of the A38 off slip road at Caton, most likely due to excess surface water run off during a very wet winter.

12.50. A spring is located in the CBLF at Higher Lemonford, approximately 2km northeast of Linhay Hill Quarry. The spring flows to ab small watercourse (referred to as the Lemonford stream) which discharges to the River Lemon at Bickington. The Lemonford stream catchment extends west under the A38.

12.51. Lower Mead Farm is situated 600m southeast of the quarry. A stream (referred to as the Mead Farm stream) flows from the farm north to the CBLF. At a site visit by Atkins in December 2016, the Mead Farm stream was observed to flow directly into a small swallow hole (approximately 0.1-0.15m diameter), located approximately 200m north of the farm. The swallow hole had not been observed previously and is susceptible to blockage, following clearance of the nearby field drainage channel by the farmer. Cessation in flows to the swallow hole has been observed as a result, but when open there is reduced flow in the Kester Brook watercourse north of Gale Road between Mead Cross and Goodstone. When the swallow hole is blocked or flows are sufficient to pass it, the Mead Farm stream flows northeast under Mead Cross and into the Kester Brook.

12.52. The Kester Brook is a tributary of the River Lemon. The major input of the Kester Brook is the Goodstone Spring, though the Goodstone Spring does not flow during periods of low rainfall. The Goodstone Spring overlies Alluvium and the Foxley Tuff Formation, close to the boundary of the Foxley Tuff Formation with the CBLF. The origin of the Goodstone springs may be from upwelling groundwater at the contact between the limestone and the Foxley Tuff causing groundwater mounding within the Alluvium. The Goodstone Spring area is the most significant known spring outflow from the CBLF in the area. Glendale Spring is located in close proximity to the Goodstone Spring area and also discharges to the Kester Brook, but from observation is a very minor flow in comparison to the Goodstone Spring area. The underlying limestone deposit spans across the middle of the Balland Stream and Kestor Brook catchments which increases the complexity of the hydrological and hydrogeological interaction.

12.53. Alluvial deposits extend from the western part of the CBLF to the Goodstone Spring and continue to the River Lemon. The Kester Brook follows the path of the alluvial deposits and joins the River Lemon approximately 3km to the east.

Water Quality Monitoring

12.54. Water quality monitoring has been carried out since December 2016 monthly when flows allow within the quarry and of watercourses, the main locations being the Balland Stream upstream of the quarry discharge, the quarry discharge, the quarry sump, the north east face conduit inflow, the Alston stream, the Caton stream, the stream from behind the Samastar property, the Lemonford stream, the Kestor Brook, the Mead Farm stream. That was supplemented with occasional spot samples from several additional springs, discharges to and from ponds and monitoring boreholes during the monitoring period. The aim was to determine whether the geochemistry can be used to develop an improved understanding of groundwater flow pathways though the CBLF, and to better conceptualise interactions between groundwater and surface water.

12.55. Based on piper plots the majority of locations can be characterised as having a calcium bicarbonate dominant water type. High levels of total dissolved solids and calcium bicarbonate water type indicates that a substantial component of the flow at Lemonford stream and Kester Brook has come from the CBLF, whereas the data is interpreted to indicate that the chloride component of the water in the Kester Brook, Lemonford stream and Mead Farm stream monitoring locations is likely to originate from the Foxley Tuff and not from the limestone.

12.56. Monitoring locations to the north and northeast of the quarry, on the Balland Stream, Alston stream, Caton stream and adjacent to the A38 slip road (spring source being the property 'Samastar') have lower concentrations of major ions than other locations within the limestone outcrop, most notably calcium and bicarbonate, though were still classified as having a calcium bicarbonate dominant water type due to low concentrations of other major ions. Many springs which emerge from the Tavy and Crackington Formations north of the limestone are of calcium/ sodium & potassium – bicarbonate/ chloride dominant water types. The available groundwater sampling data show substantially higher concentrations of bicarbonate than were observed at the surface water monitoring locations, with the exception of the Kestor Brook and Lemonford stream, which are likely to be fed by a significant proportion of groundwater from the limestone.

12.57. Monitoring locations within the quarry, at the sump and at the NE face conduit have high concentrations of major ions (most notably calcium), while total dissolved solids and sulphate concentrations are particularly high in the sump, and both locations show a calcium bicarbonate dominant water type. Elevated sulphate is apparent in the sump and quarry discharge, most likely due to quarry operations.

12.58. Kester Brook and Lemonford stream have higher absolute carbonate concentrations than the NE face. The waters are all supersaturated with respect to calcite. However, the variation of the saturation index for the NE face is relatively uniform, whereas the saturation index for Kester Brook and Lemonford stream fluctuates, presumably because of the influence of rainfall and mixing with surface water. The Kester Brook and Lemonford saturation index peaks are higher than the NE face peaks, which indicates a longer groundwater flow path through the CBLF for the Lemonford stream and Kester Brook.

12.59. The Hydrogeological Impact Assessment (2016) considered that there may be a direct link between the Alston sinkhole and the NE face conduit. Tracer was injected within the Alston swallow hole but not detected at the NE face. Since then the monitoring has shown the Alston stream to be a calcium and sodium bicarbonate type water with significant chloride present, whereas the NE face conduit is a calcium carbonate type water. These findings indicate there may not be direct or rapid hydraulic connection between the Alston swallow hole and the quarry's NE face.

12.60. Overall the water quality monitoring has not revealed clear and definitive flow pathways between the recharge and discharge zones of the CBLF, though some general characteristics are apparent as described above. Also of note occasional higher nitrate concentrations are apparent at some watercourses which may reflect the local agricultural land use, and also higher nitrate in the quarry sump than observed in the NE face inflow, suggesting the sump inflows are from deeper groundwater within the limestone and is consistent with the sump receiving diffuse inflows from both agricultural and non-agricultural parts of the catchment.

Water Resource Monitoring

12.61. A programme of data collection to inform the overall conceptual model of the site and develop the water balance for the area has been carried out comprising:

- Daily rainfall from three locations.
- Stream levels at 15-minute intervals and daily flow estimates.
- Daily monitoring of flow from the NE face and SE face conduits in the quarry, metering of water pumped from the quarry sump, level monitoring of the Balland Pit and metering of water discharged to the Balland Stream
- Monitoring of water levels in boreholes, mostly automatically at 15 minute intervals, and some boreholes by monthly dip meter measurement.
- Monitoring of water levels in boreholes at 20-30 second intervals and monitoring of water levels within the quarry sump at 20 second intervals, during a signal test to investigate vertical flow paths within the CBLF.

Flows

12.62. The Balland Stream, Alston stream, Caton stream and the Kestor Brook are characterised by relatively consistent, low flows in summer and autumn, with short-lived peaks in winter and early spring in response to the combined effects of rainfall and wet soils, leading to increased runoff. Estimated flows in the Lemonford stream are more consistent throughout the year, suggesting a greater contribution from groundwater, particularly during summer. The Mead Farm stream shows both flashy responses to rain events and sustained flow during the summer, indicating significant contributions from both surface runoff and groundwater

12.63. The quarry transfers excess water to the Balland Stream and that discharge is authorised by the Environment Agency under an environmental permit which limits the rate at which water can be discharged to 10,000m3/day (115.7 litres per second on average) and 277 litres per second instantaneously. The pumped discharge volume from the quarry varies considerably seasonally, an example being discharge of around 6,480, 1019, 5450m^3/day in January 2016, 2017 and 2018 respectively, compared to 530, 792, and 1192m^3/day in May 2016, 2017 and 2018 respectively, and an estimated water usage by the quarry of less than 75m^3/day. There was negligible discharge to the Balland Stream from the quarry during June to September for 2016 and 2018. The volume pumped from the sump is substantially greater than the inflows from the NE face or SE face conduits.

Groundwater Levels

12.64. The groundwater level data provides an indication of groundwater flow directions near the quarry, though karst features may lead to localised variations in groundwater level. The data show a groundwater level low around the quarry void and suggest a component of groundwater flow from the northeast. During monitoring the highest groundwater levels occurred in March 2018 and the lowest in September 2018. Observed groundwater levels are below the Caton stream and below Mead Cross Unconfirmed Wildlife Site and the Kestor Brook south of the wildlife site for the majority of the time.

12.65. Groundwater levels within two boreholes within the Tavy Formation are relatively consistent over the monitoring period compared to those monitored in the CBLF, with one showing persistent artesian conditions. This combined with the low permeability of the Tavy Formation as measured by borehole hydraulic tests, suggests that historical dewatering from the quarry has not appreciably affected groundwater levels within the Tavy Formation.

12.66. Within the CBLF seasonal variations in groundwater levels differ notably between different boreholes close to the quarry, and there are also differing responses to rainfall which provide further evidence of the heterogeneity of the CBLF. Observed flows within the NE face conduit respond rapidly to rainfall and decline markedly during dry periods, despite nearby groundwater levels remaining substantially above the base of the conduit, which suggests that rainfall, rather than groundwater seepage, is the main control on flow at the NE face conduit. Boreholes in the deeper part of the CBLF show a dampened response to rainfall over a longer period which indicates groundwater flow to the deeper parts of the CBLF is controlled by piston flow, which represents prolonged drainage from the matrix of the limestone following rainfall, while recharge to the shallower parts of the formation is controlled by rapid bypass flow through conduits. A signal test was undertaken in 2018 which entailed cessation of pumping from the quarry for ten days during which time groundwater levels rose by 8m within the sump, However a signal was only detected in two boreholes within the quarry near to the sump, and the cessation of pumping did not induce detectable changes in the other boreholes, which displayed an overall decline in water levels over the test period. Flow from the NE face conduit also did not respond to the signal test. Overall it is apparent that the deep and shallow parts of the limestone are not well connected hydraulically.

12.67. There is flow from a small number of conduits within the quarry and the absence of seepage faces in the surrounding network of fractures within the limestone indicates that flow within the CBLF is controlled by conduits and that they are distributed unevenly within the formation. The anisotropic response to the signal test further highlights the uneven distribution of conduits. The presence of shallow conduits within the quarry and swallow holes demonstrate that conduits exist within a shallow zone of the limestone, which includes the epikarst. The occurrence of deep water strikes during drilling within the limestone, and the subsequent large rise in groundwater levels, suggests that there is an additional set of conduits at depth, which are not well connected to the shallow zone. The differing responses of these shallow and deep zones to rainfall, supports a conceptual model of a two-zone flow system.

12.68. When the quarry intercepts a shallow zone conduit, water drains into the quarry, and gradually removes fines from infilled conduits, instigating groundwater flow. The sump pump itself is well below the epikarst and the data indicates dewatering of the deeper conduits intercepted by the sump is unlikely to affect the flow regime within the epikarst. The available data indicate that groundwater from the deep zone dominates inflows to the quarry, with a substantially smaller component coming from the shallow zone.

12.69. The presence of numerous springs to the north of the CBLF outcrop, the upward hydraulic gradient in the Tavy Formation, as demonstrated by water levels in boreholes and the low hydraulic conductivities from borehole hydraulic tests indicate that groundwater flow from the Tavy Formation to the CBLF is limited. Furthermore, the boreholes in the Tavy Formation showed no response to the signal test. The persistent artesian groundwater levels in one of the boreholes in the Tavy Formation also provides further evidence that dewatering from the quarry has not affected groundwater resources in the low permeability formations to the north of the CBLF.

Water Balance

12.70. In karst systems, there is typically uncertainty over the location and hydraulic significance of conduits, leading to difficulties in defining groundwater flow paths and predicting effects on individual receptors. However, transient water balances can greatly assist in quantifying the overall scale of effects and provide a basis for determining mitigation measures, and hence a water balance has been estimated for the CBLF for the period June 2017 to May 2018. It is intended that this water balance will be revisited with future data acquisition on a regular basis. Rainfall is the ultimate source of all inflows to the catchment of the limestone which comprises:

1. Direct recharge to the limestone outcrop.
2. Surface runoff to streams within the limestone outcrop.
3. Recharge to other units that crop out within the topographic catchment of the limestone.
4. Surface runoff to streams or ponds that lie upstream of the limestone outcrop; and
5. Direct rainfall to the Balland Pit.

12.71. Once evapotranspiration and changes in soil moisture have been accounted for, the soil moisture balance assigns any excess moisture to either recharge or runoff. But as rainfall entering neighbouring formations as recharge may resurface near the boundary of the CBLF, before once more recharging the underlying aquifer, the results of the water balance are reported as a combination of recharge and runoff, to avoid double accounting.

12.72. Qutflows from the CBLF comprise:

1. Stream flows within the Kestor Brook, the River Lemon and the Balland Stream, which joins the River Ashburn at the south-western edge of the limestone.
2. Evapotranspiration from soil and vegetation.
3. Evaporation from the Balland Pit. =
4. Water used by the quarry for the production of limestone aggregate, ready-mix concrete, speed screed, black sand, ground limestone, concrete masonry blocks and dust suppression.

12.73. A separate water balance was developed for the quarry and includes the following inflows:

1. inflows from the SE face and NE face conduits;
2. deep groundwater inflows to the sump;
3. surface runoff to the sump;
4. surface runoff to the Balland Pit; and
5. direct rainfall to the Balland Pit.

12.74. Outflows from the quarry comprise:

1. Pumped discharge from the Balland Pit to the Balland Stream.
2. Evaporation from the Balland Pit.
3. Infiltration through the base of the Balland Pit.
4. Water used for the production of limestone aggregate, ready-mix concrete, speed screed, black sand, ground limestone and concrete masonry blocks,
5. Evaporation from dust suppression.

12.75. To estimate recharge within the topographic catchment of the CBLF, a soil moisture balance was set up, based on the standard Food and Agriculture Organisation of the United Nations (FAO) method described by Allen et al. (1998) and Rushton et al. (2006) as detailed in the Hydrogeological Impact Assessment 2018.

12.76. Overall, inflows exceeded outflows by approximately 1.5% over the period of the water balance. This is consistent with the relatively high rainfall recorded at the Bickington rainfall gauge over the period of the water balance (1230 mm), which exceeded recorded rainfall for the previous 12 months (760 mm) by more than 60%. As is commonly the case with water balances in temperate climates, the largest increases in storage occur during the winter months, where reduced evapotranspiration leads to relatively high recharge and surface runoff. Recharge and runoff from rainfall upstream of the CBLF ultimately provide the largest component of inflows to the limestone, accounting for 52% of the total. This may reach the outcrop of the limestone either as groundwater flow from adjacent formations, or via surface watercourses, which may remain in streams as surface water, or enter the limestone itself via the beds of these streams or via swallow holes.

12.77. Recharge and runoff from rain falling on the outcrop of the CBLF makes a comparable, although slightly smaller contribution to inflows, providing 47% of the total, while rain falling directly on the Balland Pit provides less than 1%.

12.78. Surface water courses constitute the dominant outflow mechanism from the CBLF, with groundwater flows to neighbouring, low permeability formations are likely to be negligible by comparison. Pumped discharges to the Balland Stream accounted for 86% of outflows from the quarry, with infiltration from the base of the Balland Pit to the limestone contributing a further 10% of outflows. Evaporation from the Balland Pit, evaporation from dust suppression and embodied water leaving the quarry in various manufactured products all accounted for less than 3% of quarry outflows. Inflows to the quarry exceeded outflows by approximately 1.5% over the period of the water balance. This is comparable to the ratio of inflows to outflows for the CBLF as a whole, which suggests the quarry's effect on the water balance of the CBLF is minimal, an assertion supported by the fact that the quarry lies within the topographic catchment of the Balland Stream and returns the majority of inflows to this watercourse.

12.79. Comparison of the two water balances suggests that inflows to the quarry were equivalent in magnitude to 17% of inflows to the CBLF as a whole. The contribution of shallow groundwater inflows was equivalent to 2.5% of the total for the limestone, with inflows of deeper groundwater equivalent to 7.4% of inflows.

Flood Risk

12.80. The Environment Agency provides Flood Zone maps available via its website and from inspection the following flood zone classifications apply to the development proposals:

Development Area	Flood Zone classification
• Widening of Balland Lane	Flood Zone 3
• Junction of Waye Lane new public road with Balland Lane	Flood Zone 3
• Waye Lane new public road and footpath diversion	Flood Zone 1
• New private access to Alston Cottage and Alston Farm	Flood Zone 1
• Diversion of electricity and water supply from Alston Lane	Flood Zone 1
• Extension of quarry extraction area into Alston Farm fields	Flood Zone 1
• Bunds in south and east of Alston Farm fields	Flood Zone 1
• Balland Stream flood flow diversion to quarry	Flood Zone 3
• Restored quarry, lake discharge control to Balland Stream	Flood Zone 3

12.81. Planning Practice Guidance also requires the flood risk vulnerability of the development or land use to be taken into account because the consequences of flooding may not be acceptable for particular types of development. Flood Risk Vulnerability Classification is provided in the Planning Practice Guidance Table 2. With reference to that table, mineral working and processing (except sand and gravel working) which applies to extension of the quarry extraction and the new bunds, is classified as 'Less Vulnerable'. The new access to Alston Farm and electricity and water supply diversions from Alston Lane, the new Waye Lane public road and footpath diversion and widening of Balland Lane are also considered to be 'Less Vulnerable' as they do not represent essential infrastructure. Flood control infrastructure which is to be installed to improve the Balland Stream flood flow diversion to the quarry, and for discharge control from the quarry once restored to a lake, is classified as 'Water-Compatible Development'.

12.82. The surface water flow routes to and within the central confluence area of Ashburton have a history of flooding. Consequently the Environment Agency has designated much of the Balland Stream as a Critical Drainage Area, i.e. an area that has critical drainage problems and which has been notified to the Local Planning Authority as such by the Environment Agency in line with the National Planning Policy Framework (NPPF). The Critical Drainage Area lies mainly west of the A38 and includes the existing quarry and spoil tip, land at Waye and along the Balland Stream north of the quarry, and parts of Ashburton east of the Balland Stream confluence with the River Ashburn.

12.83. The proposals cover an area of more than one hectare and include land within Flood Zones 1 to 3 which has critical drainage problems being within the Ashburton Critical Drainage Area, hence the proposal fall within the terms of the Town and Country Planning (Consultation) (England) Direction 2009.

Surface Water Runoff

12.84. The Environment Agency's maps 'Risk of Flooding from Surface Water' show many areas at risk within the existing Linhay Hill Quarry, but those areas are actively managed by the quarry as part of its daily operations. Surface water flood risk is also shown along the minor watercourses from the silted former fish pond at Waye, and from Waye Plantation and Higher Brownswell which lead to a relatively large area shown as 'High' risk over the farm track between Waye and Place.

Groundwater

12.85. There is anecdotal evidence that during the winter 2013-2014 there was prolonged standing water within the area south of the A38, north of Gale Road between Mead Cross and south of Goodstone. The fact that flooding was prolonged may suggest a seasonally high water table, though it can be observed that the water flow route also has several constraints which hinder flow, such as hedge field boundaries, small pipes susceptible to blockage, and an overgrown poorly defined channel in places.

12.86. The then lowest level of Linhay Hill Quarry, level 5 (82-68mOD) was also flooded from approximately 18th December 2013 to 1st March 2014 due to the wet weather and the Balland Pit reached capacity, meaning no water could be pumped from level 5 for about four weeks. However the level of that standing water was well below the standing water north of Gale Road during winter 2013-2014. The lowest level of the quarry will occasionally flood during prolonged heavy rain, and that provides attenuation of pumped water to the Balland Pit to ensure sufficient retention time for settlement within the Balland Pit prior to transfer discharge to the Balland Stream.

Key findings

12.87. The Hydrogeological Impact Assessment 2018 concludes that the karst characteristics of the limestone environment of the CBLF means that the specific approach for karst in the Environment Agency's Science Report – SC040020/SR1 Hydrogeological impact appraisal for dewatering abstractions, 2007 is the appropriate methodology to follow.

12.88. Overall it is apparent that the deep and shallow parts of the limestone are not well connected hydraulically. The differing responses of these shallow and deep zones to rainfall, supports a conceptual model of a two-zone flow system.

12.89. The available data indicate that groundwater from the deep zone dominates inflows to the quarry, with a substantially smaller component coming from the shallow zone.

12.90. Groundwater flow from the Tavy Formation to the CBLF is limited. The boreholes in the Tavy Formation showed no response to the signal test, and the persistent artesian groundwater levels in one of the boreholes in the Tavy Formation also provides further evidence that dewatering from the quarry has not affected groundwater resources in the low permeability formations to the north of the CBLF.

12.91. Comparison of the water balances of the CBLF and the quarry suggests that inflows to the quarry were equivalent in magnitude to 17% of all inflows to the CBLF as a whole. The contribution of shallow groundwater inflows was equivalent to 2.5% of the total for the limestone, with inflows of deeper groundwater equivalent to 7.4% of inflows. Hence, the quarry's effect on the water balance of the CBLF is minimal, an assertion further supported by the fact that the quarry lies within the topographic catchment of the Balland Stream and returns the majority of inflows to this watercourse.

Future Baseline

12.92. The future baseline is defined as changes to the baseline which would occur if the proposed quarry extension did not place – the Do Nothing Scenario.

12.93. In the Do Nothing Scenario, rock extraction at Linhay Hill Quarry will cease when the reserves are exhausted or no longer viable to extract and restoration will proceed as per a scheme to be agreed with the DNPA under the terms of conditions on the existing planning permission(s). The scheme will entail ceasing the pumping of water so that the void will begin to fill with water from rainfall and groundwater, with restoration to open water. The water level in the void will recover until inflow equates to groundwater outflows, and it is expected groundwater movement will follow flow paths similar to those prior to dewatering of the quarry.

12.94. Prior to formation of the existing quarry, surface water runoff from the land was to the Balland Stream to which there would also have been some baseflow from groundwater. However there is now no natural surface water outflow route from the quarry extraction void, so the concern from a flood risk mitigation perspective is that if rainfall and surface water runoff to the lake exceed the groundwater outflow then the lake water level will continue to rise. If the water within the quarry void was to rise above the lowest elevation around that perimeter of the void and so overflow, that would be an uncontrolled discharge which would represent a flood risk to the maintenance and block manufacturing and storage areas of the existing quarry, and to Ashburton downstream. That risk is the same for the proposed quarry extension and hence has been appraised in the Flood Risk Assessment accompanying the extension application.

12.95. The lowest elevation around the quarry void is 102.16mOD at a point west of the south west corner of the Balland Pit, so there are several metres elevation of rock between the quarry void and the Balland Stream, effectively a rock buttress around the Balland Pit. Therefore to enable control of discharge from a lake it is envisaged a channel to the Balland Stream would need to be cut through the rock buttress as part of the restoration of the existing quarry. The channel would be formed in open cut, although it is envisaged that a pipe with manholes would be installed and then the pipe backfilled over.

12.96. As with restoration of the proposed extended quarry as detailed in the Flood Risk Assessment for the proposed quarry extension (paragraphs 6.46 to 6.56), in the restoration of the existing quarry the lake water discharge would be restricted to a maximum rate, which would be agreed with the flood authorities to ensure flood protection to Ashburton. Discharge from the lake would not be able to occur above the agreed maximum discharge rate. Instead the water level in the lake would rise to provide flood attenuation storage during heavy or prolonged rainfall as appraised in the Flood Risk Assessment for the proposed quarry extension.

12.97. For the existing quarry void the minimum area of a lake to a level of 96mOD is estimated as 25.43 ha with a topographic catchment including the lake area of 51.78 ha. That is smaller than the proposed extension 37.34 ha lake area to 96mOD with topographic catchment 81.43 hectares including the lake area, hence by comparison the discharge and lake level rise during attenuation following restoration of the existing quarry would be less than that evaluated in the Flood Risk Assessment for the proposed quarry extension.

12.98. Regarding potential climate change the Flood Risk Assessment for the proposed extension follows guidance within the National Planning Policy Framework Flood Risk Assessments: Climate Change Allowances, applicable from 19th February 2016 (last updated 3rd February 2017). Its Table 2 'peak rainfall intensity allowance in small and urban catchments' prescribes for peak rainfall intensity 'Upper end' and 'Central' allowances of 40% and 20% respectively for the total potential change anticipated for 2060 to 2115 to be used to understand the range of possible effect. For comparison the Flood Risk Assessment also included the UKCP09 climate change projections for precipitation for the locality of Linhay Hill Quarry for the period 2070-2099, which indicated the NPPF allowances are likely to be more conservative.

12.99. If the proposed quarry extension did not proceed then the existing quarry will move into its restoration stage within about seven to ten years, which is sooner than the timeframe for the climate change projections used in the Flood Risk Assessment for the proposed extension. Hence the climate change projections used in the Flood Risk Assessment for the proposed extension will be conservative for the water resource future baseline. The UKCP09 projections over UK land areas has been updated by the UKCP18 projections from late November 2018, however until that time the Government in its technical note 'Is UKCP09 still an appropriate tool for adaptation planning? Land Projections', April 2016, concluded *"that UKCP09 continues to provide a valid assessment of future UK climate over land, and it can still be used for adaptation planning. In particular, it demonstrates that UKCP09 gives results consistent with CMIP5 for future changes to summer and winter temperature, and winter rainfall in the UK".*

12.100. In general terms, climate change is expected to result in more extreme weather, including more very hot days, more intense rainfall, and an increase in dry spells. In addition, the probability of short periods of intense cold weather and of more frequent storms and high winds is also likely to increase but with a higher level of uncertainty. These changes in climatic averages and extreme weather events may become more pronounced during the operational lifetime of the quarry and thereafter, unless the driving cause of climate change is reversed.

12.101. UKCP18 provides ranges that aim to capture a spread of climate response based on current knowledge and uses new emissions scenarios, called Representative Concentration Pathways (RCPs). RCPs are the emissions scenarios used in the Intergovernmental Panel on Climate Change's latest 5th assessment report. UKCP09 used the SRES (Special Report on Emissions Scenarios) emissions scenarios which were reported on in the IPCC's 4th assessment report. RCPs specify the concentrations of greenhouse gases that would result in target amounts of radiative forcing at the top of the atmosphere by 2100, relative to pre-industrial levels. Four forcing levels have been set: 2.6, 4.5, 6.0 and 8.5 W/m2, reflecting low to high emissions and which create four RCPs that are used in UKCP18 for which the predicted best estimate global mean surface temperatures (with 5-95% range in brackets) by 2081-2100 are: RCP2.6 1.6°C (0.9-2.3°C), RCP4.5 2.4°C (1.7-3.2°C), RCP6.0 2.8°C (2.0-3.7°C) and RCP8.5 4.3°C (3.2-5.4°C).

12.102. Detailed regional projections are not yet readily available to download so reference has been made to the 'Key Results – Land Projection Maps: Probabilistic Projections' for the precipitation winter, summer and annual anomaly for the period 2080-2099 minus 1981-2000. The 50-percentile projection for annual rain for RCP8.5 is 0% to +10% whereas for RCP2.6 it is 0% to -10%. The 50-percentile projection for winter rain (December, January, February) for RCP8.5 is +20% to +30% whereas for RCP2.6 it is +10% to +20%. The 50- percentile projection for summer rain (June, July, August) for RCP8.5 is -40% to -50% whereas for RCP2.6 it is -20% to -30%.

12.103. Those projections indicate a potential for wetter winters and drier summers, but annual rainfall is likely to remain similar to 1981-2000 i.e. effectively the same as currently. Therefore it is considered that no further appraisal of potential climate change effects on the water resource future baseline is required.

Summary of Baseline in the Water Environment

12.104. The water environment features identified as being impacted are surface watercourse and catchment water resources with a potential for effects on those and nearby abstractions around the quarry, and flood risk areas. The following table provides a summary of the baseline importance of features in the water environment around the proposed extension of Linhay Hill Quarry.

Table 12-4 Water Environment Baseline

Water Environment Feature	Importance
Surface Water	
- Balland Stream ordinary watercourse.	Low
- Balland Stream main river.	Medium
- Alston stream ordinary watercourse which flows across Alston Farm fields.	Minimal
- Ordinary watercourse which flows down Caton Road, referred to as Caton stream.	Minimal
- Kestor Brook ordinary watercourse which runs from parallel to and north of Gale Road from Mead Cross to south of Goodstone.	Minimal to Low
- Kestor Brook ordinary watercourse and springs south of Goodstone at Four Acres and Glendale, which provide baseflow to the Kestor Brook.	Low
- Lemonford stream ordinary watercourse which flows to the River Lemon.	Medium
- River Lemon main river.	Medium
Water resources	
- Within the River Ashburn catchment.	Medium
- Within the River Lemon catchment.	Medium
Private water supplies	
- Secondary A aquifer spring and well supplying properties at Brownswell.	Low
- Secondary A aquifer spring supplying Alston Farm and Alston Cottage.	Low
- Secondary A aquifer well supplying Little Barton.	Low
- Secondary A aquifer spring supplying Lower Mead Farm.	Low
Ecological sites	
- Little Barton Unconfirmed Wildlife Site (locally designated at County level)	Minimal to Low
- Mead Cross Unconfirmed Wildlife Site (locally designated at County level)	Minimal to Low
Flood Risk – from fluvial flows and or surface water runoff	
- Within the quarry and proposed extension.	Low
- To Ashburton from the Balland Stream.	High
- Along the Kestor Brook.	Low
Flood Risk – from groundwater	
- Within the quarry and proposed extension.	Low to Medium
- Along the Kestor Brook north of Gale Road from Mead Cross to south of Goodstone.	Low

Sensitive Sites

12.105. The Hydrogeological Impact Assessment (2018) identifies the following water environment features as sensitive sites for Step K3 of the Environment Agency's hydrogeological impact assessment approach for karst aquifers (Science Report – SC040020/SR1). These sites are effectively included in Table 12-4:

Within the River Ashburn catchment

a. The Balland Stream to the northwest of the proposed extension.
b. Private water supplies to the north and north west at Brownswell and in Alston Wood for Alston Farm.

Within the River Lemon catchment

c. Private water supply at Little Barton.
d. Caton stream to the east of the proposed extension, and which flows south adjacent Caton Lane and around the north side of the Caton Farm buildings.
e. Samastar stream, which flows south to the east of Caton stream.
f. The Mead Cross UWS south of the A38, underlain by the limestone.
g. The Kestor Brook which flows seasonally adjacent the Gale Road and from springs south of Goodstone at Four Acres and Glendale, from where the Kestor Brook flows east.
h. The Lemonford stream at Higher Lemonford, which flows to the River Lemon.
i. The River Lemon, where it flows over the CBLF at Bickington.

Identification and Evaluation of Potential Effects

12.106. The proposed extension to Linhay Hill Quarry and associated infrastructure works will result in some modifications to the existing surface water drainage, and there will be new surface water drainage provided to convey runoff and increase attenuation storage and to prevent runoff off-site. Those changes are shown in the Planning Application drawings (LINHAY-ATK-S0-Z-PL-001, S1-Z-PL-1000, S2-Z-PL-2000, S3-Z-PL-3000, S4-PL-4000, S5-Z-PL-5000, S6-Z-PL-6000) and detailed in the Flood Risk Assessment and the Hydrogeological Impact Assessments. The dewatering by the extended quarry will extend the existing area of influence on groundwater with the potential without mitigation to cause some effects on flow in watercourses and a potential to effect other nearby water features such as abstractions or habitat areas or flood risk.

12.107. These impacts and effects are examined in the text below. It is also relevant to understand that the quarry extension has a long timescale with several stages, which provides opportunities to review the hydrological and hydrogeological conceptual model and effectiveness of monitoring and mitigation for the design, and the trigger levels for mitigation before subsequent stages progress.

Potential Hydrogeological Impacts without Mitigation

Potential Effects from Deepening the Existing Quarry

12.108. The proposed deepening of the existing quarry will bring the quarry base to a maximum depth of 0mAOD, consistent with the maximum depth of the extension area. In both areas, these deeper excavations are likely to occur either within or below the deep zone of groundwater flow, and effects are likely to be diffuse in nature i.e. spread out over a wide area and so manifest as small or not discernible change locally. Although numerous studies describe an overall reduction in permeability with depth in both karstic limestone and more broadly in all aquifer types, it is notable that the quarry has intercepted a deep zone of permeable conduits.

12.109. Based on a sump elevation of 36.5mOD and the groundwater levels, the quarry currently dewaters to a depth of approximately 80m below the pre-existing water table. If it is conservatively assumed that the deeper parts of the CBLF are equally as permeable as the sections already intersected by the quarry, groundwater inflows may increase by approximately 46% at the maximum excavation depth of 0mOD. This would lead to an increase in annual groundwater inflows of nearly 238 ML (650 m^3/day) compared for example to the 742ML (2,032 m^3/day) pumped to the Balland Stream between June 2017 and May 2018.

12.110. It is likely that deeper inflows of groundwater to the quarry currently come from a broadly easterly direction. Hence a substantial component of this water is likely to come from the catchment of the

Kestor Brook and its tributaries, and it is probable that much of the additional inflow due to deepening of the existing quarry would also come from the Kestor Brook catchment.

Potential Effects on Water Resources

12.111. The existing quarry has intercepted a small number of shallow, sediment-filled conduits, which have subsequently discharged groundwater to the quarry void. The rapid response of flow within these conduits to rainfall indicates that they are well-connected to the surface. Although these conduits account for a small component of the quarry water balance and a smaller component of the water balance for the CBLF as a whole, there is the potential for these discharges to affect flow in nearby surface water courses, which are connected to the shallow groundwater system by infiltration or exfiltration through the stream beds or swallow holes. In addition the Mead Cross Unconfirmed Wildlife site may be sensitive to potential changes in groundwater level near the surface.

12.112. According to the Environment Agency's Catchment Data Explorer, the quarry currently sits within the catchment of the River Ashburn and it is clear that the site lies within the topographic catchment of the Balland Stream, a tributary of the Ashburn. Therefore it is probable the quarry already intercepts some baseflow and runoff to the Balland Stream. Combined runoff and shallow groundwater inflows to the quarry are estimated to be 462 ML from June 2017 to May 2018 while 830 ML are likely to have been returned to the Balland Stream over the same period, either as pumped discharges or via infiltration to the CBLF from the base of the Balland Pit.

12.113. The deep CBLF is not well connected to the shallow subsurface and effects from dewatering of the deeper zone near the base of the quarry are likely to be diffuse. To further understand these potential effects, monitoring of flow in larger watercourses which drain a more significant portion of the CBLF will be required. It is likely that deeper inflows of groundwater to the quarry come from a broadly easterly direction, such that a substantial component of this water is likely to come from the catchment of the Kestor Brook and its tributaries. As the proposed extension would represent an easterly expansion of the quarry, it is assessed that additional inflows would also come from the Kestor Brook catchment.

12.114. Following the completion of Stage 4 of the proposed quarry extension, approximately 40 years after works commence in Stage 1, the quarry will cover an area of 0.21 km^2, representing a 46% increase in its areal extent. After approximately 50 years, the extension could ultimately reach 0 mOD, a greater depth than the quarry at present, (though the existing quarry will have reached 0 mOD at Stage 2) leading to an increase in groundwater inflows of up to 238 ML based on the water balance June 2017 to May 2018 and conservative assumptions. Assuming the water balance is representative of typical conditions within the CBLF and assuming similar climatic conditions in the future, annual inflows to the quarry may increase by a further 514 ML (1,408 m^3/day) as a result of the proposed extension.

12.115. During periods of high flow, the Alston stream runs through the land proposed for bunds to the east of the quarry extension. Therefore it will be necessary to divert the Alston stream drainage over a short section around the north west corner base the bunds, before allowing it to flow southwards through its existing channel towards the Kestor Brook. This diverted drainage section has the potential to locally change infiltration to the shallow subsurface and develop additional pathways for shallow groundwater flow, with potential effects for ground stability.

12.116. Following restoration of the quarry, it is envisaged the open water in the quarry would have a discharge route to the Balland Stream at a level of approximately 96-97 mOD with storage above that level. The water level in the quarry and the discharge rate would be controlled to provide flood risk attenuation to Ashburton. The envisaged water level in the post-restoration void is close to, or slightly exceeds, late summer groundwater levels at the southern end of the proposed extension area, and although it is below groundwater levels at the end of the winter recharge season it is substantially above the base of the NE face and SE face conduits. As such inflows to the quarry are likely to be significantly reduced following restoration, leading to a much lower likelihood of effects to the nearby groundwater and surface water system.

Potential Effects on Water Quality

12.117. As Linhay Hill Quarry and the proposed extension area are within a predominantly rural area where the land is mainly utilised for farming, groundwater quality is not anticipated to have been affected by pollution. Monitoring of water chemistry of surface water or groundwater has not identified a potentially hazardous substance at a concentration above an Environmental Quality Standard for freshwater, and indicates the water discharged from the quarry is similar in quality to nearby surface water bodies. The quarry sump, the Kestor Brook and the Lemonford stream have a signature typical of groundwater boreholes within the CBLF.

12.118. Groundwater provides baseflow to the Balland Stream and Kestor Brook, and the quarry's pumped discharge of inflowing groundwater and direct rainfall will continue to be to the Balland Stream in compliance with the environmental permit to discharge, so a chemical or ecological water quality effect due to the proposed extension dewatering is not foreseen.

12.119. The bunds around the south east and north east of the proposed extension will be formed using soil and rock derived from the proposed extension area, so the chemical quality of water draining from those bunds is expected to be the same as for water currently draining from those soils and rock and hence an adverse effect to that surface water is not foreseen.

Potential Effect on Ecological Sites

12.120. Consideration has been given to the potential effects on the Little Barton Fields UWS (unconfirmed wildlife site) and Mead Cross UWS habitat areas as a consequence of the dewatering abstraction.

12.121. A potential effect on the Little Barton Fields UWS which includes a substantial part of Alston Wood north east of Alston Farm, is not predicted because:

1. It is located mainly on the low permeability Tavy Formation from which there is expected to be only slow leakage to the CBLF.
2. There are springs in the woodland which are recharged from higher surrounding ground, including land underlain by the St Mellion Formation, and hence the groundwater resurgence within the woodland is expected to continue.

12.122. A potential effect to the Mead Cross UWS woodland south of the A38 is foreseen in terms of some reduced surface water flow to the watercourse through that woodland, and it may also be sensitive to changes in groundwater level near the surface.

12.123. The maximum potential effect due to loss or groundwater drawdown is typically desiccation i.e. reduction in moisture levels of the soil or strata beyond natural levels of variability, or consolidation of the soil as a consequence of abstraction.

12.124. However those maximum potential effects are not envisaged to occur to the Mead Cross UWS because surface water is already absent from the woodland for most of the year, even during winter when water tables are typically highest, and observed groundwater levels are below the Mead Cross UWS and Kestor Brook at the southern end of the wildlife site for the majority of the time. There are also nearby recharge points to the soil, such as from springs in Alston Wood / Little Barton UWS which flow to the Alston stream. The Alston stream will still be able to flow across Alston Farm to the ditch adjacent the A38 and so to Mead Cross UWS. There are also springs south of the A38 at Higher Mead and the stream parallel to Gale Road which flows to the Kestor Brook, though the recharge to the limestone from those sources also varies notably seasonally. It is also believed that water levels in the post-restoration lake would lie within the range of observed groundwater level fluctuations at the southern edge of the proposed extension.

Potential Impacts on Flood Risk without Mitigation

Widening of Balland Lane

12.125. Widening of Balland Lane will lead to a slight increase in surface water runoff along Balland Lane into the Balland Stream, estimated to be up to 4.7 litres per second for a 1 in 100 year event including an allowance for potential climate change.

Waye Lane Public Road and Footpath Diversion

12.126. It is estimated construction of the Waye Lane public road will form an impervious area of 0.814 hectares, of which 0.160 ha from chainage 0 to chainage 330 will have to drain directly towards the Balland Lane and Balland Stream. The other 0.655 hectares will drain to the Balland Stream channel which flows around the northwest of the quarry workshop area. This represents 0.65% of the 100.64 hectares of upper sub-catchment of the Balland Stream to its existing overflow point to the quarry.

12.127. The Waye Lane junction with Balland Lane will be at a lower elevation than the nearby Balland Stream and so could also cause an increase in surface water runoff to existing drainage in Balland Lane.

Alston Farm and Alston Cottage Access Route

12.128. Alston Lane and the private access to Alston Farm and Alston Cottage lie within the topographic catchment of the Kestor Brook, and with the quarry extension there will be a loss of a section of Alston Lane and formation of a new impermeable tarmac road access to Alston Cottage and Alston Farm. However that will lead to a reduction in impermeable area from approximately 7,500m^2 to 3,360m^2, hence as there will be no increase in the surface water runoff there is no requirement for attenuation storage to restrict runoff from the new access road.

Stages 1 – 5 Quarry Extension and Operation

12.129. As the quarry extends north east the Kestor Brook sub-catchment area of 'Alston Farm Fields' will reduce, and the Balland Stream sub-catchment area which drains to the quarry will be commensurately increased, as summarised in the following table. The largest catchment change occurs between stages occurs from Stage 3 to Stage 4 when the quarry will extend eastwards to the south of Alston Cottage and Alston Farm as shown in the following Table 12-5.

Table 12-5 Sub-catchment area change due to quarry extension

Stage	Quarry extension area (ha)	Land around extension area which will drain to sub-catchment: Alston Wood (ha)	Land around extension area which will drain to sub-catchment: Quarry void (ha)	Sub-catchment Waye Pond, flows to Balland Stream (ha)	Sub-catchment Quarry Void, with pumped discharge to Balland Stream (ha)	Sub-catchment Alston Farm Fields, runoff flows to Kestor Brook (ha)
Existing	0	20.66	0	3.93	51.78	56.20
Stage 0 change due to new Alston Farm access and new attenuation storage and drainage	0	-0.50	0.25	0.90	0.25	-0.65
Stage 1 change	5.25	0	0.61	0	5.86	-5.86
Stage 2 change	6.97	0	0.84	0	7.80	-7.80
Stage 3 change	4.10	0	0.47	0	4.57	-4.57
Stages 4 and 5 change (also applies to Stage 6)	5.16	0	5.73	0	10.90	-10.90
Total change	21.47	-0.50	7.91	0.90	29.38	-29.78
Final sub-catchment		20.16		4.84	81.16	26.42
Catchment					Balland Stream	Kestor Brook
Total change					29.78	-29.78
Total catchment					385	813
Percentage change					+7.74%	-3.66%

12.130. The changes due to the quarry extension will reduce flood risk from surface water runoff in the upper catchment of the Kestor Brook, where flooding mainly occurs south of the A38 and west of Goodstone. The Balland Stream catchment will increase, but flood risk to Ashburton will not increase because the surface water will flow into the quarry void and will drain to the quarry's lowest level. That level is below the Balland Pit and Balland Stream, therefore water which inflows will require pumping to discharge to the Balland Stream. Pumping is undertaken under an Environmental Permit from the Environment Agency and pumping logistics ensures that water is discharged after the passage of excess flows along the Balland Stream.

Spoil Tip Formation and Restoration

12.131. Bunds will be formed within the Alston Farm Fields sub-catchment to the Kestor Brook, and the formation of the bunds will be regulated under a Mining Waste Permit to comply with the Mining Waste Directive 2006/21/EC (as transposed to UK legislation). That permit will be for the management of inert extractive waste by passive treatment, controlled by the conditions for the discharge set in the permit; for example, provision of a settlement pond that will become part of the site restoration when dry, and will include a water discharge management for the rainfall dependent discharge.

12.132. New drainage ditches will be formed around the bunds to intercept surface water runoff, and divert the Alston stream, an existing spring fed seasonal minor watercourse which crosses the Alston Farm fields. That diversion will require Land Drainage Consent from Devon County Council. The new drainage will positively drain the water towards the Alston Farm fields' existing discharge point, namely the vegetated ditch parallel to the A38, but for the bund drainage there will be a single point of discharge to the inlet of the 300mm diameter pipe that passes under the A38 approximately 150m north east of Alston Cross.

12.133. For structural stability the bunds will have basal drainage and internal drainage, most likely in the form of herringbone gravel drains, and during the bund construction phase that drainage and surface water runoff will be conveyed by drainage to temporary ponds for settlement of suspended solids. Those settling ponds may be moved as the working area of bund construction moves, and it is envisaged some settlement pond areas at the perimeter of the bunds will be restored to form shallow detention basins once the bunds have become vegetated.

12.134. Formation of the bunds will increase the local terrain slope gradient and restoration will increase the proportion of woodland compared to the existing generally grassed land. The change in terrain gradient is the major factor which will affect surface water runoff. There may be local variation such as during construction when there will be no vegetation cover in working areas, but at that time the overall average slope is likely to be less than the completed bunds and temporary drainage will intercept surface water runoff.

12.135. The Flood Risk Assessment shows that although the rate of surface water runoff from the land used for bunds is likely to increase, the increase is mitigated by the reduction in the Alston Farm Fields sub-catchment area. As there will be a reduction in surface water runoff to the Kestor Brook there is no requirement for attenuation of runoff from the bund areas.

12.136. Suspended solids in the runoff may occur from exposed soil in the new drainage channels, from disturbed soil along vehicle trafficking routes, and from the bund construction earthworks, though the natural overburden soils are not expected to have a propensity to go into suspension. That expectation is based on observation of the turf growing and lifting operations of Fine Turf (Devon) Ltd. in the fields east of Alston Lane, where the soil exposed to rainfall for extended periods does not seem to erode notably.

12.137. The size and location of the bund operational areas i.e. disturbed ground, and undisturbed or re-established areas will vary during the bund construction, though the maximum operational area is expected to occur during Stage 1 at commencement of the overburden stripping. Settlement ponds will be utilised to reduce suspended solids in the surface water runoff from the bunds and drainage. Perimeter drainage ditches will have check dams to slow the rate of flow, and eventually it is envisaged they will convey 'clean' runoff and become naturalised, i.e. grassed. Where suited within the restoration plan it is envisaged the settlement pond areas would be restored to form naturalized detentions basins which will also slow surface water runoff. But the perimeter new drainage will have the potential to locally change infiltration to the shallow subsurface and develop additional pathways for shallow groundwater flow, with potential effects for ground stability.

Restoration (Stage 6)

12.138. As is the case for the existing quarry, once rock extraction ceases and pumping of water from extraction void is stopped, the void will begin to fill with water from rainfall and groundwater and restoration will be to open water. The future stable groundwater level is expected to be the same as within the ground prior to the quarrying in the Linhay area north east of Ashburton, but the maximum lake level will be set to control discharge to the Balland Stream and provide ongoing mitigation of flood risk to Ashburton.

12.139. To enable control of discharge from a lake within the quarry void it will be necessary to form a discharge route from the rock buttress around the Balland Pit between the quarry workshop area and the Balland Stream, which exits the quarry's block storage area at an elevation of 95.13mOD.

12.140. Discharge from the lake would not be able to occur above the agreed maximum discharge rate, instead the water level in the lake would rise to provide flood attenuation storage during heavy or prolonged rainfall.

Mitigation Measures

12.141. The Environment Agency's Science Report SC040020/SR1 'Hydrogeological impact appraisal for dewatering abstraction' provides an eight step approach for karst aquifers such as the CBLF. Step K5 of that approach entails the design of mitigation for the sensitive sites based on preliminary monitoring, with Step K6 the specification of trigger levels for the mitigation measures. Monitoring is continued as Step K7 and mitigation measures are implemented when trigger levels are reached or passed. Hence in the Hydrogeological Impact Assessment 2018 and this ES, mitigation measures are identified for foreseen effects on water resources, surface water flows, water quality and ecological sites due to the proposed extension to Linhay Hill Quarry, as informed by further monitoring. Flood risk mitigation will be by drainage design for specific storm event flows and the management of exceedance flows.

Water Resources and Surface Water Flows

12.142. Groundwater and surface water inflows to the quarry excavation will continue to be discharged to the Balland Stream thereby effectively mitigating the potential for loss of flow in that watercourse. The consumption of water by the quarry operations is not anticipated to change because the quarry's future productivity is expected to remain similar to its current levels. The abstraction and water use by the quarry will be included in a new full abstraction licence to be applied for before the end of December 2019, as required following removal by the Water Abstraction and Impounding (Exemptions) Regulations 2017 of water licensing exemptions previously applicable to dewatering the quarry.

12.143. New drainage routes around the screening bunds will be formed as grassed channels over a low permeability membrane to prevent the infiltration of storm event surface water runoff to the shallow sub-surface along those new linear drainage routes. The membrane would be at a depth sufficient to retain water to maintain grass growth and to ensure the long term integrity of the channels, thereby minimising maintenance. The sequence of the planned extension works may also delay the onset of an effect or prevent it from being significant and monitoring data can be collected, such as from maintaining existing surface water courses and aquifer recharge points wherever possible until the adjustment, e.g. a watercourse diversion, is implemented.

12.144. That mainly applies to the Alston stream sinking watercourse across Alston Farm which will require a partial diversion at Stage 2 and at Stage 4, but will still be able to flow to the drainage ditch adjacent the A38 and the pipe under the A38 north east of Alston Cross, as occurs for the existing situation. A short section of that watercourse will be diverted via a pipe or grassed channel over a low permeability membrane to ensure flow continues to reach the drainage ditch adjacent the A38 and maintain the infiltration and recharge to the limestone which occurs presently at that location.

12.145. It is considered the Kestor Brook catchment is the most likely to be affected so a pumped discharge to either that watercourse or its tributaries could be required, dependent on the results of further monitoring. If monitoring identifies that augmentation of flows in the Kestor Brook may be beneficial, that can be achieved for example by pumping from the extended quarry to discharge to the drainage ditch adjacent the A38 to infiltrate and recharge the limestone south east of the A38, or direct to the pipe under the A38. The water source would be the quarry's sump or a holding pond formed at a higher level.

12.146. In the event that water levels in boreholes in the Tavy Formation north of the limestone are shown to be affected by the proposed extension, then the monitoring programme will be reviewed to incorporate monitoring for potential effects to private water supply locations further afield north of the quarry. Suitable mitigation measures will also be defined at that time, in consultation with the owners of these water supplies, to come into effect in the event that dewatering-related impacts are identified and range from monetary compensation, provision of additional storage, equipment or infrastructure, compensation or alternative supply as outlined in the Hydrogeological Impact Assessment 2018.

12.147. The drainage system within the quarry's planning permission area will be managed, monitored and maintained by the quarry operator E & JW Glendinning Ltd., and a monitoring strategy and the development of trigger levels are detailed in the Hydrogeological Impact Assessment (2018). The drainage along Balland Lane and Waye Lane will continue to be managed by Devon County Council.

Water Quality

12.148. Water discharge from Linhay Hill Quarry to the Balland Stream will comply with its environmental permit to discharge, and that permit is subject to regular review by the Environment Agency.

12.149. Discharge of surface water runoff from bunds around the south east and north east of the proposed extension will be to the pipe under the A38 which discharges to Mead Cross UWS and will flow to the Kestor Brook. That discharge will be authorised as 'rainfall dependent trade effluent' under a water discharge activity permit to be applied for, which may be included in a mining waste permit for the formation of the bunds. The discharge will be made in compliance with the permit.

Ecological Sites

12.150. The drainage proposals enable the Alston stream watercourse at Alston Farm and surface water runoff from the bunds around the proposed extension to discharge to the pipe under the A38, hence surface flow through the Mead Cross UWS, which in any case is seasonal, will be maintained.

Flood Risk

12.151. Due to the Balland Stream Critical Drainage Area, the overarching flood risk mitigation aim is to reduce flood risk to Ashburton. But commensurate with that aim is also the need to reduce flood risk to the quarry operations, reduce flood risk to the new Waye Lane public road, reduce the potential for an effect due to surface water runoff from the bunds, and to mitigate the effect of changes to the existing surface water drainage.

12.152. The increase in surface water runoff due to the new Waye Lane public road and footpath diversion will be mitigated by catchment attenuation measures along the Balland Stream north of the quarry, and by diversion of peak flows into the quarry.

12.153. An obvious option to reduce flood risk to Ashburton is to divert high or all flows in the Balland Stream into the quarry. However water diverted to the quarry will subsequently need to be managed and pumped out, and so diverting water into the quarry will increase the operating costs of the quarry. Therefore to lessen the volume of water that might need to be diverted into the quarry, upstream catchment attenuation storage areas will be formed, the aim being that only the most extreme events would cause water from the Balland Stream to be diverted into the quarry. The upstream catchment attenuation storage will also be formed to reduce flood risk to the new Waye Lane public road. Minor drainage improvements will also be carried out over the land to the north of Alston Cottage and Alston Farm within the Alston Farm Fields sub-catchment, in order to minimise the surface water runoff which will have to drain to the extended quarry.

12.154. The Chuley Road Strategic Flood Risk Assessment indicates flooding could occur at Love Lane for a 1 in 10 year event due to culvert constraints, and though that flooding may initially only be shallow overland flow down the lane, that return period has been used as a comparative guide. That return period also aligns with the Ashburton Critical Drainage Area, which requires surface water discharges to "mimic greenfield performance up to a maximum 1 in 10 year discharge rate". Therefore, based on the results of the Flood Risk Assessment it is proposed to initially restrict flow in the Balland Stream at the quarry to 1m^3/s, with flow above that rate diverted into the quarry. That will provide notable flood risk mitigation benefit by attenuating from the current 1 in 10 year event flows to slightly less frequent than 1 in 30 year event flows predicted by the Devon Hydrology Strategy for 3.22km^2 of the the Balland Stream catchment to Jordan Meadows, there being a further 0.63km^2 of catchment to its confluence with the River Ashburn.

12.155. The combined approach of upstream catchment attenuation storage and diversion of flow into the quarry will need to be sufficient to mitigate local areas where surface water runoff will increase towards Ashburton, and where flow control with attenuation storage cannot be practically provided. Those areas are the widening of Balland Lane and of the junction of Waye Lane with Balland Lane. Therefore, with the proposed widening of Balland Lane, its vertical alignment has also been adjusted to ensure that surface water runoff from the lane's catchment east of Balland Stream is diverted to the Balland Stream.

12.156. Drainage around the quarry extension as it progresses in stages to the north east will reduce the direct run off into the quarry, and drainage around the new bunds will intercept run off and enable settlement of suspended solids until the bunds are wholly restored with vegetation. The quarry extension will reduce the upper topographic catchment of the Kestor Brook, and that is likely to offset the potential for increased runoff from the bunds. Settlement ponds will be formed to ensure settlement of suspended solids during the bund construction and can be restored to form naturalised detention basins once the bunds are fully vegetated. There will also be diversion of a spring fed seasonal ordinary watercourse around the bunds, such that it can continue to discharge to the wide vegetated ditch parallel to the A38, where the water infiltrates or can flow under the A38 via a 300mm diameter pipe. Other new drainage around the quarry and bunds will have a single discharge point to that pipe inlet.

Residual Effects after Mitigation

12.157. The topographic catchment of the Kestor Brook will be reduced permanently by approximately thirty hectares, which is estimated to be 3.66% of its total catchment, so from that impact there will be a residual effect of reduced surface water infiltration and runoff flows from the Alston Farm field area north of the A38 to that watercourse. However the surface water run off from that area to the Kestor Brook only occurs when the run off is sufficient to reach the pipe under the A38. That tends to be seasonal i.e. in winter when the ground is saturated, or after heavy rainfall, hence the residual effect will be limited. Similarly it is expected that with augmentation of flows, such as pumping to the Kestor Brook if found necessary during the quarry extension until restoration is complete, the residual effect on flows in watercourses will be limited.

12.158. As is the case for the existing quarry void, restoration will be to open water. Hence the additional lake area of the extended quarry, compared to restoration of the existing quarry, may be considered a residual impact. But as the water balance for June 2017 to May 2018 suggests the Balland Pit receives more water from direct rainfall than it loses from evaporation, it is anticipated that evaporation from a larger lake post-restoration will be offset by increases in direct rainfall to this feature, although the precise relationship between these factors will depend on future weather patterns. When the lake discharge control structure is agreed with the flood authorities it is envisaged that will also aim to ensure the long-term effect on groundwater flows to the Kestor Brook are minimal.

12.159. There will be residual flood risks resulting in a potential for temporary flooding at:

- The lowest level of the quarry during its operation.
- The inlet to the 300mm pipe under the A38 to which the Alston Farm fields currently drain.
- Waye Lane at Brownswell detention basin where discharge is constrained to an existing 450mm pipe.

12.160. However those are areas which are currently at risk of flooding due to existing constraints, and the temporary flooding which occurs already reduces the potential for a downstream flood impact. Reducing the constraint would lead to greater flood flow downstream which could increase the flood risk downstream, whereas temporary flooding at the identified locations will be localised and not have an adverse effect.

12.161. The residual risks due to an extreme event are of rainfall of higher intensity over a longer duration causing higher surface water runoff velocities and greater total runoff volume than anticipated.

12.162. Such an event could cause temporary flooding at the residual flood locations and would result in a greater volume of flow being diverted from the Balland Stream into the quarry. However, the diversion of flow from the Balland Stream into the quarry will provide flood risk mitigation to Ashburton. In other areas the risk of an extreme event has been mitigated by design including an allowance for potential climate change and other measures such as including 0.3m freeboard to drainage features.

Significance of Potential Impacts with Mitigation

12.163. The following table provides an assessment of the significance of the potential impact to water environment features due to the proposed extension to Linhay Hill Quarry and associated infrastructure works, with reference to the significance criteria outlined earlier in this chapter.

Table 12-6 Summary Assessment of Potential Impact to Water Environment Features with mitigation

Activity	Water Environment Feature Affected	Water Environment Feature Importance	Magnitude and Duration of Potential Impact	Overall Significance of Potential Impact (Adverse unless stated otherwise)
Widening of Balland Lane.	Surface water runoff to the Balland Stream main river.	Medium	Negligible to Minor adverse – permanent.	Low significance.
Junction of Waye Lane new public road with Balland Lane.	Surface water runoff to the Balland Stream main river.	Medium	Negligible to Minor adverse – permanent.	Low significance.
Waye Lane new public road and footpath diversion.	Surface water runoff to the Balland Stream ordinary watercourse.	Low	Moderate beneficial – permanent.	Low significance beneficial.
New private access to Alston Cottage and Alston Farm.	Surface water runoff to the Balland Stream ordinary watercourse.	Low	Negligible – permanent.	Not significant.
	Surface water runoff to the Kestor Brook ordinary watercourse downstream of the A38 at Mead Cross Unconfirmed Wildlife Site.	Minimal to Low	Negligible – permanent.	Not significant.
Deepening of the existing quarry	Water resources in the River Ashburn catchment.	Medium	Minor beneficial to Negligible – occurs from Stage 2 to Stage 4.	Low significance beneficial.
	Water resources in the River Lemon catchment.	Medium	Minor adverse – occurs from Stage 2 to Stage 4.	Low significance.
Extension of quarry extraction area into Alston Farm fields.	Surface water runoff to the Balland Stream ordinary watercourse.	Low	Negligible – permanent.	Not significant.
	Surface water runoff from Alston Farm fields to the Kestor Brook ordinary watercourse upstream of Goodstone.	Minimal to Low	Minor to Moderate adverse – progressive from Stage 1 over the long term, permanent.	Low significance.
	Alston stream ordinary watercourse which flows across Alston Farm fields.	Minimal	Negligible to Minor – permanent changes occur in Stage 2 and in Stage 4.	Low significance.
	Mead Cross Unconfirmed Wildlife Site	Low to Minimal	Negligible to Minor adverse – progressive over Stage 1 to Stage 5.	Not significant.

Activity	Water Environment Feature Affected	Water Environment Feature Importance	Magnitude and Duration of Potential Impact	Overall Significance of Potential Impact (Adverse unless stated otherwise)
	Flow in Kestor Brook ordinary watercourse which runs from parallel to and north of Gale Road from Mead Cross to south of Goodstone.	Minimal to Low	Negligible to Minor adverse – permanent, progressive from Stage 1.	Not significant.
	Flow in Kestor Brook ordinary watercourse and springs south of Goodstone at Four Acres and Glendale, which provide baseflow to the Kestor Brook.	Low	Negligible to Minor adverse – progressive over Stage 1 to Stage 5, thereafter recovery.	Low significance.
	Flow in Lemonford stream ordinary watercourse at Higher Lemonford.	Medium	Minor adverse to Negligible – progressive over Stage 1 to Stage 5, thereafter recovery.	Low significance.
	Flow in the River Lemon main river Bickington to confluence with Kestor Brook.	Medium	Minor adverse to Negligible – progressive over Stage 1 to Stage 5, thereafter recovery.	Low significance.
	Water resources in the River Ashburn Catchment.	Medium	Minor beneficial permanent – progressive over Stage 1 to Stage 5.	Low significance beneficial.
	Water resources in the River Lemon catchment.	Medium	Minor adverse – progressive over Stage 1 to Stage 5, thereafter recovery.	Low significance.
	Private water supplies from Secondary A aquifer supplying properties at Brownswell.	Low	Negligible to Minor adverse – Stage 2 to end of Stage 6.	Not significant.
	Private water supplies from Secondary A aquifer spring supplying Alston Farm and Alston Cottage.	Low	Negligible to Minor adverse – Stage 2 to end of Stage 6.	Not significant.
	Private water supplies from Secondary A aquifer well supplying Little Barton.	Low	Negligible to Minor adverse - Stage 2 to end of Stage 6.	Not significant.
	Flood risk from fluvial flows and or surface water runoff within the quarry and proposed extension.	Low	Minor adverse – until end of Stage 5.	Not significant.

Activity	Water Environment Feature Affected	Water Environment Feature Importance	Magnitude and Duration of Potential Impact	Overall Significance of Potential Impact (Adverse unless stated otherwise)
	Flood risk from groundwater within the quarry and proposed extension.	Low to Medium	Minor adverse – until end of Stage 5.	Low significance.
	Flood risk from surface water along the Kestor Brook north of Gale Road from Mead Cross UWS to south of Goodstone.	Low	Negligible to Minor beneficial – progressive until end of Stage 6.	Not significant beneficial.
	Flood risk from groundwater along the Kestor Brook north of Gale Road from Mead Cross UWS to south of Goodstone.	Low	Minor beneficial to Negligible – progressive until end of Stage 6.	Not significant beneficial.
Bunds in south east and east of Alston Farm fields	Surface water runoff to the Kestor Brook ordinary watercourse.	Low	Minor adverse to Negligible – permanent, progressive from Stage 1.	Not significant.
Balland Stream flood flow diversion to quarry	Flood risk from fluvial flows and or surface water runoff within the quarry and proposed extension.	Low	Minor to Moderate adverse – until end of Stage 5.	Low significance.
	Flood risk from fluvial flows and or surface water runoff to Ashburton from the Balland Stream.	High	Moderate beneficial – permanent, from end Stage 0.	Highly significant beneficial.
Restored quarry lake with controlled discharge to the Balland Stream	Flow in the Balland Stream main river.	Medium	Minor beneficial, permanent from Stage 6	Low significance beneficial.
	Flow in the Kestor Brook ordinary watercourse downstream of the A38 at Mead Cross Unconfirmed Wildlife Site.	Low	Negligible, permanent from Stage 6.	Low significance.
	Flow in Kestor Brook ordinary watercourse and springs south of Goodstone at Four Acres and Glendale, which provide baseflow to the Kestor Brook.	Low	Negligible to Minor adverse, permanent from Stage 6.	Low significance.
	Flow in Lemonford stream ordinary watercourse at Higher Lemonford.	Medium	Negligible, permanent from Stage 6.	Not significant.

Activity	Water Environment Feature Affected	Water Environment Feature Importance	Magnitude and Duration of Potential Impact	Overall Significance of Potential Impact (Adverse unless stated otherwise)
	Flow in the River Lemon main river from Bickington to confluence with the Kestor Brook.	Medium	Negligible, permanent from Stage 6.	Not significant.
	Water resources within the River Ashburn catchment.	Medium	Minor beneficial, permanent from Stage 6.	Low significance beneficial.
	Water resources in the River Lemon catchment.	Medium	Negligible, permanent from Stage 6.	Not significant.
	Private water supplies from Secondary A aquifer supplying properties at Brownswell.	Low	Negligible, permanent from Stage 6.	Not significant.
	Private water supplies from Secondary A aquifer spring supplying Alston Farm and Alston Cottage.	Low	Negligible, permanent from Stage 6.	Not significant.
	Private water supplies from Secondary A aquifer well supplying Little Barton.	Low	Negligible, permanent from Stage 6.	Not significant.
	Mead Cross Unconfirmed Wildlife Site	Minimal to Low	Negligible, permanent from Stage 6.	Not significant.
	Flood risk to Ashburton from the Balland Stream.	High	Moderate beneficial – permanent i.e. from Stage 6.	Highly significant beneficial.
	Flood risk from surface water flows in the Kestor Brook north of Gale Road from Mead Cross UWS to south of Goodstone.	Low	Negligible, permanent from Stage 6.	Not significant.
	Flood risk from groundwater along the Kestor Brook north of Gale Road from Mead Cross UWS to south of Goodstone.	Low	Minor beneficial, permanent from Stage 6.	Low significance beneficial.

Cumulative Effects

12.164. The proposed extension to Linhay Hill Quarry with the associated necessary infrastructure entails extensive changes to improve control and management of the local surface water drainage and reduce flood risk. The cumulative effect will be reduced flood risk to Ashburton from the Balland Stream, and reduced flood risk in the upper catchment of the Kestor Brook south of the A38.

12.165. The Environment Agency is also developing a scheme of measures for reducing flood risk in Ashburton, and future development proposed within the Dartmoor National Park Authority's Chuley Road Masterplan area will require flood mitigation measures. Hence drainage improvements undertaken as part of the proposed extension to Linhay Hill Quarry will have a beneficial cumulative effect in combination with the Environment Agency's flood risk mitigation plans.

Summary of Effects and Conclusions

12.166. A Flood Risk Assessment and Hydrogeological Impact Assessments have been undertaken to inform preparation of this ES chapter on Water Resources.

12.167. The quarry is working the Chercombe Bridge Limestone Formation, a buried karst with sinking streams, swallow holes, and conduits, and the quarry currently lies within the River Ashburn catchment but will extend east into the catchment of the Kestor Brook. The main inflow to the existing quarry is deep groundwater which is not hydraulically well connected to shallow groundwater, and is likely to have a component of flow from the east i.e. the Kestor Brook catchment. Hence it is likely a substantial component of the future inflows from deepening the existing quarry and extending the quarry to the east will be from the Kestor Brook catchment.

12.168. However the inflowing water is returned to the environment currently by transfer by pumping from the quarry to the Balland Stream. Hence should an effect on a water feature such as the Kestor Brook be discerned by monitoring, it would be possible to augment flows by also pumping to that watercourse or its tributaries. Local springs and abstractions to the north of the quarry and south of the A38 are recharged from higher land to the north or south, and the watercourse will continue to flow over the Chercombe Bridge Limestone, including the seasonal stream from Alston Wood through Alston Farm to the A38 and so to the Kestor Brook. Flood risk concern will be mitigated by attenuation basins along the Balland Stream and by new drainage at Alston Farm. The quarry void will continue to act as a water storage area and following the cessation of extraction and dewatering the void will naturally be restored to open water with outflow control to provide ongoing flood attenuation.

12.169. A range of mitigation measures is planned and are incorporated into the design proposals, with a monitoring plan outlined in the Hydrogeological Impact Assessment 2018 which would provide data from which to design and set trigger levels for future mitigation of effects on water resources as per the Environment Agency's Science Report – SC040020/SR1 methodology.

12.170. There will be residual flood risk at specific locations due to existing constraints which cannot be wholly removed, though the long term surface water management will be improved with the cumulative effect being reduced flood risk to Ashburton from the Balland Stream, and reduced flood risk in the upper catchment of the Kestor Brook south of the A38.

12.171. The overall residual effect is considered to be slight in EIA terms, with no significant adverse effects and beneficial effects ranging from 'not significant' to 'highly significant'.

Appendices

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