South Tees Development Corporation

# Former Steelworks Land, South Tees

## Flood Risk Assessment and Drainage Strategy


Wood Environment & Infrastructure Solutions UK Limited – June 2019

Report for

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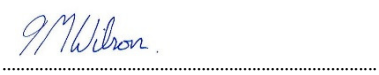

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## Document revisions

| No. | Details | Date |
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| **PO1** | Flood Risk Assessment and Drainage Strategy | 25 June 2019 |
| **A-PO1** | Flood Risk Assessment and Drainage Strategy | 27 June 2019 |

# Contents

# 1. Introduction

## 1.1 Terms of Reference

Wood Environment & Infrastructure Solutions UK Ltd (Wood) was commissioned by Tees Valley Combined Authority (TVCA) on behalf of South Tees Development Corporation (STDC) to prepare an outline Flood Risk Assessment and Drainage Strategy (FRS & DS) relating to the six storage mound sites in which STDC intend to temporarily store material for future and use of the material in the remediation and preparation of land for development. The commission was undertaken in accordance with Wood's proposal ref: 41825-WOD-XX-XX-proposal-OC-0001_S0_P01 dated 31 May 2019.

The outline flood risk assessment and drainage strategy has been developed based on information available for the site at the time of writing, as contained within the document.

## 1.2 Background

TVCA was formed in April 2016 to drive economic growth and job creation in the area. STDC was launched in August 2017 as a Mayoral Development Corporation.

STDC are responsible for the former TATA Steel (TATA) / Sahaviriya Steel Industries UK (SSI) Redcar Steelworks site as well as other industrial assets within its constitutional boundary. The South Tees Regeneration Master Plan was published in March 2019, setting out the vision for transforming the STDC area into a world-class example of a modern, large-scale industrial business park by providing a flexible development framework where land plots can be established in a variety of sizes to meet different occupier needs in the most efficient manner possible.

STDC are submitting a planning application to import soils from the Sirius Minerals (Sirius) site at Wilton and to temporarily store these for use in future remediation works of former industrial land. The STDC area covers land to the south of the River Tees, in the Borough of Redcar and Cleveland, and includes the former TATA/ SSI Redcar Steelworks site as well as other industrial assets.

Sirius has commenced tunnelling operations on an adjacent site at Wilton. The tunnelling operations will generate in the order of 800,000$m^3$ of naturally occurring soil and rock material, which is suitable for use in the future remediation works at the STDC site. This is to be temporarily stored at a series of six land parcels, which comprise approximately 20ha of the overall 286ha acquired from TATA by STDC.

This FRA & DS will cover the application relating to the six storage mounds in which STDC intend to temporarily store material for future use in remediation and redevelopment of their site, as well as defining the requirements with respect to the sediment management. The application also seeks to obtain permission to use the material in the remediation and preparation of land for development, leading to an increase in ground levels of typically no more than 500mm; this is also covered at high level in this FRA & DS.

## 1.3 Scope of Study

The report presents the findings of a FRA & DS in support of the planning application. It has been prepared in accordance with NPPF requirements and guidance set out by Lead Local Flood Authority (LLFA), which in this instance is Redcar and Cleveland Borough Council (RCBC). The majority of the full site is within Flood Zone 1 with a small portion of land within Flood Zone 2 and can therefore be considered at a 'low risk' of flooding from rivers or the sea. However, this assessment will consider flood risk from other sources, as well

as and an assessment of the impacts of runoff from the storage mounds. Each individual storage mound exceeds 1ha and the cumulative area is approximately 20ha. The total application site area is 286ha.

As part of this study it was necessary to initially consult with the RCBC and the EA to discuss and agree requirements for surface water discharges and permitting associated with the proposed development, both during works to place the materials and from the sites following completion of capping works.

Following review of existing documentation and site walkovers, a baseline assessment was undertaken, and simple models created to establish the baseline drainage requirements for the development proposals for all six sites.

The key objectives of this assessment were as follows:

- To summarise flood risks from all sources, and to identify if required, mitigation measures to protect the site;
- To set out the overall approach to surface water management during works in order to manage flood risk and water quality considering including any allowance for climate change in accordance with current UK Government guidance;
- To provide outline design and sizing of collection and drainage attenuation systems (SUDS);
- To identify discharge locations and any permitting requirements;
- To identify the requirement for silt and sedimentation management;
- To define a drainage maintenance and management plan, which will set out the tasks, frequency and methodology required to ensure that the operation of the surface water management system is maintained at an optimal level; and,
- To provide appropriate drainage details in-order to updated drawings to support the planning application.

## 1.4 Regulatory Context

### National Planning Policy Framework (NPPF)

The revised National Planning Policy Framework (NPPF) which was published 24 July 2018 and subsequently updated and provides guidance for local planning authorities and decision-makers, both in drawing up plans and making decisions about planning applications. It is accompanied by online Planning Practice Guidance on Flood Risk and Coastal Change (the 'NPPF PPG')[1], which was published in 6 March 2014.

In addition, the Environment Agency (EA) produced updated guidance on 15 February 2019 for climate change allowances for FRA to support NPPF.

The Environment Agency's Flood Map for Planning indicates that all of the soil storage mounds are situated within Flood Zone 1, indicating a low likelihood (less than 0.1% Annual Exceedance Probability or AEP) of flooding from fluvial or tidal sources. However, some parts of the wider site are located within Flood Zone 2 and are therefore have a medium likelihood of flooding from rivers and the sea (between 1% AEP and 0.1%AEP).

Therefore, the NPPF specifies that a site-specific FRA is still required to support the planning application.

[1]. .National Planning Policy Framework – Planning Practical Guidance, Flood Risk and Coastal Change March 2014

### Redcar and Cleveland Borough Council Planning Policy

The RCBC local plan was adopted in May 2018[2]. Policy SD7 'Flood and Water Management' is of relevance to flood risk management for new developments. It advises that new development in areas of flood risk should be avoided. It advises prospective developments to consult the NPPF and the RCBC Strategic Flood Risk Assessment (discussed below) for further guidance.

### Redcar and Cleveland Strategic Flood Risk Assessment (Level 1 and Level 2)

The Redcar and Cleveland Strategic Flood Risk Assessment (SFRA) Level 1[3] was produced 2010 and updated in 2016 to inform the development of the Local Plan using up to date flood risk information and current flood risk and planning policy available from the NPPF and its associated Flood Risk and Coastal Change PPG.

The Level 1 SFRA provides some basic guidance on requirements for a FRA within the area it covers including requirements for the Sequential Test and the Exception Test, but largely refers to national guidance on flood risk (i.e. the NPPF guidance). The SFRA provides a broad scale assessment of flood risk across Redcar and Cleveland, although limited information is given specific to the site.

The Level 2 SFRA[4] also produced in 2010 contains more detailed assessment of flood hazards for key areas of the Borough where areas of flood risk and proposed development coincide, including consideration of climate change up to 2107.

## 1.5 Sequential and Exception Test

### Sequential Test

The NPPF and the accompanying PPG describe the principles of the Sequential Test, which aims to steer new development to areas with the lowest probability of flooding. The Sequential Test is a decision-making tool designed to promote sites at little or no risk of flooding in preference to sites in areas at higher risk. As all of the proposed storage mounds are located within Flood Zone 1 and the small areas of Flood Zone 2 in the wider site will be avoided in subsequent remediation works (with reference to the definitions provided in Table 1.1), the requirements of the Sequential Test are considered to be met.

### Exception Test

The NPPF online flood risk matrix provides a classification of the prospective flood risk based on land use classification. The proposed soil storage and subsequent remediation works are considered to be 'less vulnerable' to flooding in terms of the Flood Risk Vulnerability Classification provided as Table 2 in the NPPF PPG . The NPPF PPG Table 3 Flood Risk Vulnerability and Flood Zone Compatibility matrix is reproduced as Table 1.2 and identifies that, for 'less vulnerable' development within Flood Zones 1 and 2, the Exception Test does not need to be applied. For this reason the type of development proposed is considered to be appropriate for this location, and therefore the Exception Test has not been considered further in this FRA & DS.

[2] Redcar and Cleveland Borough Council Local Plan, Map 2018
[3] Redcar and Cleveland Borough Council Level 1 Strategic Flood Risk Assessment, May 2016
[4] Redcar and Cleveland Borough Council Level 2 Strategic Flood Risk Assessment, August 2010

## Table 1.1 Flood Zone Definitions and Associated Annual Exceedance Probability

| Flood Zones | Probability of flooding | Annual Exceedance Probability (AEP) | Definition |
|---|---|---|---|
| **Zone 1** | Low Probability | <0.1% AEP of river or sea flooding | Land having a less than 1 in 1,000 probability of river or sea flooding in any year. |
| **Zone 2** | Medium Probability | 1% - 0.1% AEP of river flooding<br>0.5% – 0.1% AEP of sea flooding | Land having between a 1 in 100 and 1 in 1,000 probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 probability of sea flooding |
| **Zone 3** | High Probability | >1% AEP of river flooding<br>>0.5% AEP of sea flooding | Land having a 1 in 100 or greater probability of river flooding in any year; or land having a 1 in 200 probability or greater of sea flooding in any year. |

## Table 1.2 Flood Risk Vulnerability Classification

| Flood Zone | 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 | × | × | × | ✓~ |

Development is appropriate (✓)
Development should not be permitted. (×)

## 1.6 Information Sources

The key sources of data used in the development of this FRA & DS are summarised in Table 1.3.

Table 1.3 Key Data Sources

| Data | Supplier | Sourced |
|---|---|---|
| **Nation Planning Policy Framework** | Dept. Housing, Communities and Local Government | https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf |
| **Climate Change Guidance** | Environment Agency | Flood risk assessments: climate change allowances. Published 19 Feb 2016; last updated 3 Feb 2017. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances |
| **Redcar and Cleveland Local Plan** | RCBC | https://www.redcar-cleveland.gov.uk/resident/planning-and-building/strategic%20planning/Documents/Local%20Plan%20Adopted%20May%202018.pdf |
| **Redcar and Cleveland SFRA Level 1** | RCBC | https://www.redcar-cleveland.gov.uk/resident/planning-and-building/local-plan/Local%20Plan%20Documents/Redcar%20and%20Cleveland%20Strategic%20Flood%20Risk%20Assessment%20(Level%201)/RCBC%20Level%201%20SFRA%20Update%202016.pdf |
| **Redcar and Cleveland SFRA Level 2** | RCBC | https://www.redcar-cleveland.gov.uk/resident/planning-and-building/local-plan/Local%20Plan%20Documents/Redcar%20and%20Cleveland%20Strategic%20Flood%20Risk%20Assessment%20(Level%202)/2010s4006%20-%20RCBC%20Level%202%20SFRA%20V2.pdf |
| **LIDAR/DTM (1m)** | Environment Agency | From Environment Agency Open Source (Downloaded 31/05/19) https://data.gov.uk/publisher/environment-agency |
| **Historical Mapping** | eMapSite | Purchase from eMAPsite (07/06/19) |
| **Historical Photographs** | Google Earth | https://www.google.com/intl/en_uk/earth/ |
| **FEH DDF rainfall and catchment descriptors** | FEH-Web | Obtained from CEH Website (Downloaded 28/05/19) |
| **Guidance for Pollution Prevention (GPP5)**[1] | Netregs | http://www.netregs.org.uk/media/1303/gpp-5-works-and-maintenance-in-or-near-water.pdf (accessed 18/06/18). Although |
| **Pollution Prevention Guidelines PPG21**[1] | Netregs | http://www.netregs.org.uk/media/1436/gpp-21-final.pdf (accessed 18/06/18) |
| **Environmental Good Practice on Site** | CIRIA | CIRIA (2015) Environmental good practice on site guide (fourth edition) (C741), ISBN 978-0-86017-746-3 |
| **Conduit Roughness** | Engineering Toolbox | https://www.engineeringtoolbox.com/mannings-roughness-d_799.html |

[1] Although GPPs and PPGs are no longer formally endorsed by the Environment Agency for use in England, they still offer a useful source of best practice guidance on pollution prevention issues.

## 1.7 Consultation

Consultation has been undertaken with the key stakeholders, which includes the LLFA and The Environment Agency. The results of these consultation exercises are shown in Table 1.4

Table 1.4 Key Stakeholder Consultation

| Consultee | Date of Consultation | Contact | Summary of discussions |
|---|---|---|---|
| **Redcar and Cleveland Borough Council (RCBC)** | 24 May 2019 and 19 June 2019 | Lynsey Hall, Nigel Hall & Michael Kay | Initial discussion with the LLFA highlighted that the default position with regards to discharge would be to ensure all flows are restricted to $Q_{BAR}$, in-line with standard RBCB requirements for new development. However, due to the nature of the proposal the LLFA agreed to consider a relaxed rate which still resulted in betterment from existing.<br><br>Following calculation of the existing brownfield rates (Section 4.2). It was confirmed by RCBC that flows could that it would be acceptable to discharged flows at the more relaxed Brownfield rates, with betterment only required at sites t Grange Town Prairie (1A and 1C) and also at Warrenby (3A). |
| **The Environment Agency (EA)** | 11 June 2019 | Marion Williams Planning Advisor, Sustainable Places North East | Initial consultation was undertaken with the EA in order to confirm the need for any further detailed discussions. The EA responded that since none for the sites were located within Flood Zones 2 or 3 they was no further need to consult with the ' Sustainable Places' team<br><br>However, consultation with the Environment Agency highlighted that due to the intention to discharge runoff from large areas of land, which in principle can be considered impermeable in nature, into local watercourses and ultimately the River Tees an Environmental Permit may be required from the Environment Agency. This will need to be confirmed during subsequent stages. |

# 2. Site Details

## 2.1 Site Locations

The Site is located on the southern bank of the River Tees, covering an area of approximately 286ha in total. The six identified areas for the temporary storage of materials which are located within the full site cover a combined area of 20ha.

The condition of the land varies across the site and mostly consists of previously developed land formerly in heavy industrial use. Most of the land surrounding the site is within the STDC Site and planned for future regeneration. The Site and surrounding areas have a long and layered industrial history. The main land uses were dominated by extensive iron and steel works together with auxiliary industries, infrastructure, power generation and distribution, together with waste management.

The Site planning boundary and the location of the storage mounds are shown in Figure A.1 (41825-WOOD-XX-XX-DR-OW-0001_S2_P01.1) within Appendix A.

## 2.2 Storage Mounds

STDC has identified six locations for temporary storage of imported soil material. There are three at Grangetown Prairie, two at Warrenby and a single parcel at the Metals Recovery Area.

The activities proposed include the demolition of structures and engineering operations associated with the ground preparation and the temporary storage of materials and its final use in the remediation and preparation of land for regeneration and development. STDC would be responsible for the management of the storage mounds prior to its future re-use in the development of the wider STDC site.

### Grangetown Prairie

STDC has identified three storage mounds at the Grangetown Prairie area, at approximate NGR 454838, 521671. These are referred to as storage mounds 1A, 1B and 1C and are 1.3ha, 1.1ha and 4.5ha in size respectively. These are located to the northwest of the junction of the A1053 Tees Dock Road and the A66 Trunk Road, south of the Middleborough to Saltburn railway and west of the old British Steel site. These locations are mainly associated with the former Cleveland Steel Works. The area is currently disused and largely derelict, comprising areas of concrete slabs/ hard-standing or unsurfaced ground with sparse emergent scrub vegetation.

The area is generally level with the majority lying between 8.0m and 9.0m AOD. There is a gradual south to north fall, with ground levels ranging from 13.0m AOD in the extreme south western corner to approximately 7.5m AOD on the north eastern boundary. The storage mounds are bounded by the Holme Beck Culvert to the west and the Knitting Wife Culvert to the east, both of which ultimately discharge into the River Tees via the Cleveland and Lackenby Channels. However, given the local topography, it is anticipated that existing runoff from the area would drain to the River Tees via the Cleveland or Lackenby Channels.

### Metals Recovery Area

STDC has identified a single storage mound at the Metals Recovery Area, at approximate NGR 454755, 522600. This is referred to as storage mound 2, which is 2.7ha in size. The site is located to the north and west of the A1053 Tees Dock Road and is part the former South Bank Works.

The area is generally level with the majority lying between 7.0m and 8.0 AOD. There is a gradual north to south fall, with ground levels ranging from 7.0mAOD in the extreme south western corner to approximately 16.0m AOD on the north western corner. The site is bounded by the Cleveland and Lackenby Channels, which ultimately discharge into the River Tees. Due to the local topography, it is anticipated that existing runoff from the site would drain to the River Tees via the Cleveland or Lackenby Channels.

## Warrenby

STDC has identified two storage mounds in the Warrenby area, at approximate NGR 457780, 524618. These are referred to as storage mounds 3A and 3B, which are 4.8ha and 5.2ha in size, respectively. They are located to the north of the junction of the A1053 Tees Dock Road and the West Coatham Lane and north of the Middlesbrough to Saltburn railway.

Site 3A is a permitted landfill site, which is closed, but has yet to be restored. Site 3B is a south of the landfill and is the extension site which was prepared for the placement of waste steel works materials but not used. The site is generally level ground (excluding the Warrenby landfill site) and lies at a ground elevation of between 5.0m and 10.0m AOD. The Warrenby Landfill area is raised above the surrounding ground by up to 15.0m and has an irregular surface profile reflecting its former use for tipping of wastes. The general site is an area of largely disused derelict land, containing former access roads and tracks. The site is partly vegetated by poorly established grass and scrub vegetation, and there are large areas of bare ground.

The two areas 3A and 3B are bisected by the Fleet watercourse into which the areas drain. The Fleet watercourse ultimately discharges into the River Tees via the Dabholm Gut

# 3. Flood Risk Appraisal

## 3.1 Potential Sources of Flooding

### Tidal and Fluvial

From inspection of the EA Flood Map for Planning, it was established that the six storage mounds are all located within Flood Zone 1. Therefore, the sites are considered to be at a low risk of flooding from fluvial or tidal sources (less than 0.1% AEP).

When considering the full site area, there is an interaction with Flood Zone 2 (between 1%AEP and 0.1%AEP), but this is only along the length of the Fleet watercourse and in the vicinity of the Warrenby storage mounds.

The extents of the tidal and fluvial Flood Zones are shown in Figure A.2 (41825-WOOD-XX-XX-DR-OW-0002_S2_P01.1) within Appendix A

### Surface Water

From inspection of the EA surface water flood risk map extents it was established that the vast majority of six storage mounds, are classified as being at very low risk of surface water flooding (defined as having a probability of less than 0.1% AEP). There a number of isolated pockets across the full site that are at a higher risk of surface water flooding, these are restricted to ponding at the low spots and are either at Medium (between 1% and 3.3%) and high risk (greater than 3.3%).

A further assessment has been made of the potential for surface water run-off and run-on from the six storage mounds. Preliminary 2D model runs were carried out of the sites in their current state using Innovyze's ICM version 9.5, built from open source 1m DTM LiDAR data. It was confirmed that, due to undulating nature of the existing topography there is limited opportunity for surface water to affect neighbouring areas. It is anticipated that the majority of rainfall is probably retained on-site, which then saturates the surface and percolates through the sub-surface or is lost by evaporation. This is described further within the baseline assessment in Section 4.2. Incident rainfall on the proposed storage mounds will be managed via a temporary drainage system that will ensure that surface water flood risk to adjacent areas is not increased. This is described further within the proposed surface water drainage strategies in Section 4.3.

The extents of the area at risk of flooding from surface water are shown in Figure A.3 (41825-WOOD-XX-XX-DR-OW-0003_S2_P01.1) within Appendix A.

### Flooding from Sewers

It is considered unlikely that there are any public sewers within the proposed development area or in the near vicinity which could surcharge and result in sewage flooding and affecting the development. In addition, during the site visit on the 24 May 2019 no existing manholes or other drainage infrastructure was noted.

### Flooding from Reservoirs

On inspection of the EA Flood Risk from Reservoirs flood extents, it was noted that the six storage mounds are unlikely to be affected by flooding for this source. Regarding the full site, there does appear to be a risk of flooding from reservoirs along the Fleet watercourse with similar extents to Flood Zone 2.

### Flooding from Groundwater

The risk of flooding from groundwater is considered to be low, considering that the underlying geology is largely impermeable (i.e. Mercia/Redcar Mudstones, overlain by tidal flat deposits or made ground). Furthermore, no significant excavation works are proposed as part of the proposed stockpiling operations.

### Artificial Sources

The only artificial sources of flood risk will be from the existing ponds and existing water retaining structures within the existing steelwork site. Any structures relating to the past operation will be removed as part of the remediation process and unlikely to cause any further risk.

## 3.2 Flood Risk Mitigation

The flood risk review presented above has demonstrated that there is a low risk of flooding to the six storage mounds from all sources. As a consequence, no specific flood risk mitigation measures are required to address flood risks to the mounds. However, the placement of raised material on the sites could increase runoff rates from them, potentially resulting in an increase in downstream flood risk. Drainage strategies have been prepared for each of the storage mounds in order to avoid this, which are presented in Section 4.4.

With regards the full Site, any placement of material for remediation and preparation of land for development will be avoided on land within Flood Zone 2. Drainage requirements for future use of the stored soils for land remediation and preparation for development is considered at a high level in Section 4.1.

# 4. Drainage Strategy

## 4.1 Overview

This main focus of the Drainage Strategy section of this report is on the managing surface water runoff from the six storage mounds. With regards the full site, it is anticipated that placement of material resulting in an increase in ground levels of no more than 500mm will not materially affect existing drainage regimes or current surface water runoff rates. It would not increase the risk to any downstream areas or interrupt and displace any existing surface water pathways.

## 4.2 Modelling Approach

The approach of this drainage strategy is to firstly undertake a high-level assessment of the existing or baseline drainage regimes for the areas where the six storage mounds are to be located. This was done using the 2D overland flow functionality within *Innovyze's ICM (Integrated Catchment Modelling) software (Version 9.5)*. The results of the baseline assessment were used to establish the likely proposed discharge in agreement with the LLFA. The modelling of the theoretical Greenfield rates, as well as the proposed drainage systems, has been undertaken using *Innovyze MicroDrainage Version 2018*.

In-order to calculate baseline runoff rates, it was necessary to establish certain assumptions to aid the assessment of the amount of rainfall that gets converted to runoff. This was required for both baseline and proposed scenarios. Runoff can be considered a function of two parameters, the 'Impermeability Factor' which is a measurement of the amount of area which exhibits a quick response to rainfall and the 'Volumetric Runoff Coefficient ($V_C$)' which is an factor defining the amount of rainfall which falls on a surface and is converted to runoff.

Both assessments are detailed further in the following sections. However, with regards to the proposed scenarios, this approach was used to estimate the amount of volume that is needed in-order to attenuate flows to the agreed rates using *MicroDrainage* software.

In each case, Flood Estimation Handbook 1999 (FEH 1999 ) rainfall data was used to generate rainfall for the six storage mounds sites. Two drainage catchments were identified, one covering the Grangetown Prairie and Metal Recovery sites and the other covering the two sites at Warrenby.

## 4.3 Baseline Surface Water Runoff

In-order to establish the most practical baseline rates, a range of potential baseline runoff rates were calculated. This included the more stringent theoretical $Q_{BAR}$ and $Q_{1\%AEP}$ Greenfield runoff rates, as well as $Q_{1\%AEP}$ Brownfield rates to represent the upper end of the range.

The Greenfield rates were established using the ICP SUDS methodology and the calculations for this are presented in Appendix B. This approach assumes that the site is fully permeable and volumetric runoff coefficients are established from the catchment FEH parameters.

Brownfield rates were established using the following approach. Preliminary 2D model runs for the six storage mounds were undertaken using 1m open source LiDAR topography data. This was used to create four 2D ground models (Grangetown Prairie, Metals Recovery Area, Warrenby 3A and Warrenby 3B).

For the baseline conditions and as a conservative assumption, representation of any subsurface drainage systems was excluded at all of the six storage mounds. Then using OS background maps, the different

surfaces areas within the site boundaries were identified and assigned different 'volumetric runoff coefficients', based on the following:

- Impermeable areas (i.e. Highways, concrete hard-standing areas or building) - 0.9; and,
- Permeable or semi permeable areas – 0.4 to 0.7 (depending upon specific ground conditions).

This was backed up with historic aerial photographs and mapping and this assessment is summarised in Table 4.1.

Direct rainfall was then simulated onto the 2D ground models and runoff generated and the modelled peak overland flow discharge rates for each of the six storage mounds extracted from the results. The results of this baseline assessment in terms of theoretical Greenfield and estimated Brownfield rates are shown in

Table 4.2

Table 4.1 Assumed Baseline Areas

| Site | Storage Mounds Area (ha) | $V_C$ | Comments |
|---|---|---|---|
| **Grangetown Prairie 1A** | 1.3 | 0.5 | Area 1A has no history of buildings or other impermeable surfaces, with the exception the road which is a relatively well maintained concrete/tarmacadam surface. The remaining surface was historically used as storage/laydown with some areas of concrete hardstanding. Therefore, the area is understood to have some permeability. |
| **Grangetown Prairie 1B** | 1.1 | 0.5 | Same as 1A |
| **Grangetown Prairie 1C** | 4.5 | 0.7 | Up to 2010 the western part of Area 1C housed a large structure with a concrete base. The remaining surface was historically used as storage/laydown with some areas of concrete hard-standing. Therefore, the area and is assumed to have limited permeability. |
| **Metals Recovery** | 2.7 | 0.7 | The site has historically always been used for storage of materials. There are some areas of concrete hard-standing. Due to its historical use it is anticipated that this site will generally be of a low permeable nature. |
| **Warrenby 3A** | 4.8 | 0.5 | This site is a historic landfill site. Although there are no areas of hard-standing, it is anticipated that the site will have limited permeability area due to its use as a landfill site. |
| **Warrenby 3B** | 5.2 | 0.4 | From inspection of historical maps it is apparent that this site has had limited use over recent years and is therefore considered to have a significant level of permeability., Therefore, the assumed impermeability is estimated to be similar to the FEH catchment SPRHost value of 0.396, |

Table 4.2 Baseline Discharge Rates

| Site | Theoretical $Q_{BAR}$ (l/s) | Theoretical 1%AEPyr Greenfield Rate (l/s) | Calculated 1%AEPyr Brownfield Rate (l/s) |
|---|---|---|---|
| **Grangetown Prairie 1A** | 4.9 | 11.9 | 60.5 |
| **Grangetown Prairie 1B** | 4.2 | 9.2 | 31.9 |
| **Grangetown Prairie 1C** | 17.1 | 35.7 | 297.6 |
| **Metal Recovery** | 10.3 | 21.5 | 32.2 |
| **Warrenby 3A** | 18.2 | 38.2 | 210.3 |
| **Warrenby 3B** | 19.8 | 41.7 | 108.5 |

## 4.4 Surface Water Drainage Strategy

Proposed discharge rates and attenuation volumes were calculated based on the assumption that the six storage mounds were smooth, bare earth, compacted mudstone and therefore likely to be virtually fully impermeable in nature. However, it was assumed that the sites would possess a volumetric coefficient of 0.6 to allow for any runoff losses due fracturing or wetting/absorption in the runoff surfaces.

Other design assumptions considered in the calculations of the proposed discharge rates and attenuation volumes, include:

- Drainage ditches will to be designed to contain the 3.33%AEP event (i.e. 1 in 30 year return period event) and events up to the 1%AEP (1 in 100 year return period event) are to be retained on site without affecting neighbouring sites:
- Attenuation structures will be designed to hold flows from events up to and include the 1%AEP (1 in 100 year return period event), plus a 20% uplift on rainfall intensities to account for climate change in-line with government projections up to 2069 [5];
- Ditch gradient will be kept to a maximum gradients of 1 in 500 or 0.2% to allow a degree of settlement and maximise any upstream storage;
- Side slopes for ditches to be 1 in 1.5 with base width of 500mm and a minimum depth of 400mm;
- Side slope of basin to be 1 in 3;
- Roughness values assumed to be k = 0.6mm for pipes and n= 0.018 for ditches; and
- Flow controls are to be represented as a HydroBrake, but other similar control devices could be considered.

### Proposed Discharge Rates

From discussions with the LLFA, it was established that any discharges would be limited to a rate close to that of the baseline 100 year (0.1%AEP) Brownfield discharge rate. It was agreed that this was an acceptable and practical approach to define proposed rates given the past historic use of the sites and temporary nature of the development. However, RCBC requested a percentage betterment at the Grangetown Prairie 1A, Grangetown Prairie 1C and Warrenby 3A sites.

The agreed discharge rates are summarised in Table 4.3

[5].UK Government, Flood risk assessments: climate change allowances, 19 Feb 2016;

Table 4.3 Agree Proposed Discharge Rates

| Site | Agreed LLFA 1%AEP or 100yr Rate (l/s) | Comment |
|---|---|---|
| **Grangetown Prairie 1A** | 35.0 | Limit is estimated to be a 43% betterment from the baseline 100 year Brownfield rate |
| **Grangetown Prairie 1B** | 31.9 | Limit agreed is equivalent to the baseline 100yr Brownfield rate |
| **Grangetown Prairie 1C** | 64.0 | Limit is estimated to be a 79% betterment from the baseline100 year Brownfield rate |
| **Metals Recovery** | 32.2 | Limit agreed is equivalent to the baseline 100yr Brownfield rate |
| **Warrenby 3A** | 125 | Limit is estimated to be a 41% betterment from the baseline 100 year Brownfield rate |
| **Warrenby 3B** | 108.5 | Limit agreed is equivalent to the baseline 100yr Brownfield rate |

## Proposed Drainage Systems

Details of the proposed drainage system for each of the six storage mounds along with agreed discharge rates, attenuation volume and areas are shown as follows and also summarised in Table 4.4 and the full results are held within Appendix C.

### Grangetown Prairie

The proposed infrastructure for the management of surface water flows from the storage mounds 1A, 1B and 1C comprise the provision of a drainage ditch around the perimeter of each mound. These will gravitate flows westward for collection within a single attenuation pond located directly north of storage mound 1C. Discharge from the pond will be into the Knitting Wife Culvert at a restricted rate of 130.9l/s, which is in accordance with the summation of the preferred rates agreed with the LLFA for the three Grangetown Prairie sites.

The 1% AEP attenuation volume required to restricted flows to the agreed rate is estimated to be 1,900m$^3$, which includes an allowance for 20% for climate change. This is estimated to result in a pond of approximately 2,150m$^2$ in area. It is anticipated that there will be a degree of settlement within attenuation ponds, which will be contribute to the removal of suspended sediment from the surface water discharge from these sites.

### Metals Recovery

The proposed infrastructure for the management of surface water flows from the storage mound site 2 comprises the provision of a drainage ditch around the perimeter of the mound. These will gravitate flows to the southeast corner of the site for collection within a single attenuation pond. Discharge from the pond will be into the Lackenby Channel at a restricted rate of 32.2l/s, which is in accordance with the preferred rates agreed with the LLFA.

The 1% AEP attenuation volume required to restricted flows to the agreed rate is estimated to be 800m$^3$, which includes an allowance for 20% for climate change. This is estimated to result in a pond of approximately 1,000m$^2$ in area. It is anticipated that there will be a degree of settlement within the

attenuation pond, which will be contribute to the removal of suspended sediment from the surface water discharge from this site.

### Warrenby

The proposed infrastructures for the management of surface water flows from the storage mound site 3A comprise the provision of a drainage ditch around the perimeter of the mound. Due to local levels it is necessary to have two outlets from the ditch, one in the south-eastern corner and the other in the south-western corner, each with its own attenuation pond. Discharge from the ponds will be into the Fleet watercourse at a restricted rates of 27.5l/s and 97.5l/s for the western and eastern pond respectively, which is in accordance with the preferred rates agreed with the LLFA.

The 1%AEP attenuation volumes required to restricted flows to the agreed rate is estimated to be 300m$^3$ and 900m$^3$ for the eastern and western pond respectively, which includes an allowance for 20% for climate change. This is estimated to result in ponds of approximately 400m$^2$ and 1,100m$^2$ in area, respectively.

The proposed infrastructures for the management of surface water flows from the storage mound site 3B comprise the provision of a drainage ditch around the perimeter of the mound. These will gravitate flows to the southwest corner of the site for collection within a single attenuation pond. Discharge from the pond will be into the Fleet watercourse at a restricted rate of 108.5l/s, which is in accordance with the preferred rates agreed with the LLFA.

The 1%AEP attenuation volumes required to restricted flows to the agreed rate is estimated to be 1,400m$^3$, which includes an allowance for 20% for climate change. This is estimated to result in a pond of approximately 1,650m$^2$ in area.

For both Warrenby 3A and 3B model results show that minor flooding occurs from the drainage ditches during 1%AEP event. These exceedance flows will be held locally on site through minor changes in the site levels which will be addressed during subsequent design stages.

It is anticipated that there will be a degree of settlement within the attenuation ponds, which will be contribute to the removal of suspended sediment from the surface water discharge from these sites.

Table 4.4 Estimated Attenuation Volumes

| Sites | Site Area/Imp Area | Discharge Rate (l/s) | Attenuation Volume (m$^3$) | Estimated Footprint Area (m$^2$) | Critical Event | Half Drain Down Time (Mins) |
|---|---|---|---|---|---|---|
| Grangetown Prairie | 7.184 | 130.9 | 1900 | 2,150 | 240min Summer | 127 |
| Metal Recovery | 2.722 | 32.2 | 800 | 1,000 | 360min Summer | 215 |
| Warrenby 3A (West) | 1.105 | 27.5 | 300 | 400 | 120min Summer | 74 |
| Warrenby 3A (East) | 3.725 | 97.5 | 900 | 1,100 | 120min Summer | 78 |
| Warrenby 3B | 5.278 | 108.5 | 1,400 | 1,650 | 180min Summer | 109 |

# 5. Sediment Management

Sediment pollution could be generated on site from several sources, but primarily the runoff from the exposes storage mounds are anticipated to result in elevated levels of suspended sediment. It is considered best practice to ensure that this sediment laden runoff is not allowed to directly flow into the Fleet, Lackenby Channel or the Knitting Wife Beck. In addition, it is anticipated that higher level of suspended sediment may be generated from set-up activities and placement of the soils.

This section of the document provides the methodology by which any sediment laden flows will be managed, treated and return to watercourse during the set-up, temporary storage and placement of the soils. This plan is intended to minimise and mitigate the effects of sediment pollution into the nearby watercourses. However, it is noted that this does not remove responsibilities from the appointed contractor who will be required to manage the operations in accordance with a Construction Environmental Management Plan (CEMP).

Any discharge of potentially contaminated surface water runoff may require an additional environment permit from Environment Agency, which will take up to 20 days to be approved. The details of the requirements for this permit will need to be confirmed with the Environment Agency.

## 5.1 General Set-up Activities and Material Placement

The following will need to be adhered to during the set-up of the soils storage mounds:

- All roads kept free of dust and mud deposits through regular cleaning or immediately after significant dust or mud deposits;
- All material deposition works to be carried out in accordance with BS6031:2009 Code of Practice for Earthworks; and,
- If any additional temporary drainage is required in-order to channel any surface water into the ponds, this will be carried out as and when required to a minimum gradient to ensure self-cleansing velocities are achieved.

### Working near to Watercourses

With regards to the Warrenby sites, during the set up activities and placement of the material, the following will need to be considered when working in the vicinity of the Fleet:

- Where practical, works close to the water body are to be avoided during periods of wet weather;
- Ensure that potential hazardous material such as are kept in bunded areas at least 10m away from any water bodies; and,
- Any incidents of pollution in to nearby watercourse, the EA are to be notified immediately. Immediate steps will then be taken to resolve the cause of the pollution and where possible, mitigate against the impact of the pollution. Pollution incident response measures are specified further within the CEMP documentation.

### Plant Washing and Highway Runoff

During the set-up and placement phases, the movement and maintenance of plant on site will generate silt. Sources of silt (e.g. plant and wheel washing and site roads) carry a risk of causing pollution.

Washing of plant, vehicles and boots are to be undertaken only in dedicated wash areas will be at least 10m from any watercourse. It is anticipated that wash water would not be contaminated and therefore could be discharged into the sedimentation pond. If wash waster is considered to be contaminated, then it is to be collected in a sealed tank for removal from site by a licensed waste disposal contractor or discharge to the sewerage network if permitted by NWL.

The following measures are to be considered, including:

- Biodegradable oils are to be used for vehicles and plant where possible, however these will still be prevented from entering the water environment;
- All roads kept free of dust and mud deposits through regular cleaning or immediately after significant dust or mud deposits;
- Putting small dams or silt fencing in artificial roadside ditches to retain silt;
- Settled solids are removed regularly and appropriately disposed;
- Use of clean aggregate for haul road; and,
- Use non-hazardous and non-solvent based cleaning products where possible.

## 5.2 Sediment Removal

During the placement and storage of the soils, sediment management will need to be provided. This is to be provided within the attenuation ponds and collection ditches.

The below can be considered a good practice check list for ponds or ditches:

- Maintain a constant inflow rate into the settlement ponds;
- Minimise the inlet flow as much as possible by using energy dissipaters or rip rap when draining by gravity to settlement ponds;
- Position inlet pipe work vertically to dissipate energy;
- Provide lined inlet chamber to reduce velocity of flow;
- Line the inlet chamber and outlet weir with materials like geotextiles, brickwork, polythene or timber;
- Have a long outlet weir to minimise disturbance; and,
- De-silt inlet chamber regularly.

Other secondary method could be employed to assist in the removal of sediment from surface water runoff, including:

- Cover storage mounds and placed extractive material with geotextiles or granular capping material to minimise erosion risk; and,
- Use of geotextile silt fencing at the toe of any slopes to reduce the movement of silt.

# 6. Maintenance and Management Plan

Measures for the routine inspection and maintenance of the set-up and placement phase runoff and sediment management measures are to be described in the CEMP.

During storage of the soils, a maintenance plan will be required to ensure all those involved in the maintenance and operation of the system understand the functionality and maintenance requirements in terms of supporting long term performance, in accordance with the design criteria.

A full maintenance plan is to be developed in accordance with the best practice suggested in the *CIRIA SuDS Manual (C753), Appendix B8*.

For the purpose of this report, maintenance refers to the following:

- Inspections are required to identify performance issues and plan appropriate maintenance needs;
- Operation and maintenance of the drainage system, storage and settlement ponds; and,
- Waste management associated with any contaminated silt or other products as a result of maintenance.

It is important to ensure that function of the surface water management system is understood by those responsible for maintenance, regardless of whether components are above or below ground. If the system is designed, monitored and maintained in an efficient manner then performance deterioration can usually be minimised.

At this stage the maintenance plan has been specified to account for the management of the key elements of drainage infrastructure proposed within the site. This plan documents the tasks, frequency and methodology required to ensure that the operation of the surface water management system is maintained at an optimal level of service for current and future uses of the site. This will include both traditional drainage infrastructure and SuDS.

The key pieces of drainage infrastructure identified include the following:

- Basins or Ponds;
- Drainage ditches;;
- Pipework, manholes and catch-pits; and,
- Outfalls.

These key maintenance and management activities have been established using the *CIRIA SuDS Manual (C753)* and are held within Appendix D.

# 7. Conclusions and Recommendations

This Flood Risk Assessment and Drainage Strategy (FRA & DS) has been produced to support the STDC planning application, relating to the import, temporary storage and placement of material for remediation and restoration of former industrial land at the site of the TATA Steel (TATA) / Sahaviriya Steel Industries UK (SSI) at Redcar.

## 7.1 Flood Risk Assessment

The results of the flood risk assessment are summarised as follows:

- The six storage mounds can be considered to have a flood risk vulnerability classification of 'less vulnerable' and are an acceptable development within Flood Zone 1; and,
- The storage mounds are located with Flood Zone 1 and therefore considered to be at a low risk of flooding from fluvial or tidal sources (less than 0.1% AEP). With regards to the full site, a section of land adjacent to the Fleet Watercourse is situated within Flood Zone 2. To avoid any associated fluvial flood risk, it will be ensured that no material is placed within this area and therefore levels will not be altered from existing;
- The vast majority of the six storage mounds are classified as being at a very low risk of surface water flooding (defined as having a probability of less than 0.1% AEP). For the full site, there are some areas that are shown to be at a higher risk due to ponding at low spots.
- The flood risk from all other sources is also considered to be low. Therefore, no mitigation measures are required to protect the sites from flooding;
- Surface water runoff is expected to increase as a result of the development. However this is to be managed via a drainage system that will ensure that surface water flood risk to adjacent areas is not increased.

## 7.2 Drainage Strategy

The overall approach to surface water management is to discharge runoff generated from the six storage mounds into nearby watercourses at rates agreed with the Lead Local Flood Authority, Redcar and Cleveland Borough Council. Any flows in excess of these rates will be attenuated in ponds/basin close to the storage mounds before discharge into a nearby watercourse.

A drainage system comprising of ditches and pipes will be provided to collect runoff from the storage mounds and gravitate flow into the pond/basins. Associated discharge rates, attenuation volumes and areas for the sites at Grangetown Prairie, Metal Recovery, Warrenby 3A and Warrenby 3B can be summarised as follow:

- Grangetown Prairie 1A, 1B and 1C will discharge into the Knitting Wife Culvert (Lackenby Channel) at a maximum 100 year rate of 130.9l/s. This is result in a 100 year attenuation volume of 1,900m$^3$ requiring an approximate area of 2,150m$^2$.
- The Metals Recovery area will discharge into the Lackenby Channel at a maximum 100 year rate of 32.2 l/s. This will result in a 100 year attenuation volume of 800m$^3$ requiring an approximate area of 1,000m$^2$.

- Warrenby 3A will discharge into the Fleet at two locations and at maximum 100 year rates of 27.0l/s and 97.5l/s. This will result in a 100 year attenuation volumes of 300m$^3$ and 900m$^3$ and requiring approximate areas of 400m$^2$ and 1,100m$^2$.
- Warrenby 3B will discharge into the Fleet at a maximum 100 year rate of 108.5 l/s. This will result in a 100 year attenuation volume of 1,400m$^3$ requiring an approximate area of 1,650m$^2$

All attenuation volumes will include a 20% uplift on rainfall intensities to take account of climate change projections up to 2069.

It is anticipated that the runoff from the storage mounds will contain significant levels of sediment and therefore consideration needs to be given to the management of these silt laden flows. It will be the contractor's responsibility to ensure that appropriate measures are incorporated into the CEMP for the stockpiling work, and that any Environmental Permits required by the Environment Agency are in place prior to commencement of works.

With regards the full site, it is anticipated that placement of material resulting in an increase in ground levels of no more than 500mm will result in minor alteration of the existing drainage regimes. It is intended that these increases will be adequately managed through the provision of future surface water drainage as to not increase the risk to any downstream areas or interrupt and displace any existing surface water pathways.

## 7.3 Maintenance and Management Plan

A maintenance and management plan has also been developed as part of the Flood Risk Assessment and Drainage Strategy. This plan documents the tasks, frequency and methodology required to ensure that the operation of the surface water management system is maintained at an optimal level of service for over the lifetime of the storage mounds.

# Appendix A
# Drawings

# Appendix B
# Greenfield MicroDrainage Results

# Appendix C
# Proposed MicroDrainage Results

# Appendix D
# Maintenance and Management Plan