APPENDIX 9-6
Flood Risk Assessment

Tarmac Trading Limited
Northern Extension at Stanninghall Quarry

June 2020
SLR/T57/024/FRA

Technology Centre
Wolverhampton Science Park
Wolverhampton, WV10 9RU

tel: 01902 824111
fax: 01902 824112
email: henry@bclhydro.co.uk
web: www.bclhydro.co.uk

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Registered in England & Wales
Company Registration Number: 4043373
Registered Office: 33 Wolverhampton Road, Cannock
VAT Registration Number: 754 0924 29

1 BACKGROUND

1.1 BCL Consultant Hydrogeologists Limited (BCL) has been instructed by SLR Consulting Limited (SLR), acting on behalf of Tarmac Trading Limited (the Applicant), to carry out a Flood Risk Assessment (FRA) for the Northern Extension (the Proposed Development) at their existing Stanninghall Quarry (the Site).

1.2 The current circumstances at the quarry are illustrated on plan ref KD.SH.D.006. This illustrates the location of the processing plant site, the perimeter soil storage / screen bunds; the silt and fresh water lagoons; the current working and progressive restoration area, and the remaining area to be worked in the western area of the Existing Site (phase 4B). The plan illustrates the constrained nature of the Existing Site and the area of mineral reserve currently sterilised by the plant site, bunds and related infrastructure.

1.3 The northern extension area represents the 'undisturbed agricultural land', as shown on the Current Situation Plan. The development would be integrated into the phasing scheme for the existing quarry, with a clockwise phased approach to extraction and progressive restoration, progressing from the existing phase 4B in the Existing Site northwards in the western area of the Extension Site as phases 5 and 6 and then southwards towards the plant site as phases 7 and 8.

1.4 The proposed phasing of operations is illustrated at drawing no's KD.SH.D.009 to KD.SH.D.016 (showing proposed working Phase 4B through to Phase 8; followed by Final Works, Concept Restoration and Technical Sections).

1.5 The existing and proposed quarrying operations involve extraction of sand and gravel from above the watertable.

1.6 In common with the existing operations, there is no requirement for dewatering or sub-watertable working at the Extension Site. The full depth of mineral reserve (sand and gravel) is above the watertable.

1.7 The free-draining nature of the sand and gravel allows works to proceed without the need for active surface water management.

1.8 There is no requirement for off-site discharge at the Application Site.

1.9 Progressive restoration would be undertaken behind the advancing working phase using soils and overburden stripped from the advancing working area for direct placement behind the working area. This will ensure that only the minimum part of the Site forms part of the operational area at any one time.

1.10 The proposed restoration strategy is illustrated on plan ref KD.SH.D.015. The aim of the scheme is to re-create an agricultural landscape with enhanced wildlife habitat, with the potential for increased biodiversity. The intention is that the local character of the landscape would be strengthened through native hedgerow and woodland planting. Wildlife buffer strips would help to protect and integrate agricultural production into the existing peripheral vegetation structure of the site. Restored land gradients would be appropriate for agricultural production along with the replacement of soil profiles.

1.11 All land would be subject to a minimum 5-year aftercare management period, under the control of the Applicant, to ensure the successful delivery of the restoration land uses.

2 TERMS OF REFERENCE / METHODOLOGY

2.1 The assessment has been conducted in accordance with guidance given in Diagram 1 of "Planning Practice Guidance (PPG) for Flood Risk and Coastal Change" (DCLG, updated 6th March 2014). In this instance, the assessment has therefore involved:

i. An appraisal of the availability and adequacy of existing information.

ii. Qualitative appraisal of the potential flood risk to the development.

iii. Qualitative appraisal of the potential impact of the Development Site on flood risk elsewhere.

iv. Qualitative demonstration of the effectiveness of any proposed mitigation measures.

3 INFORMATION CONSULTED IN THE PREPARATION OF THIS FRA

3.1 Policy and data sources consulted in the course of this assessment have included:

i) "National Planning Policy Framework" (NPPF: Ministry of Housing, Communities and Local Government [MHCLG], July 2018).

ii) "Planning Practice Guidance for Flood Risk and Coastal Change", DCLG, updated 6th March 2014 (referred to herein as PPG).

iii) "Rainfall Runoff Management for Developments", joint DEFRA / Environment Agency (EA) Flood and Coastal Erosion Risk Management R&D Programme, Report SC030219, Kellagher R, October 2013.

iv) Storm event data from the Flood Estimation Handbook (FEH), with online Web Service (Centre for Ecology & Hydrology 2016, developed by Wallingford HydroSolutions).

v) ReFH2 software, developed by Wallingford HydroSolutions and approved by the Environment Agency. For full details, please refer to: "ReFH2, The revitalised Flood Hydrograph Modelling Tool", Version 3.1.7439.12207, 2019.

vi) "Flood Map for Planning (Rivers and Sea) centred on NGR TG 25887 18271", EA drawing, 24th June 2020.

vii) "Risk of Flooding from Surface Water", EA mapping, 24th June 2020.

viii) "Risk of Flooding from Reservoirs", EA mapping, 24th June 2020.

ix) Various policies and plans relating to flood risk in the study area have been published, as follows:

- Greater Norwich Area Strategic Flood Risk Assessment (November 2017) covering the Norwich City Council, Broadland District Council, South Norfolk Council and parts of the Broads Authority administrative areas;
- Norfolk County Council's guidance for developers: Norfolk County Council, Lead Local Flood Authority, Statutory Consultee for Planning, Guidance Document (March 2019). The guidance provides information on how SuDS proposals for new developments will be considered by the LLFA.

x) Published mapping data obtained from the Ordnance Survey (1:25,000 scale) and British Geological Survey (1:50,000 scale).

xi) Detailed topographic survey data and development plans, provided by the Applicant and SLR.

4 SITE DESCRIPTION

4.1 Topographic survey

4.1.1 The Site is characterised by flat, subdued relief. Ground elevations average between 16 to 18 metres above Ordnance Datum (maOD) across the majority of the Site.

4.1.2 There is a slightly raised area of land at the north east corner of the Site, with a summit elevation of 24 maOD.

4.1.3 A broad, shallow, dry valley feature extends across the eastern boundary of the Site. Ground elevations within this feature decrease in an easterly direction, from 15 maOD at the centre of the Site to less than 10 maOD at the boundary.

4.1.4 To the north and east of the Site, the land slopes gently down to the valley of the River Bure (less than 5 maOD). At its closest approach, the valley is some 700 metres (m) to the north east of the Site boundary.

4.1.5 The valley of Spixworth Beck (which drains into Dobbs Beck, a tributary of the River Bure) lies to the south of the Site. The valley lies some 1.1 km to the south of the Site boundary, at its closest point. Ground elevations within the valley do not exceed 5 maOD.

4.1.6 The flat, subdued topography encountered upon the Site extends for several kilometres to the west and northwest, with no marked variation in ground levels.

4.1.7 The topography of the Site area is illustrated at *figure 9-2* of the accompanying Hydrological and Hydrogeological Impact Assessment (H&HIA).

4.2 Geological Setting

4.2.1 An extract from the published 1:50,000-scale BGS geological map of the area is reproduced at *figure 9-3* in the H&HIA, with keys included at *figure 9-4* of the same report.

4.2.2 The published drift is necessarily simplified; the field situation is complex, vertical relationships between differing materials varying from area to area in the vicinity of the Site.

4.2.3 The overburden is composed of dark brown, very sandy, gravelly, humic topsoil (some 0.3 m thick) overlying brown, firm silts and clays (averaging 1.7 m thick).

4.2.4 The economic mineral consists of:

- Yellow brown, clean to slightly silty, fine to fine/medium grained sand with some 30% gravel content. The unit averages 2.8 m in thickness.
- Dark (orange) brown, slightly silty to silty, fine/medium to medium grained sands with approximately 40% gravel content. The unit has an average thickness of 2.9 m.

4.2.5 Interburden is generally absent from the geological sequence but sporadic and laterally impersistent horizons of brown silts and clays do occur within the economic mineral.

4.2.6 The base of the economic deposit is marked by the gently undulating surface of the Upper Chalk, which is generally weathered to a white, soft, clayey chalk

4.3 Hydrological Setting

River Bure

4.3.1 The largest watercourse in the vicinity is the River Bure, which lies some 700 m to the north east of the Site at its closest approach.

4.3.2 The river follows a meandering course from north west to south east. On a local scale, the meanders generally range in amplitude from less than 50 m up to 500 m. Downstream of the village of Belaugh (NGR TG 289 184), their amplitudes increase to some 1.5 km.

4.3.3 The valley floor is some 250 to 400 m in width and comprises water meadows and woodland draining via a network of ditches into the main river.

4.3.4 Looking upstream of the Site, the River Bure has a catchment area of some 330 km^2.

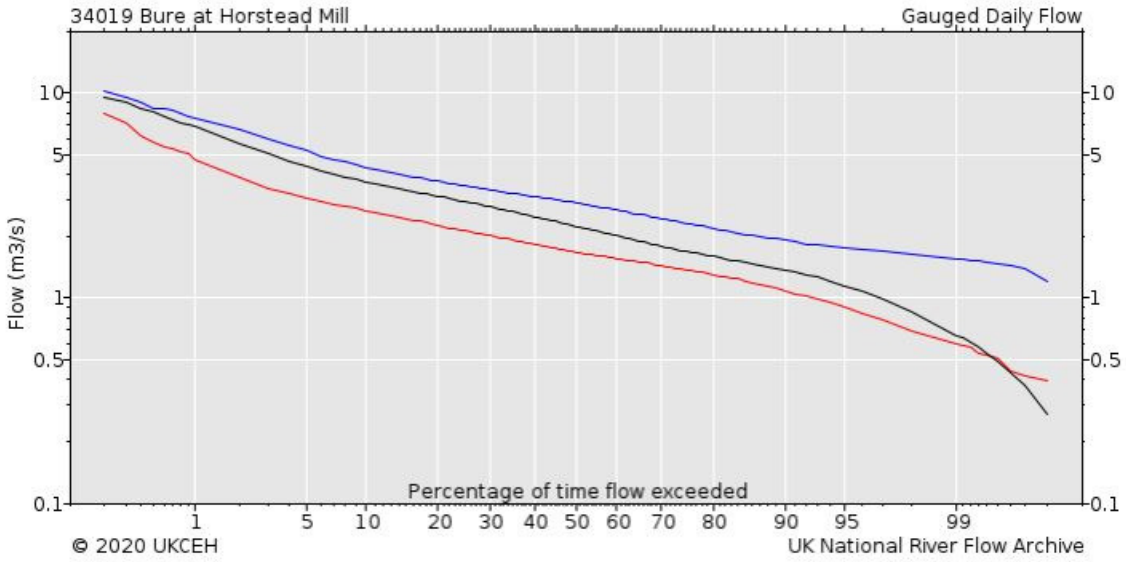
4.3.5 The National River Flow Archive includes “Gauged Daily Flow” data for the River Bure at Horstead Mill (Station No. 34019; NGR TG 266 193). For the period 1974 to 2018, the mean flow rate equates to 2.452 cumecs.

4.3.6 Flow percentiles (Q values) for the Bure at Horstead Mill are computed using gauged daily flow data only for those years with five days, or less, missing on the NRFA.

Period of Record:	1974 - 2018
Percent Complete:	99 %
Base Flow Index:	0.81
Mean Flow:	2.452 m^3/s
95% Exceedance (Q95):	1.15 m^3/s
70% Exceedance (Q70):	1.79 m^3/s
50% Exceedance (Q50):	2.235 m^3/s
10% Exceedance (Q10):	3.69 m^3/s
5% Exceedance (Q5):	4.38 m^3/s

4.3.7 The Q95 flow is a significant low flow parameter particularly relevant in the assessment of river water quality consent conditions. Q95 is the 5 percentile flow: The flow in cubic metres per second which was equalled or exceeded for 95% of the flow record. At this location, the Q95 flow rate is 1.15 cumecs.

4.3.8 The flow duration curve is presented below:



Key: Black line - annual; blue line - December to March; red line - June to September.
Underlying data supplied by the Environment Agency

Spixworth Beck

4.3.9 Spixworth Beck lies some 1.1 km to the south of the Site, at its closest point. It flows from west to east, converging with Dobbs Beck (a tributary of the River Bure) at NGR TG 274 168. Continuing eastwards, some 1 km downstream, the beck reaches its confluence with the River Bure (NGR TG 284 172).

4.3.10 Water levels in Spixworth Beck decrease from some 5 maOD at Spixworth Bridge (NGR TG 239 165) to less than 1 maOD at its confluence with the River Bure (NGR TG 284 172).

4.3.11 Along the majority of its length, the valley of Spixworth Beck comprises water meadows, marsh and woodland, with extensive drains and ditches.

4.3.12 The most westerly reach of the Beck arises close to Church Farm near Felthorpe, some 8.25km to the west of the Application Area. The upstream catchment area measures 45km^2 (based upon FEH Web Service mapping).

4.3.13 The EA have undertaken spot flow measurements, recorded in cumecs, at several locations along the beck.

4.3.14 At Spixworth Bridge (NGR TG 239 165), the average flow rate for the period 2003-2020 is some 0.15 cumecs. The lowest recorded flow was 0.018 cumecs..

4.3.15 In the Crostwick area (at NGR TG 255 162, some 1.5 km downstream of Spixworth Bridge), historic data is available for the low flow periods that occurred during the summer of 1976 and 1977. The lowest recorded flow was 0.012 cumecs.

4.3.16 A further 1 km downstream (at NGR TG 265 166), a preliminary spot flow measurement was taken in August 1989 followed by monthly visits from September 1990 through to January 1991. The flow rate for this period averaged some 0.1 cumecs. It is not possible to make a direct comparison with the Spixworth Bridge data, because there are no contemporaneous measurements.

4.4 Hydrogeological Setting

4.4.1 The glaciofluvial sands and gravels constituting the economic mineral of the currently consented operations, and Proposed Extension area, are designated by the EA as a "Secondary A" superficial aquifer. As will be demonstrated below, the full thickness of the drift deposits at the Application Site is unsaturated.

4.4.2 The Chalk is classified as a Principal Aquifer. The watertable is at or near the upper surface of the Chalk. Rainfall drains through the sand and gravel and recharges the underlying, unconfined Chalk aquifer.

4.4.3 It is considered that the groundwater flow direction in the vicinity of the Site is predominantly from west to east, towards the River Bure. This is based upon comparison of average groundwater levels in west-east piezometer pairings. Water levels in the Chalk decrease from 6.0 maOD in Piezometer T57/99/18 to 3.0 maOD in the abstraction borehole in Cooper's Grove (750 m to the east). Within the valley of the Spixworth Beck, water levels in the Chalk decline from 5.0 maOD in the EA's Spixworth Bridge piezometer to 1.9 maOD at Crostwick Marsh (some 2.25 km to the east).

4.4.4 Groundwater elevations in the monitoring piezometers (as recorded by the Applicant and the EA) have been compared with surface water levels in adjacent streams, ponds and field ditches (taken from OS and LIDAR mapping).

4.4.5 Within the valleys of the Spixworth Beck and Cooper's Grove, groundwater and surface water levels are in concordance. This indicates that the streams, ponds and field ditches in these valleys are in hydraulic continuity with the groundwater in the Chalk. At Spixworth Bridge, water level in the EA's monitoring piezometer (some 5.0 maOD) is consistent with that in the beck. The same applies to water level in the Cooper's Grove abstraction borehole (3.0 maOD) and adjacent field ditch.

4.4.6 Upon the intervening higher ground between Cooper's Grove and Spixworth Beck, there are isolated ponds within small shallow depressions, with surface water levels of 15-20 maOD. Comparison with groundwater elevations (which average 6.5 maOD in Piezometer T57/99/31) indicates that these are perched features.

4.4.7 Data collected from groundwater level monitoring piezometers installed on Site indicate that, within the proposed extraction area, the sand and gravel deposit is dry.

4.4.8 This is consistent with the findings of the exploration drilling programme undertaken in January 2000 and May 2001, during which no watertable strikes were recorded within the 94 boreholes located on Site.

4.4.9 Thus, it is considered that the deposit will continue to be worked dry i.e. there will be no sub-watertable working.

4.4.10 The free-draining nature of the sand and gravel allows works to proceed without the need for active surface water management.

5 APPRAISAL OF THE FLOOD RISK POSED TO THE SITE

5.1 Fluvial Flooding

5.1.1 The Environment Agency designated floodplain is published on the Agency's website. An extract from the EA Flood Map is reproduced in *appendix FRA1*.

5.1.2 The EA mapping shows 100% of the proposed extraction area to reside within fluvial Flood Risk Zone (FRZ) 1 (*i.e.* the lowest risk flood zone; having an Annual Exceedance Probability [AEP] of fluvial flooding of 1:1,000 or less frequent).

5.1.3 The extents of FRZ2 (AEP of between 1:1,000 and 1:100) and FRZ3 (AEP of 1:100 or more frequent) are effectively confined to the valleys of the River Bure (700 m to the north east of the Site at its closest approach) and Spixworth Beck (1.1 km to the south).

5.1.4 Due to the topography of the river valleys, the extent of EA mapped FRZ2 and FRZ3, when taking account of currently accepted climate change forecasts, are virtually indistinguishable from those shown for present day conditions.

5.1.5 Therefore, the predicted future risk of fluvial flooding to the Site, when taking account of climate change forecasts, are no greater than currently exists.

5.1.6 The Proposed Development falls into the category "Sand and Gravel Workings".

5.1.7 According to Table 2 of PPG, an extract from which is presented below, the Flood Risk Vulnerability Classification for "Sand and Gravel Workings" is defined as "Water-Compatible Development".

Water-Compatible Development

- Flood control infrastructure.
- Water transmission infrastructure and pumping stations.
- Sewage transmission infrastructure and pumping stations.
- Sand and gravel working.
- Docks, marinas and wharves.
- Navigation facilities.
- Ministry of Defence defence installations.
- Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.
- Water-based recreation (excluding sleeping accommodation).
- Lifeguard and coastguard stations.
- Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.
- Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

5.1.8 Table 3 of PPG (reproduced below) indicates that the Proposed Development, being classed as "Water-Compatible", can be undertaken within any Flood Risk Zone.

Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	✗	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	✗	✗	✗	✓*

Key:

✓ Development is appropriate

✗ Development should not be permitted.

5.1.9 There is no requirement to apply the "exception test" in this instance.

5.2 Flooding from Land

5.2.1 The Application Area constitutes a sub-catchment that is largely isolated from runoff from adjacent land due to (*i*) the topographic setting and (*ii*) the existing configuration of field boundaries, which will continue to intercept and divert any runoff coming from third-party agricultural land. Therefore, runoff generation is largely limited to rainfall that is directly incident upon the Proposal Site itself.

5.2.2 Reference made to EA online mapping shows that there are no significant areas within the Site that reside within modelled surface water flood risk zones (*i.e.* flooding resulting from impeded drainage of incident rainfall or rainfall runoff).

5.2.3 The limited areas and extents of those areas that are shown at risk are associated with shallow hollows in the (current) topography of the Site. In particular, surface water flooding would collect in the broad, shallow, dry valley feature that extends across the eastern boundary of the Site. Ground elevations within this feature decrease in an easterly direction, from 15 maOD at the centre of the Site to less than 10 maOD at the boundary.

5.2.4 The proposed quarry operation is classed as a "Water-Compatible Development" in terms of fluvial flooding and this classification might be extended to cover for surface water flooding.

5.2.5 In conclusion, there is considered to be negligible potential for significant flooding of the Proposal Site from rainfall runoff from surrounding lands.

5.3 Flooding from Groundwater

5.3.1 Data collected from groundwater level monitoring piezometers installed on Site indicate that, within the proposed extraction area, the sand and gravel deposit is dry.

5.3.2 Floor level in the extraction area will equate to 8-10 maOD.

5.3.3 During the monitoring period (October 1999 to date), water levels have ranged between 6.2-7.1 maOD in T57/99/31 and 5.5-6.7 maOD in T57/99/18; declining eastwards to 2-4 maOD in the abstraction borehole at Cooper's Grove.

5.3.4 Thus, the workings will maintain 1-3 m standoff above the peak groundwater levels recorded at the up-gradient piezometer. Moving eastwards across the Site, the standoff above the watertable increases to 4-6 m.

5.3.5 Thus, there is considered to be negligible risk of groundwater flooding.

5.3.6 Furthermore, the proposed quarry operation is classed as a "Water-Compatible Development" in terms of fluvial flooding and this classification might be extended to cover for groundwater flooding.

5.4 Flooding from Reservoirs

5.4.1 EA mapping illustrates the extent of flood risk from reservoirs.

5.4.2 There is no such risk at the proposed extension area.

5.5 Flooding from Sewers and Drainage Systems

5.5.1 There is no connection to mains drainage (water supply, foul sewer or storm drains) at the proposed extension area.

5.5.2 It is considered that there is negligible risk of flooding from artificial sources.

6 APPRAISAL OF THE FLOOD RISK POSED ELSEWHERE WITHIN THE CATCHMENT BY THE PROPOSED DEVELOPMENT

6.1 Background

6.1.1 The FRA process requires that downstream flooding problems are not exacerbated by run-off from the developed area.

6.1.2 The key requirement relevant to the Proposal Site is as follows: For the range of annual flow rate probabilities up to and including the one per cent annual exceedance probability (1 in 100 year) event, incorporating an appropriate allowance for climate change, the developed rate of run-off into a watercourse, or other receiving water body, should be no greater than the existing rate of run-off for the same event. Volumes of run-off should also be reduced wherever possible using infiltration and attenuation techniques.

6.2 Controlling Runoff during Mineral Extraction

6.2.1 The free-draining nature of the sand and gravel allows works to proceed without the need for active surface water management.

6.2.2 There is no requirement for off-site discharge at the Application Site.

6.2.3 During the mineral extraction phase of the development, any rainfall runoff will drain to the lowest point on the quarry floor and soak away into the underlying strata. This conclusion is drawn from Site experience, as follows:

- At the time of the water features survey on 6th March 2020, no standing water was observed in the active workings. As explained in more detail in *section 5.3*, the workings will maintain 1-3 m standoff above the peak groundwater levels recorded at the up-gradient piezometer. Moving eastwards across the Site, the standoff above the watertable increases to 4-6 m. Therefore, a significant thickness of unsaturated strata will be retained beneath the floor of the Proposed Development.
- There has been no historic requirement for drainage infrastructure in the fields and woodland surrounding the Application Area. This suggests that the land is relatively free-draining.

6.2.4 On this basis, it is considered that the mineral workings will not lead to any increase in flood risk elsewhere in the catchment area.

6.3 Controlling Runoff during Restoration

6.3.1 The proposed restoration strategy is illustrated on plan ref KD.SH.D.015. The aim of the scheme is to re-create an agricultural landscape with enhanced wildlife habitat, with the potential for increased biodiversity.

6.3.2 The agricultural land within the Restored Site will be at a lower level than the surrounding lands. The lowest point on the boundary of the completed workings is midway along the eastern margin (close to the property named "Beverley"), where ground level equates to 10 maOD. Floor level in the closest section of restored agricultural land is 8 maOD, thus giving 2 m depth of storage for storm runoff.

6.3.3 Elsewhere at the Site boundary, the floor level is typically 5-7 m below surrounding land; increasing to a maximum of 12 m difference at the northeast corner of the Site.

6.3.4 The post-development runoff characteristics will remain consistent with the pre-existing situation across the entire Site *i.e.* agricultural land with no hardstanding or impermeable areas. There is no change in runoff coefficient as it relates to surface material or gradient.

6.3.5 The restored landform should not lead to any increase in flood risk elsewhere in the catchment area.

6.4 Floodplain Storage

6.4.1 The Application Area lies outside the floodplain.

6.4.2 Therefore, there will be no development-related reduction in floodplain storage.

7 RESIDUAL RISK

7.1 Flood risk to people and property can be managed but it can never be completely removed; a residual risk will remain after flood management or mitigation measures have been put in place.

7.2 In this instance, when the Site has been restored to agricultural land, the management of residual risk will, for the most part, be the responsibility of the landowner, who will need to be aware that there may be temporary ponding of surface water at the lowest points on the restored landform following a severe storm event. This would be comparable to current risk of surface water ponding (*section 5.2*). Land use should be tailored to allow for these variations.

8 CONCLUSIONS

8.1 The various elements of the Proposed Development are classified as "Appropriate Activities" by *Table 3* of the Technical Guidance to NPPF. This conclusion remains when accounting for the assumed effects of climate change.

8.2 The Proposed Development is safe and that there is no requirement to apply the Exception Test.

8.3 There is considered to be negligible potential for significant flooding of the Proposal Site from other sources i.e. rainfall runoff from adjacent lands, groundwater, reservoirs *etc*.

8.4 Assessment has been made of the flood risk that may be posed elsewhere within the catchment by implementation of the operational and post-restoration stages of the Proposed Development. The proposals are considered to be acceptable in this regard.

Henry Lister
Senior Hydrogeologist
BCL Consultant Hydrogeologists Limited

Tarmac Trading Limited

STANNINGHALL QUARRY
Norwich Road, Norwich, NR12 7LX

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Existing Sand and Gravel Quarry

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APPENDIX FRA1
Figures

Consultant Hydrogeologists

Technology Centre
Wolverhampton Science Park, Wolverhampton, WV10 9RU
Tel: 01902 824111, Fax: 01902 824112
email: info@bclhydro.co.uk www: http://www.bclhydro.co.uk

Company Registration Number: 4043373
Registered in England & Wales. Registered Office: 33 Wolverhampton Road, Cannock.

Environment Agency

Flood map for planning

Your reference
Stanninghall

Location (easting/northing)
625887/318271

Scale
1:25000

Created
24 Jun 2020 12:14

- Selected point
- Flood zone 3
- Flood zone 3: areas benefitting from flood defences
- Flood zone 2
- Flood zone 1
- Flood defence
- Main river
- Flood storage area

0 200 400 600m