

# **Monitoring and Management Protocol First Residential Parcel**

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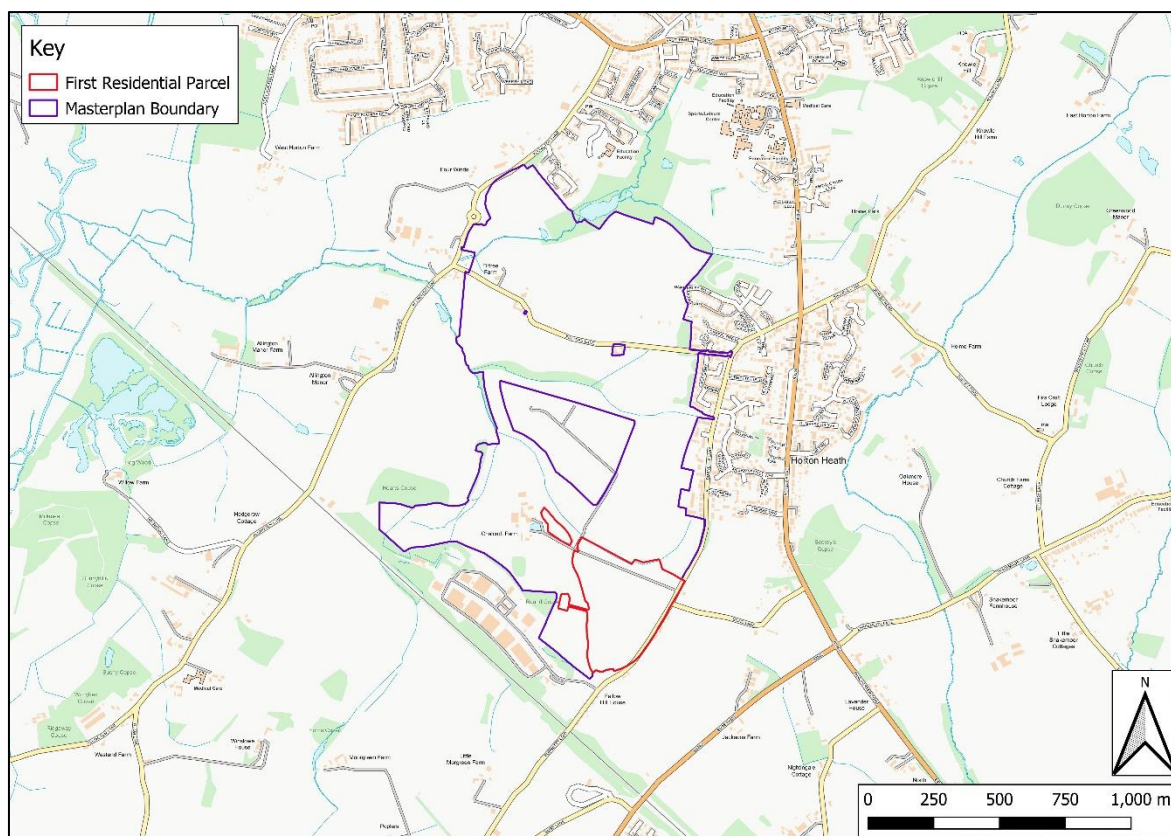
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## 1. Introduction

One Horton Heath is a masterplan development in Hampshire (National Grid Reference SU 48815 17105) that is being brought forward by Eastleigh Borough Council. Eastleigh Borough Council have set out the following vision for the development:

*“People are at the centre of our vision – the community that already live and work in Horton Heath, and the people who will live and work within the village in years to come. This project will create an exemplar development which is integral to Horton Heath engendering pride and a strong sense of place. The local area, and by extension the Borough, will become Greener, Healthier, more Prosperous with a more diverse supply of Housing as a direct result of this project”.*

The First Residential Parcel (FRP) constitutes the first phase of the masterplan development, comprising “erection of 381 residential units with public open space, hard and soft landscape works, internal roads, footway/cycleways, associated parking spaces, substation, Sustainable Drainage Systems and associated infrastructure”. The FRP comprises an area of 13.73 ha in the southern extent of the masterplan site, as identified in Figure 1.1.



**Figure 1.1** First Residential Parcel in relation to the Masterplan Site (Contains Ordnance Survey data © Crown copyright and database right 2022)

## 1.1. Background

Since 2019, residential and tourism development applications within the Hampshire area have been delayed due to the impacts associated with nitrate concentrations reaching the Solent and influencing the qualifying features of internationally designated sites associated with the Solent. These designated sites are the Solent Maritime Special Area of Conservation (SAC), Portsmouth Harbour Special Protection Area (SPA), Chichester and Langstone Harbours SPA and Solent and Southampton Water SPA. Additional nitrate loadings from new development, principally associated with increased wastewater generation, have been identified to be causing algal blooms within the Solent that influence dissolved oxygen levels within the marine waterbody as well as smothering food resources for birds and marine life.

Following a test case heard in the European court, NE advised that no planning consents should be granted within the region unless they can demonstrate nitrate neutrality. More recently, there has also been an interest in reducing phosphate loadings to downstream European protected areas and NE now also expects P neutrality to be demonstrated for all residential schemes coming forward within the River Itchen catchment, as per the OHH scheme.

The release of sediments from development schemes within the Itchen catchment is also of potential concern in relation to their impact on the riverine environment. The input of fine sediments is of particular concern in relation to the River Itchen SAC, with the chalk stream habitats for which the site is designated being vulnerable to sediment accumulation. Sediment accumulation also has detrimental impacts on fish populations in the catchment, particularly in relation to salmonids with settlement of sediments reducing the quality of spawning habitats. Developments are, therefore, required to identify appropriate mitigation that minimises sediment losses into the Itchen catchment during construction and through operation of the scheme.

## 1.2. Purpose

The purpose of this Monitoring and Management Protocol is to set out the proposed monitoring that will be established to review the effectiveness of Sustainable Drainage System (SuDS) features in removing nitrogen, phosphorus and sediments and to set out the adaptive management measures proposed to be undertaken throughout the lifetime of the project.

The following sections set out the methodology by which monitoring will take place, including identification of the determinants to be monitored, locations for monitoring and frequency, and then the management measures required.

## 1.3. SuDS Design

All surface water runoff from positively drained development areas on the site is to be treated through the SuDS Management Train, consisting of Source Control techniques and Strategic SuDS Features. Runoff will pass through at least one Strategic SuDS Feature, with the management train providing the following treatment process as a minimum:

- Sediment forebays at inlets;
- Extensive wetland areas;
- Wetland planting; and
- Secondary sedimentation areas prior to outlets.

The proposals include a series of SuDS features which will link to the FRP development area, identified in Figure 1.2, comprising the following SuDS\*:

- Strategic SuDS Feature L1 and L2 (Detention Basins);
- Strategic SuDS Feature I (Detention Basin);
- Strategic SuDS Feature J (Detention Basin); and,
- Strategic SuDS Feature K (Detention Basin).

The proper implementation of a SuDS management/treatment train using a combination of upstream Source Control and Strategic SuDS Features will create greater resilience and allow the system to collect sediment and nutrients (associated with sediment particles and plant uptake) at various points, which can be removed during periodic maintenance. Consequently, creating a diverse SuDS scheme that encourages sedimentation, filtration and biological uptake throughout the site will reduce the outputs of nutrients and sediments from the site.

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\* It should be noted that whilst there is an additional SuDS feature located on the western boundary of the FRP site, this serves the Southern Access works that are delivered by a separate planning permission and the drainage design for the FRP does not link to this. As a result, consideration of this within the Monitoring and Management Protocol has been excluded.



**Figure 1.2 Drainage Overview Plan identifying SuDS Locations within FRP**

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## **2. Methodology**

### **2.1. Approach**

Monitoring samples should initially be taken on a quarterly basis for the first five years following completion to gain an accurate understanding of how the system is initially performing on a seasonal basis. Review of the effectiveness of the wetland systems will be carried out on an ongoing basis against the predicted performance at the design stage to ensure the SuDS are operating as designed, and determine whether adaptive management is required to address any issues associated with potential high sediment and nutrient yields.

Where the SuDS features are operating effectively following the five-year sampling period, sampling will reduce to a single annual sample. However, where adaptive management is required this should be followed by a period of quarterly samples for a further two years to monitor the effectiveness of those corrective actions.

With all reasonable endeavours, samples will be taken during wet periods where possible, either during or soon after rainfall, to ensure flow is present in the system at the time of sampling. Samples for each SuDS feature should be taken on the same day, although all samples can be collected over a wider period of time.

Strategic SuDS Feature L1 and L2 forms part of the Monitoring and Management Protocol for the Link Road as well as part of the FRP, although monitoring for the Link Road is for sediment only. Where the monitoring periods for the two overlap, a single monitoring sample can be taken to report on sediment removal efficiency with the nutrient assessment carried out in addition. The frequency of sampling should be according to the most recently completed phase.

### **2.2. Determinants**

#### **2.2.1. Flow**

The water flow will be recorded at each of the inflow locations and at the flow control chamber downstream of the SuDS outlet, recording the water depth and velocity to establish the total flow in metres per second. Water flow monitoring will not be undertaken at outfall locations, with flows from the flow control chamber used to represent the flow rate.

A suitable flow meter should be utilised, however the key consideration in kit determination is that the monitoring equipment is suitable for low-flow conditions and is able to be used from the surface. Under no circumstances should entry to an inspection chamber be attempted.

#### **2.2.2. Sediment**

Water samples will be collected from all monitoring locations for laboratory analysis of the following parameters:

- Total Suspended Solids (TSS);
- Total Dissolved Solids (TDS); and,
- Turbidity.

All samples will be taken from the surface and under no circumstances will entry to an inspection chamber be attempted. It is recommended that sampling from ground level is facilitated by taping sampling bottles (*e.g.* with filament strapping tape), one at a time, to a pole and lowering the pole into the chamber. Each bottle can be fastened to the pole by holding the bottle against it and wrapping tape tightly around the bottom and the top of the bottle as the bottle is held firmly to the pole. If the flow in the chamber is shallow, the bottle may have to be positioned horizontally with the opening of the bottle somewhat higher than its bottom.

To avoid disturbing channel bed solids, care should be taken not to scrape the bottle against the sides of the pipe.

Where samples are taken from outfalls, and they are safely accessible, then sampling can be facilitated by holding bottles with the bottle opening facing into the flow, taking care not to overfill them. However, if there is any doubt about the safety of the sampling location, then sampling can be carried out using a pole from a safe, stable location, as per the chamber sampling described above.

### 2.2.3. Nutrients

Water samples will be collected from all monitoring locations for laboratory analysis of the following parameters:

- Chloride;
- Total Nitrogen (TN);
- Total Dissolved Nitrogen (TDN);
- Ammoniacal nitrogen ( $\text{NH}_4\text{-N}$ ) (*i.e.* precursor to nitrate nitrogen);
- Nitrate nitrogen ( $\text{NO}_3\text{-N}$ ) (*i.e.* intermediate step in ammoniacal to nitrate nitrogen conversion);
- Total Particulate Nitrogen (TPN) (*i.e.* through subtraction of TN-TDN, in order to estimate efficiency of sedimentation/filtration aspects of SuDS);
- Total Phosphorus (TP);
- Total Dissolved Phosphorus (TDP);
- Phosphate phosphorus ( $\text{PO}_4\text{-P}$ ) (*i.e.* organic and inorganic phosphorus available for algal growth); and,
- Total Particulate Phosphorus (TPP) (*i.e.* through subtraction of TP-TDP, in order to estimate efficiency of sedimentation/filtration aspects of SuDS).

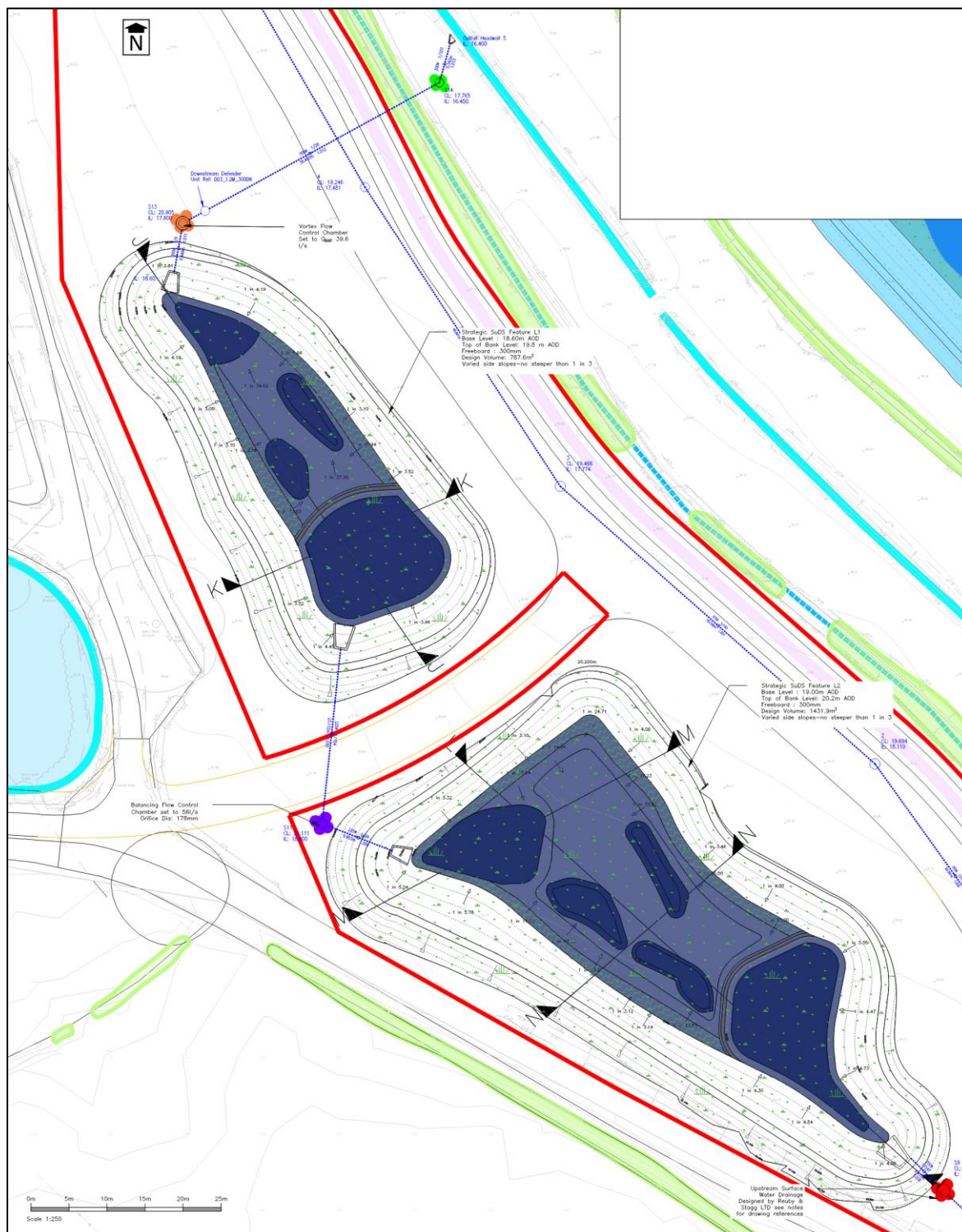
### 2.3. Locations

As discussed in Section 1.3, the proposals incorporate a series of SuDS features within the FRP boundary through which runoff will be managed. Monitoring locations within each SuDS feature are identified in the following sections, comprising the first manhole upstream of each SuDS inlet, within the flow control chamber on the downstream side of the SuDS outlet and at the first location downstream of the Defender Unit, being either the main outfall to a watercourse or manhole (whichever is foremost).

### 2.3.1. Strategic SuDS Feature L1 and L2 (Detention Basins)

Strategic SuDS Feature L1 and L2 comprises two interlinked detention basis, with one feeding directly into the other. A single inlet is located in the south-eastern corner of SuDS Feature L2, with monitoring to be carried out from the manhole upstream of the inlet c. 6 m to the south-east. The outlet from the combined SuDS Features is on the northern side of L1, with the flow control monitoring location identified in orange in Figure 2.1. In addition to these, monitoring will be undertaken between the two detention basis, from the flow control chamber identified in purple in Figure 2.1. Water samples and flow readings are required from each of these locations.

Downstream monitoring will be carried out from the manhole identified in green in Figure 2.1, located c. 38.5 m to the north-east of the flow control chamber and directly upstream of the outfall. A water sample only is required from this location.



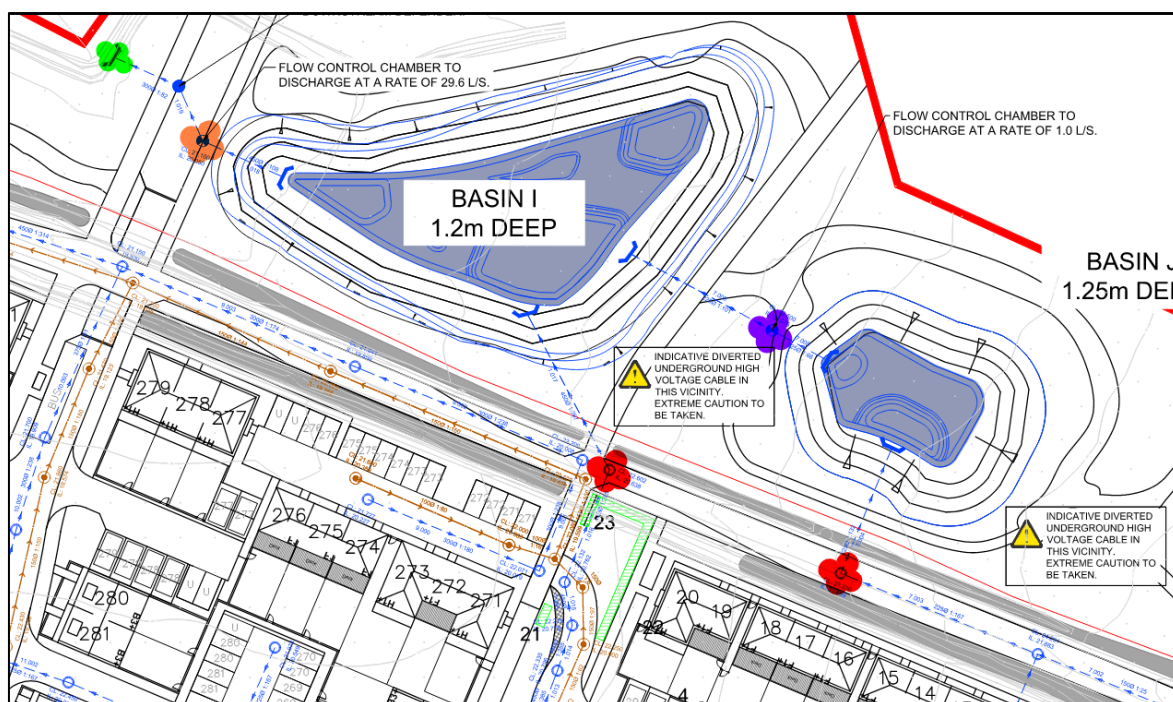
**Figure 2.1 Strategic SuDS Feature L1 & L2 Monitoring Locations (from Drawing G277/29 Rev B)**

### 2.3.2. Strategic SuDS Features I and J (Detention Basins)

Strategic SuDS Features I and J comprise two interlinked detention basis, with Feature I feeding directly into Feature J alongside another inlet.

A single inlet is located on the southern side of SuDS Feature I, with monitoring to be carried out from the manhole upstream of the inlet c. 19.5m to the south. A further inlet is located on the southern side of SuDS Feature J with monitoring also to be carried out from the manhole upstream of the inlet c. 25 m to the south-east. The locations of both are identified in red in Figure 2.2. The outlet from the combined SuDS Features is on the western side of Feature I, with the flow control monitoring location identified in orange in Figure 2.2. In addition to these, monitoring will be undertaken between the two detention basis, from the flow control chamber identified in purple in Figure 2.2. Water samples and flow readings are required from each of these locations.

As there are no manholes downstream of the Defender unit, the final sampling location should be taken from the outfall location c. 17.5 m to the north-west of the flow control chamber (identified in green in Figure 2.2). A water sample only is required from this location.

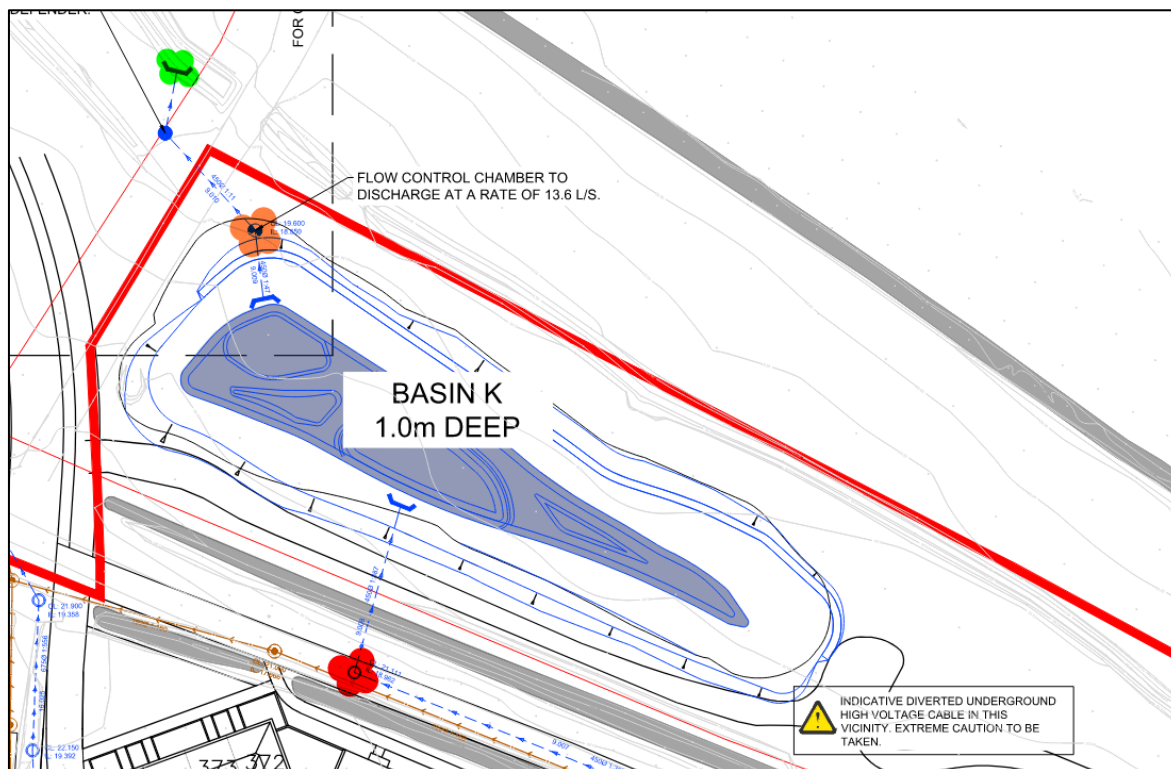


**Figure 2.2 Strategic SuDS Feature I & J Monitoring Locations (from Drawing 19-367/001 Rev F)**

### 2.3.3. Strategic SuDS Feature K (Detention Basin)

A single inlet is located on the southern side of SuDS Feature K, with monitoring to be taken from the manhole upstream of the inlet c. 21.5 m to the south and identified in red in Figure 2.3. The outlet is on the northern corner of the SuDS Feature with the flow control monitoring location identified in orange in Figure 2.3. Water samples and flow readings are required from each of these locations.

As there are no manholes downstream of the defender unit, the final sampling location should be taken from the outfall location approximately 22 m to the north-west of the flow control chamber (identified in Green in Figure 2.3). A water sample only is required from this location.



**Figure 2.3** Strategic SuDS Feature K Monitoring Locations (from Drawing 19-367/001 Rev F)

### 3. Adaptive Management

Adaptive management will be required where the operation of the SuDS Features is shown in the monitoring to fall outside of the expected design parameters. It is expected that this will be a result of changes in the system that lead to inefficient operation, with a range of corrective measures identified that can address this. Corrective measures have considered best practice recommendations, including those in the SuDS Manual<sup>1</sup> and Operation and Maintenance of Sustainable Drainage Systems research report<sup>2</sup>, along with recognised best practice from other countries, notably the Virginia Stormwater Management Handbook<sup>3</sup>. Further information on maintenance practices can be found within these documents.

Appropriate triggers/thresholds within the monitoring results at which action should be taken are discussed in the following sections.

The monitoring locations identified in Section 2.3 have been selected to assist in pinpointing the likely whereabouts in which any issue arising is occurring, and therefore target initial review for corrective measures.

#### 3.1. Sediments

##### 3.1.1. Triggers/Thresholds for Action

There are currently no statutory standards for TSS, TDS or turbidity for SuDS monitoring in the UK or for surface watercourses within the Water Framework Directive (WFD)<sup>4</sup>.

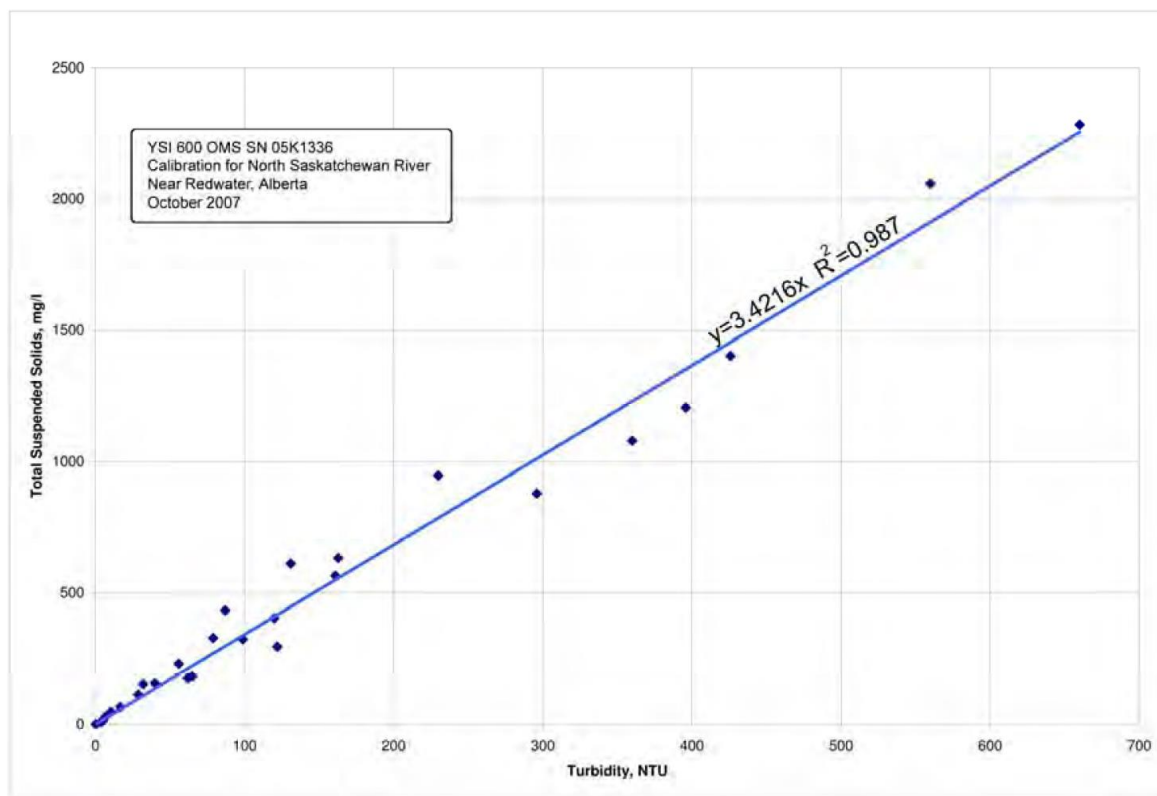
##### **Turbidity**

Turbidity ranges are cited within the WFD for transitional and coastal waters, in order to identify the appropriate application of dissolved inorganic nitrogen standards for such waters. Although primarily meant for coastal waters, it is recommended that these are used as indicative indicators for surface runoff quality passing through the SuDS features and reviewed following the initial 5-year monitoring period. The range of turbidity cited by the WFD is presented in Table 3.1.

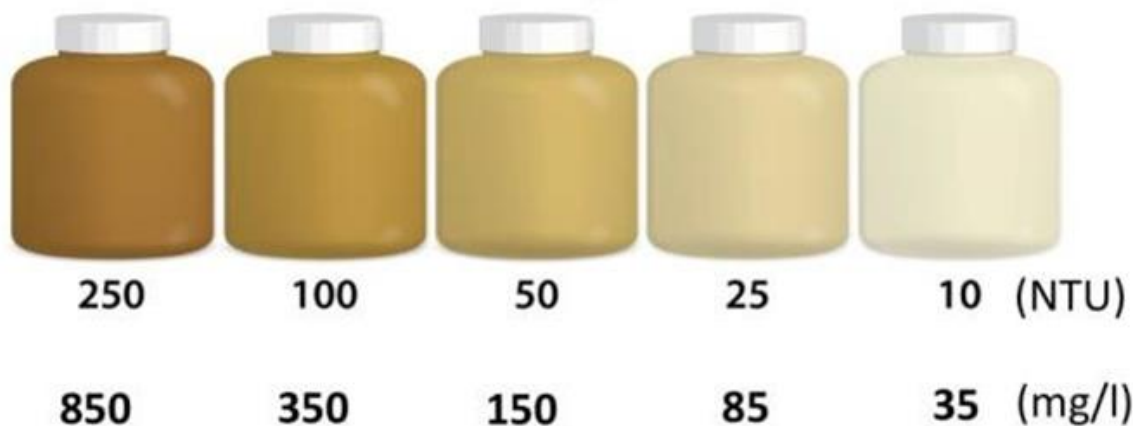
**Table 3.1** *WFD Turbidity Criteria for Identifying Types of Transitional and Coastal Water to which the Dissolved Inorganic Nitrogen Standards Apply, Together with Nephelometric Turbidity Units (NTU) derived from Nurjaya et al.*

| Turbidity              | Indicative Turbidity in NTU derived from Nurjaya et al. <sup>5</sup> | Annual mean concentration of suspended particulate matter (mg/l) |
|------------------------|----------------------------------------------------------------------|------------------------------------------------------------------|
| Very Turbid            | > 88                                                                 | > 300                                                            |
| Turbid                 | 29 – 88                                                              | 100 – 300                                                        |
| Intermediate Turbidity | 3 – 29                                                               | 10 - < 100                                                       |
| Clear                  | < 3                                                                  | < 10                                                             |

Turbidity is typically measured in Nephelometric Turbidity Units (NTU), and a conversion from NTU to mg/l TSS can be made on a site-by-site basis, by taking simultaneous turbidity and TSS samples and constructing a calibration graph. In the absence of site specific data, the relationship presented by Nurjaya et al. and used elsewhere (e.g. by the Alberta Transportation Department<sup>6</sup>) can be used as an indicative relationship, as shown in Figure 3.1, with derived values also presented in Table 3.1.



**Water Samples:**



$$y = 3.4216x$$

$$R^2 = 0.987$$

$$y = \text{TSS (mg/l)}$$

$$x = \text{Turbidity (NTU)}$$

**Figure 3.1** Alberta Transportation Indicative TSS/NTU Relationship

It is anticipated that a similar relationship can be built up with the initial 5-year seasonal monitoring campaign, which can be used to inform the need for adaptive maintenance. For example, using the above example:

- <3 NTU – no action;
- 3-<29 NTU – continue to monitor, but if turbidity continues in this range for 4 consecutive sampling occasions, then investigate upstream cause;
- 29-88 NTU - continue to monitor, but if turbidity continues in this range for 3 consecutive sampling occasions, then investigate upstream cause;
- >88 NTU - continue to monitor, but if turbidity continues in this range for 2 consecutive sampling occasions, then investigate upstream cause.

By adopting the above approach, then occasional storm events which may lead to elevated turbidity, will not unnecessarily instigate unwarranted remedial action.

### **Total Suspended Solids**

With regard to TSS, it should be noted that the working party of EIFAC (European Inland Fisheries Advisory Committee) investigated the effect of water pollution, including suspended solids, during the development of Water Quality Criteria for European Freshwater Fish. The studies used to determine the criteria were subsequently summarised by Alabaster and Lloyd<sup>7</sup> in which a series of tentative annual mean values for chemically inert solids in suspension were given for the maintenance of freshwater fisheries as follows:

- Less than 25 mg/l - no evidence of harmful effects on fisheries;
- 25 – 80 mg/l – it should usually be possible to maintain good or moderate fisheries;
- 80 – 400 mg/l – unlikely to support good freshwater fisheries; and
- Greater than 400 mg/l – only poor fisheries are likely to be found.

These criteria were taken forward into England and Wales law in 1997 under the Surface Waters (Fishlife) (Classification) Regulations<sup>8</sup>.

A further review in which the risk of suspended solids to fish habitat were assessed was regarding mining operations in the Yukon undertaken by the Canadian Department of Fisheries and Oceans<sup>9</sup>. The levels of risk were very similar to those outlined by the EIFAC working party and have been adapted below in Table 3.2 to be used as trigger levels for action within this SuDS monitoring protocol. It is anticipated that these may be modified, as deemed necessary, following review of the initial 5-year seasonal monitoring results.

**Table 3.2** *Suggested TSS Trigger concentrations adapted from EIFAC and Canadian DFO<sup>10</sup>*

| TSS Concentration | Action                                                                                                                                 |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| > 400 mg/l        | Unacceptable risk – investigate upstream cause immediately                                                                             |
| 200 - < 400 mg/l  | High risk - investigate upstream cause immediately.                                                                                    |
| 100 - < 200 mg/l  | Moderate risk- monitor closely - if TSS continues in this range for 2 consecutive sampling occasions, then investigate upstream cause. |
| 25 - < 100 mg/l   | Low risk – monitor closely - if TSS continues in this range for 3 consecutive sampling occasions, then investigate upstream cause.     |
| < 25 mg/l         | Very low risk – no action required                                                                                                     |

### Total Dissolved Solids

With regard to TDS, these are dissolved ions, including salts, minerals and metals, that can be found in all non-pure water sources. TDS can originate from a wide range of sources. Materials may leach into water from sewage, agricultural runoff or highways (e.g. de-icing salt). Natural sources, like soils and rocks, may also contain TDS.

Consequently a high TDS concentration in water is not necessarily harmful. For example, a TDS reading could be particularly high, but it might simply be because that water has a high mineral content.

The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. As such, TDS monitoring can act as a potential indicator for contamination, especially if a spike in concentration is observed above a lower background.

Although there are currently no statutory standards for TDS in surface water in the UK, US EPA Secondary Regulations advise a maximum contamination level (MCL) of 500 mg/L for TDS. When TDS levels exceed 1,000 mg/L it is considered unfit for human consumption. Changes in the amount of TDS can be harmful to aquatic organisms as the density of TDS determines the flow of water in and out of an organism's cell. Concentrations that are too high or low can affect fish growth or cause death. A maximum level of 400 mg/L is recommended for most freshwater fish. High TDS can also permit high volumes of algae bloom which detrimentally effect sensitive ecosystems.

Consequently, the concentrations presented in Table 3.3 are recommended to be used as trigger levels for action within this SuDS monitoring protocol. It is anticipated that these may be modified, as deemed necessary, following review of the initial 5-year seasonal monitoring results.

**Table 3.3** *Suggested TDS Trigger concentrations adapted from EIFAC and Canadian DFO<sup>11</sup>*

| TDS Concentration  | Action                                                                                                                                 |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| > 1,000 mg/l       | Unacceptable risk – investigate upstream cause immediately                                                                             |
| 400 - < 1,000 mg/l | High risk - investigate upstream cause immediately.                                                                                    |
| 250 - < 400 mg/l   | Moderate risk- monitor closely - if TDS continues in this range for 3 consecutive sampling occasions, then investigate upstream cause. |
| 100 - < 250 mg/l   | Low risk – monitor closely - if TDS continues in this range for 4 consecutive sampling occasions, then investigate upstream cause.     |
| < 100 mg/l         | Very low risk – no action required                                                                                                     |

### 3.1.2. Corrective Measures

#### Sediment Dredging

Dredging and sediment clearance is an important part of the ongoing and long-term maintenance of the SuDS Features, as accumulation will reduce the efficiency of the system operation. The period following initial construction of the SuDS and upstream development plots can result in rapid sediment accumulation, however sediment accumulation can occur also occur post construction and dredging may be required as a corrective measure.

Sediment accumulation in swales is generally small in volume and can be removed using hand tools.

For detention basins, sediment may tend to accumulate around the control device, which increases the risk that either the orifice may become clogged or that sediment may become re-entrained into the outflow. Small volumes of sediment can be removed using hand tools, however it may be necessary for excavation using a front-end loader or backhoe. Sediment removal will cause some damage to vegetation and potential disturbance to wildlife, including nesting birds, and therefore such activities should be scheduled outside the nesting season and re-establishment of vegetation or planting may be required.

Sediment forebays within detention basins provide pre-treatment for the removal of coarse sediments, and therefore dredging of these may be an important corrective measure to remove sediment from the system. To assist in the review, inclusion of a fixed vertical sediment depth marker should be installed into each forebay. It is likely that sediment removal would need to be completed by excavation using a front-end loader, backhoe or long-reach excavator depending on the SuDS Feature design<sup>†</sup>. As before, sediment removal may cause some damage to vegetation, and therefore re-establishment or planting may be required.

Appropriate management and disposal of sediments dredged will be required, as these may be contaminated. It is, therefore, important that appropriate measures employed through regular maintenance of the SuDS feature are followed for the management and disposal of dredged material.

#### Downstream Defender Maintenance/Clearance

Inspection of the Downstream Defender should be undertaken to review its performance and establish whether additional maintenance or clearance beyond the routine maintenance is required.

<sup>†</sup> As maintenance is a key component to the long-term operation of the SuDS Feature, consideration should be given to enabling direct access to the sediment forebay to simply maintenance, ideally with hardened access or a staging pad. Such inclusion will help reduce complexities around maintenance and restrictions on equipment that can complete the maintenance operation.

Where sediment depths are greater than 75 % of maximum clean out depths specified by the manufacturer sediment removal is required. A judgement will, however, be made as to whether cleanout is required regardless of sediment depth when considering the period of time to the next routine maintenance cleanout (*i.e.* if there are 9 months remaining and the sediment is at 50 % it may be prudent to clean out to avoid future issue).

Clearance of the Downstream Defender comprises removal of the sediments with a sump-vac from the access port in the top of the manhole which provides unobstructed access for a vactor hose and skimmer pole to be lowered to the base of the sump. It is, therefore, important that appropriate access and staging pad alongside the device is available for this process to be carried out.

### **Debris Removal/Clearance**

This requires checking and clearing of litter and debris within the drainage system to reduce blockages and minimise pollution risks and sudden and high releases of sediments from SuDS features. This should include inspection of all outlets, inlets and overflows as well as the SuDS features themselves.

### **Sweeping Pervious Surfaces**

A build-up of silt or other sediments on pervious surfaces can affect the infiltration capacity of these features, causing a greater level of run-off into the catchment. A review of pervious surfaces within the catchment upstream of the affected SuDS should be undertaken and, where necessary, sweeping of pervious surfaces using a brush and suction cleaner or rotating brush cleaner combined with power spraying using hot water should be undertaken to removal built up silt and sediment.

### **Structure Rehabilitation and Repair**

A range of rehabilitation and repair measures may be required where damage or deterioration of the SuDS Feature has occurred and is affecting its operation, particularly following any major events such as high stormwater flows or drought. The rehabilitation and repair measures are generally specific to each SuDS feature type, and are thus discussed in turn below:

#### *Detention Basin*

Following a review of the SuDS Feature against its design, the following remedial actions may be relevant and should be enacted where relevant:

- Repair erosion or other damage to the banks by reseeding or re-turfing;
- Realignment of rip-rap or other erosion protection measures;
- Repair/rehabilitation of inlets, outlets and overflows; and,
- Relevel uneven surfaces and reinstate design levels.

#### *Bio-Retention Swale*

Following a review of the SuDS Feature against its design, the following remedial actions may be relevant and should be enacted where relevant:

- Repair erosion or other damage by re-turfing or reseeding;
- Relevel uneven surfaces or reinstate design levels;
- Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip;
- Infill any holes or scour in filter medium, and improve erosion protection if required;

- Remove and replace filter medium and vegetation; and,
- Repair or realignment of erosion protection measures around outlet headwall.

Following high silt load discharge during a single event it may be necessary for the system to be rehabilitated, which will comprise

- removal of turf;
- removal of accumulated silt (subject to toxicity test) and land apply or dispose of to tip;
- cultivate remaining topsoil to levels; and,
- reuse or returf area to agreed levels.

#### *Pervious Surfaces*

If the infiltration capacity of the pervious surfaces continue to be affected by sediment accumulation, consideration may need to be given to the rehabilitation of the system comprising:

- removal of permeable blocks and cleaning;
- removal of bedding grit and geotextile and safe disposal;
- replacement of geotextile and grit bedding layer, and replacement with clean permeable blocks; and,
- removal of accumulated silt from site (subject to toxicity test) and safe disposal.

## 3.2. Nutrients

### 3.2.1. Triggers/Thresholds for Action

#### **Phosphorus Compounds**

Phosphorus may be present in freshwater environment in forms with different bioavailabilities. Orthophosphate ( $\text{PO}_4\text{-P}$ ), is the readily available dissolved fraction and is a determinant within the WFD and is the fraction primarily available for algal growth). Within the WFD it is reported as Soluble Reactive Phosphorous (SRP), however, it is important to check that values are expressed as  $\mu\text{g PO}_4\text{-P}$ , rather than simply  $\mu\text{g PO}_4$ . Furthermore, in England and Wales, total reactive phosphorus (TRP) may be monitored – this is the SRP analysis but undertaken on an unfiltered sample and is often significantly higher than SRP.

Other inorganic (reactive and condensed) and organically bound forms may be colloidal or particulate and are less available and will ideally be removed by sedimentation and filtration of the SuDS device (particularly within the sediment forebay). These forms are collectively known as Total Particulate Phosphorus (TPP), which can be derived by subtracting Total Dissolved Phosphorus (TDP) from Total Phosphorous (TP).

Within the WFD, SRP targets are presented depending on whether the water body is low or high altitude (*i.e.*  $<80\text{ m}$  or  $>80\text{ m}$ ) and whether it is low or high alkalinity (*i.e.*  $<50\text{ mg L}^{-1}\text{ CaCO}_3$  or  $>50\text{ mg L}^{-1}\text{ CaCO}_3$ ). With reference to Southern Water (2018)<sup>12</sup>, the lower Itchen, into which the SuDS discharges will eventually find their way, is classed as a low altitude high alkalinity water body. As such, the  $\text{PO}_4\text{-P}$  (SRP) WFD Environmental Quality Standards (EQS) for the River Itchen at Bishopstoke (*i.e.* upstream from the Chickenhall Wastewater Treatment Works (WwTW) outfall), presented in Table 3.4, are relevant.

**Table 3.4 WFD EQS for River Itchen at Bishopstoke**

|                               | EQS High | EQS Good | EQS Moderate | EQS Poor |
|-------------------------------|----------|----------|--------------|----------|
| mg/l PO <sub>4</sub> -P (SRP) | 0.053    | 0.095    | 0.222        | 1.113    |

Data from 2005 to 2016 inclusive<sup>13</sup> demonstrates that SRP concentration values at Bishopstoke were not consistent with the WFD standard to support good status (0.095 mg/l) for fish and invertebrates for a lowland high alkalinity river. Elevated SRP concentrations were observed throughout the two period, indicative of WFD moderate status (0.222 mg/l).

Consequently, the concentrations presented in Table 3.5 are recommended to be used as trigger levels for SuDS outfall concentrations to determine action within this SuDS monitoring protocol. It is anticipated that these may be modified, as deemed necessary, following review of the initial 5-year seasonal monitoring results.

**Table 3.5 Suggested PO<sub>4</sub>-P (SRP) Trigger SuDS outfall concentrations adapted from WFD EQS**

| PO <sub>4</sub> -P (SRP) Concentration | Action                                                                                                                                                      |
|----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| > 1.113 mg/l                           | Unacceptable risk – investigate upstream cause immediately                                                                                                  |
| 0.222 - < 1.113 mg/l                   | High risk - investigate upstream cause immediately.                                                                                                         |
| 0.095 - < 0.222 mg/l                   | Moderate risk- monitor closely - if PO <sub>4</sub> -P (SRP) continues in this range for 2 consecutive sampling occasions, then investigate upstream cause. |
| 0.053 - < 0.095 mg/l                   | Low risk – monitor closely - if PO <sub>4</sub> -P (SRP) continues in this range for 3 consecutive sampling occasions, then investigate upstream cause.     |
| < 0.053 mg/l                           | Very low risk – no action required                                                                                                                          |

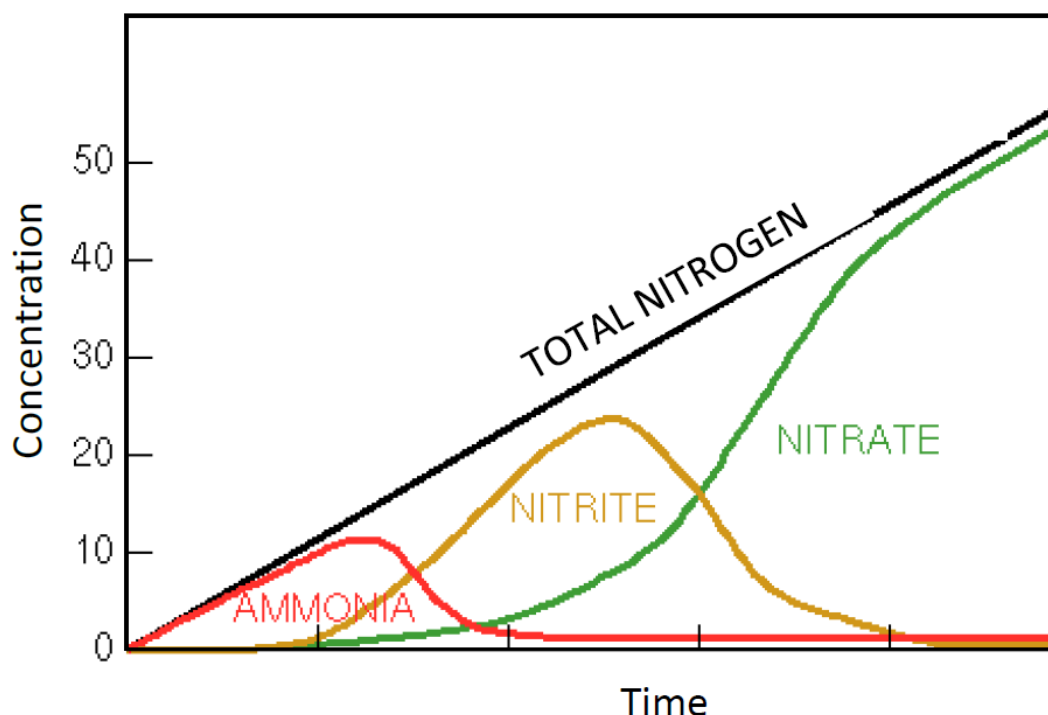
Furthermore, it is recommended that the WFD TP Standards for Lakes are most relevant to monitor TP removal efficiencies by the SuDS devices. Consequently, the Standards for WFD Region 1 (which includes the Solent area) for high alkalinity, shallow (<3 m) have been used as a basis for the trigger levels and associated actions presented Table 3.6. It is anticipated that these may be modified, as deemed necessary, following review of the initial 5-year seasonal monitoring results.

**Table 3.6 Suggested TP Trigger SuDS outfall concentrations adapted from WFD Standards for Lakes<sup>14</sup>**

| TP Concentration | Action                                                                                                                                |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| > 92 µg/l        | Unacceptable risk – investigate upstream cause immediately                                                                            |
| 46 - < 92 µg/l   | High risk - investigate upstream cause immediately.                                                                                   |
| 23 - < 46 µg/l   | Moderate risk- monitor closely - if TP continues in this range for 2 consecutive sampling occasions, then investigate upstream cause. |
| 16 - < 23 µg/l   | Low risk – monitor closely - if TP continues in this range for 3 consecutive sampling occasions, then investigate upstream cause.     |
| < 16 µg/l        | Very low risk – no action required                                                                                                    |

## Nitrogen Compounds

Nitrogen is more water soluble than phosphate and is present in several forms as part of the nitrification cycle. In this process, ammonium ( $\text{NH}_4^+$ ) or ammonia ( $\text{NH}_3$ ) is oxidized by bacteria first into nitrite ( $\text{NO}_2^-$ ) then into nitrate ( $\text{NO}_3^-$ ) and finally into harmless nitrogen gas ( $\text{N}_2$ ). Nitrate is the most stable soluble form, therefore the most abundant. Total nitrogen (TN), as the name implies, is a quantitative measure of all three forms of soluble nitrogen. The relationship between them is shown in Figure 3.2.



**Figure 3.2** The relationship between ammonia, nitrite, nitrate and total nitrogen in a closed system (adapted from Spotte 1991<sup>15</sup>)

In constructed wetlands and SuDS, the main removal mechanisms for nitrogen are conversion of the most toxic form (ammonia) into less harmful forms (nitrate) by the nitrification process, and the removal of nitrate by conversion into gaseous compounds of nitrogen by bacteria (denitrification). Denitrification occurs in sediments and decaying plant material (van Oostrom and Russell 1994<sup>16</sup>, Bachand and Horne 2000<sup>17</sup>, Vymazal 2007<sup>18</sup>). Consequently, total removal of nitrogen is typically higher in planted wetlands than unplanted ones (Bachand and Horne 2000<sup>19</sup>, Lin *et al* 2007<sup>20</sup>).

Similar to phosphate, nitrogen compounds cause excess nutrient availability and eutrophication.

Ammonia is toxic to aquatic species. The current EQS for good status ammonia is 0.6 mg/l, however concentrations of >0.1 mg/L can cause eye and gill damage (hyperplasia) and impact hatching success in some fish (Salmonid) species. At higher concentrations it causes convulsions and death and is suspected to be a leading cause of fish deaths.

Within the WFD, ammonia EQS are presented depending on whether the water body is low or high altitude (*i.e.* <80 m or >80 m) and whether it is one of five alkalinity classifications. With reference to Southern Water (2018)<sup>21</sup>, the lower Itchen, into which the SuDS discharges will eventually find their way, is classed as a low altitude high alkalinity water body.

Consequently, the WFD Standards for low altitude (<80 m) and high alkalinity have been used as a basis for the trigger levels and associated actions presented in Table 3.7. It is anticipated that these may be modified, as deemed necessary, following review of the initial 5-year seasonal monitoring results.

**Table 3.7** *Suggested Ammoniacal Nitrogen (NH<sub>4</sub>-N) Trigger SuDS outfall concentrations adapted from WFD Standards for Lakes & Rivers<sup>22</sup>*

| Total Ammonia as Nitrogen Concentration | Action                                                                                                                                                |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| > 2.5 mg/l                              | Unacceptable risk – investigate upstream cause immediately                                                                                            |
| 1.1 - < 2.5 mg/l                        | High risk - investigate upstream cause immediately.                                                                                                   |
| 0.6 - < 1.1 mg/l                        | Moderate risk- monitor closely - if NH <sub>4</sub> -N continues in this range for 2 consecutive sampling occasions, then investigate upstream cause. |
| 0.3 - < 0.6 mg/l                        | Low risk – monitor closely - if NH <sub>4</sub> -N continues in this range for 3 consecutive sampling occasions, then investigate upstream cause.     |
| < 0.3 mg/l                              | Very low risk – no action required                                                                                                                    |

The UK Nitrates Directive sets a limit of 11.3 mg/l N (50 mg/l NO<sub>3</sub><sup>-</sup>) for use in identifying polluted waters, whilst concentrations of 120 mg/l NO<sub>3</sub><sup>-</sup> and 60 mg/l NO<sub>3</sub><sup>-</sup> have been used to demonstrate “very high” and “high” agricultural conditions, respectively<sup>23</sup>.

Nitrate is one of the parameter listed in the WFD classification for assessing the river water quality. The standards used are shown in the Figure 3.3.

| Parameter      | Values and Classification |           |                |            |                 |                         |
|----------------|---------------------------|-----------|----------------|------------|-----------------|-------------------------|
| Nitrate [mg/L] | 5<br>Very Low             | 10<br>Low | 20<br>Moderate | 30<br>High | 40<br>Very High | >40<br>Excessively High |

**Figure 3.3** *WFD River Quality Classification Scale for Nitrate<sup>24</sup>*

Consequently, it is suggested that the above classification scale is modified to be used as a basis for the trigger levels and associated actions presented in Table 3.8. It is anticipated that these may be modified, as deemed necessary, following review of the initial 5-year seasonal monitoring results.

**Table 3.8** *Suggested Nitrate Nitrogen (NO<sub>3</sub>-N) trigger SuDS outfall concentrations adapted from WFD Standards for river quality*

| Nitrate Nitrogen (NO <sub>3</sub> -N) Concentration | Action                                                                                                                                                |
|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| > 50 mg/l                                           | Unacceptable risk – investigate upstream cause immediately                                                                                            |
| 30 - < 50 mg/l                                      | High risk - investigate upstream cause immediately.                                                                                                   |
| 10 - < 30 mg/l                                      | Moderate risk- monitor closely - if NO <sub>3</sub> -N continues in this range for 2 consecutive sampling occasions, then investigate upstream cause. |
| 5 - < 10 mg/l                                       | Low risk – monitor closely - if NO <sub>3</sub> -N continues in this range for 3 consecutive sampling occasions, then investigate upstream cause.     |
| < 5 mg/l                                            | Very low risk – no action required                                                                                                                    |

Total Nitrogen (TN) is the sum of the inorganic forms - nitrate-nitrogen (NO<sub>3</sub>-N), nitrite-nitrogen (NO<sub>2</sub>-N), ammonia - and organically bonded nitrogen.

TN is not currently measured under the WFD, although TN emissions into rivers from urban waste water treatment works (WwTW) are controlled by the EU Urban Waste Water Directive (91/271/EEC). Under the Directive, TN is measured in the discharge from the WwTW where there is a permit with a TN limit consent. Most river quality monitoring conducted by the Environment Agency only records the inorganic N forms. Nitrate is normally the largest component of TN but quantities of organic N are significant. In the Test catchment, dissolved organic nitrogen has been found to comprise 7 % of the potential biologically available nitrogen in the river and 13 % of that in the estuary<sup>25</sup>. Consequently, due to the uncertainty associated with TN water quality data, trigger levels for this determinant in SuDS outfalls have not been proposed for this study.

### 3.2.2. Corrective Measures

#### Litter and Debris Removal/Clearance

Checking and clearing of litter and debris within the drainage system to reduce blockages and minimise pollution risks and sudden and high releases of nutrients from SuDS features. This should include inspection of all outlets, inlets and overflows as well as the SuDS features themselves.

#### Wetland Vegetation Harvesting

The presence of vegetation is important in the removal of nutrients from a waterbody, however the majority of this is realised through growth following uptake of nitrogen and dissolved phosphorus where it is then stored in the plant. Dead and decaying organic matter within the waterbody can, therefore, become a source of nutrient inputs into the SuDS. As a result, the removal of vegetation is necessary of the continued operation of the SuDS in terms of nutrient removal efficiency.

Vegetation harvesting could assist in improving nutrient removal efficiency where monitoring identifies corrective measures to be necessary, however it should be noted that such measures will not produce a quick response as per some other measures.

Vegetation harvesting will comprise the cutting of wetland vegetation either by hand or mechanical equipment, depending on the size of the SuDS feature, and all arisings should be removed both from the SuDS waterbody and from site for appropriate disposal.

## Scarifying

Scarifying is the process of removing the ‘thatch’ of tightly intermingled organic layer of dead and living shoots, stems and roots developing between the zone of green vegetation and the soil surface. Scarifying the vegetated areas, either tractor-drawn or using self-propelled equipment, to a depth of at least 50 mm breaks up silt deposits, removed dead grass and other organic matter and relieves compaction of the soil surface.

As the breakdown of organic material in SuDS features can increase nutrient concentrations within the waterbodies this could be an important measure in reducing nitrogen and/or phosphorus concentrations.

## Substrate Removal

Substrates can become important sinks for phosphorus, notably particulate phosphorus, and a build-up of nitrogen can occur if conditions for nitrification or denitrification are not optimal. This can, therefore, become a source of nutrients for export from the wetlands if conditions change. It may, therefore, be necessary to carry out a removal and replacement of substrates within the wetland to address low efficiencies in removal within the system.

Similarly, over time the effectiveness of the sediment in acting as a sink for particulate phosphorus or in contributing to the removal of nitrogen and phosphorus could reduce over time and replacement of the substrate media could help to rehabilitate the system back to higher levels of removal efficiencies.

It is likely that substrate removal would need to be completed by excavation using a front-end loader, backhoe or long-reach excavator depending on the SuDS Feature design. The substrate removal will most likely cause damage to vegetation, and therefore re-establishment or planting may be required.

Appropriate management and disposal of substrates removed will be required, as these may be contaminated. It is, therefore, important that appropriate measures employed through regular maintenance of the SuDS feature are followed for the management and disposal of dredged material.

## Substrate Aeration

The presence of aerobic conditions within sediments is important to the nitrogen cycle within wetlands, ensuring the nitrification process continues to convert nitrite ( $\text{NO}_2^-$ ) into nitrate ( $\text{NO}_3^-$ ) to feed the denitrification process and ultimately the release of inert nitrogen to the atmosphere. Aerobic soils are also important for the sedimentation of particulate phosphorus and the sorption and precipitation of dissolved phosphorus.

Therefore, it may be necessary or beneficial to increase oxygen levels within sediments to increase the capacity for treatment, which could be achieved through breaking up areas of soil to avoid compaction and/or providing an aeration pump to increase oxygen levels in the waterbody and uncompacted soil layers.

## 4. Mechanisms for Delivery

The mechanisms for delivery are an important aspect of the Monitoring and Management Protocol, ensuring clear understanding regarding responsibility of implementation, adequate funding resource is available and clear understanding of what constitutes compliance in the results. The following sections outline these aspects.

### 4.1. Responsibility

The applicant will inform the Local Planning Authority of the relevant contact details for the responsible person prior to the commencement of development. The implementation of the Monitoring and Management Plan, as discussed, will be the responsibility of this person, and they will also ensure the results of the monitoring and any remedial action taken are reported to the local planning authority on an annual basis.

### 4.2. Funding

Eastleigh Borough Council's commitment to environmental protection is evidenced in the Vision for the development, which states that *"the development will be proactively planned to minimise the impact of the development on the existing community and environment during construction and throughout its lifetime. It will protect and enhance natural assets, integrating these with new places and creating a neighbourhood which supports green and sustainable lifestyles for all"*.

The implementation of the Monitoring and Management Protocol forms part of this commitment, ensuring the mitigation within the development continues to protect the River Itchen catchment and wider Solent and associated European designated sites, through the construction phase by adhering to measures in the CEMP and effective operation of SuDS throughout the lifetime of the scheme. As a result, Eastleigh Borough Council are committed to ensuring appropriate funding is available for the implementation of the Monitoring and Management Protocol for the lifetime of the development (taken to be 80 years).

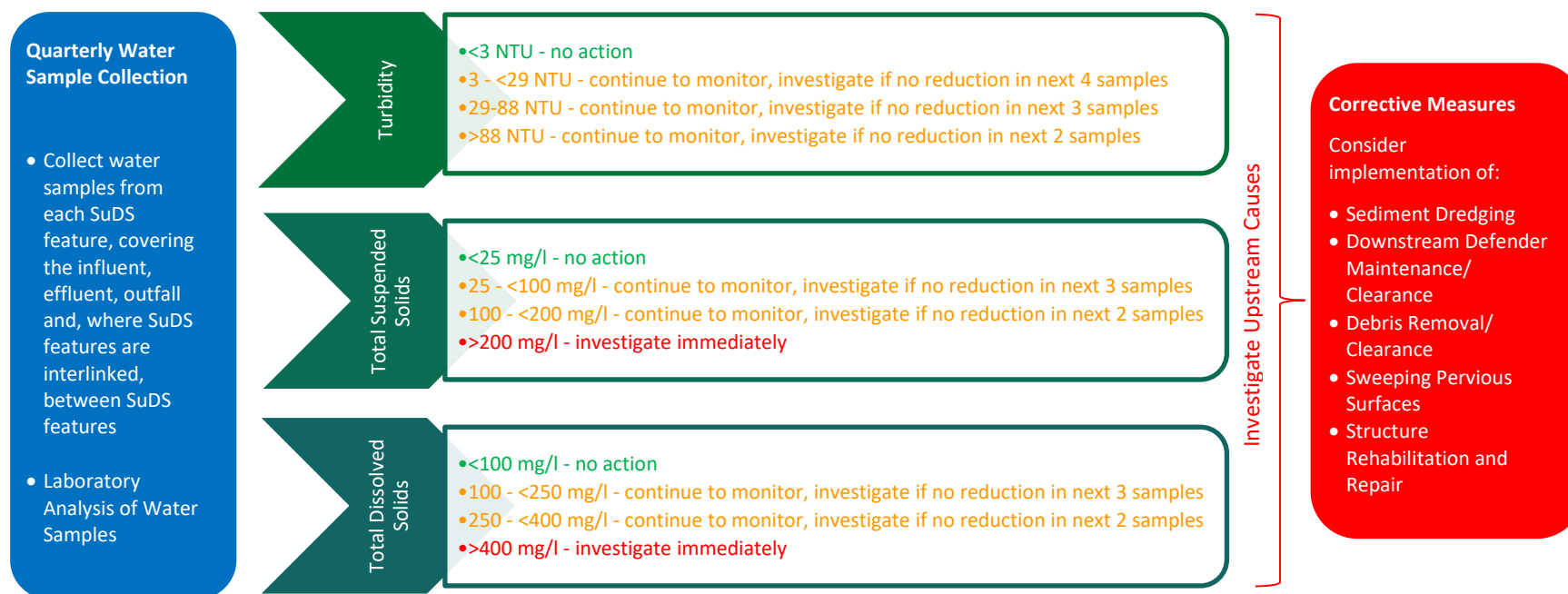
In the event that, following the implementation of various mitigation schemes, nitrogen and phosphorus loadings into the Solent reduce to such level that they are no longer a concern for Natural England, Eastleigh Borough Council will review the continued requirement for nutrient monitoring with Natural England.

### 4.3. Mechanisms for Compliance

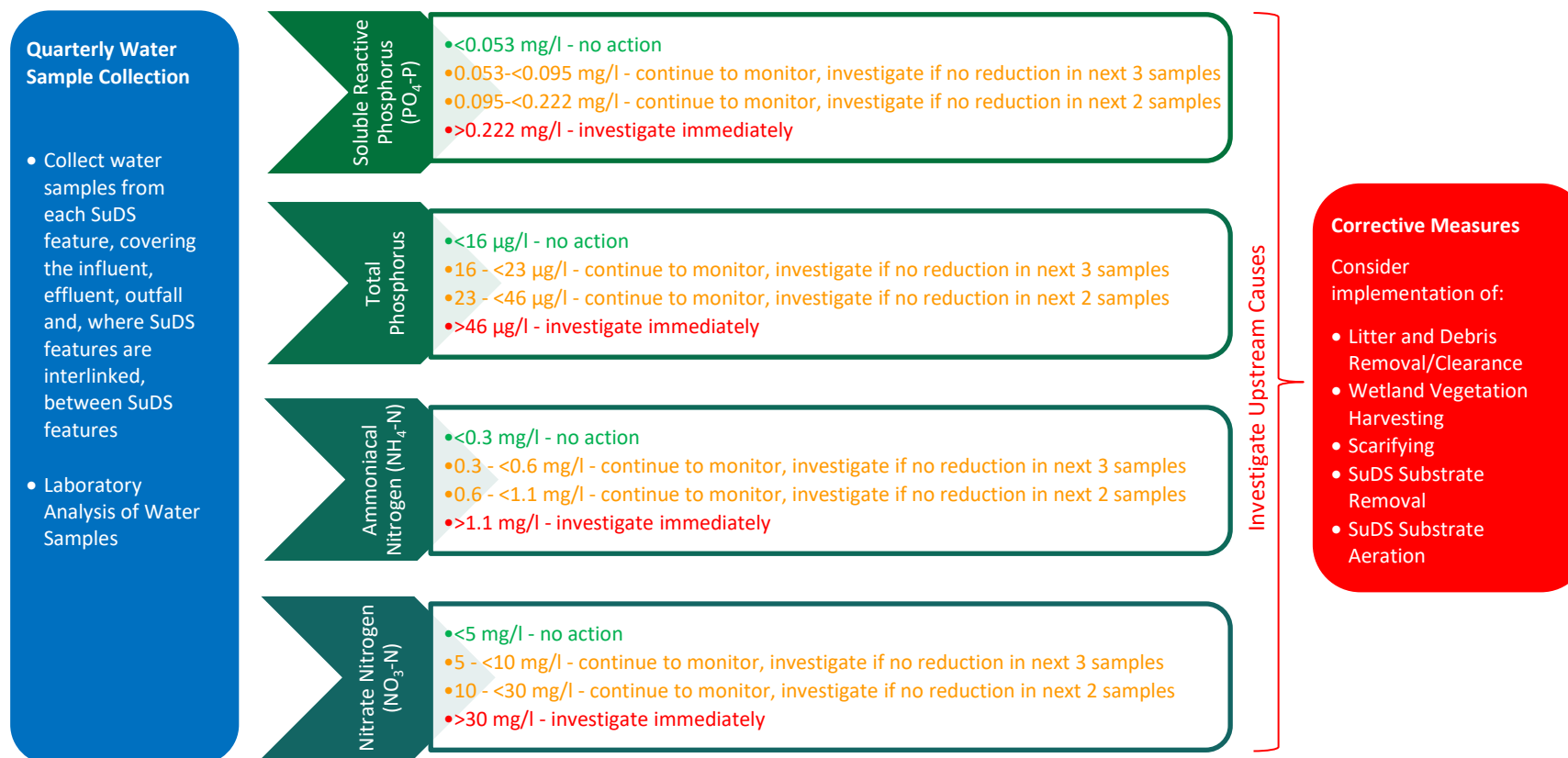
The identification of trigger thresholds for the implementation of corrective measures, discussed in Section 3, provides the mechanism through which compliance will be achieved.

## 5. Summary

The following flow diagrams in Figures 5.1 and 5.2 provide a summary of the monitoring process and trigger thresholds where further consideration, investigation and corrective measures (maintenance) would be required to maintain effective SuDS operation.



**Figure 5.1 Monitoring Process and Trigger Thresholds for Action for Sediments (Turbidity, Total Suspended Solids and Total Dissolved Solids)**



**Figure 5.2** Monitoring Process and Trigger Thresholds for Action for Nutrients (Soluble Reactive Phosphorus, Total Phosphorus, Ammoniacal Nitrogen and Nitrate Nitrogen)

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- <sup>14</sup> UK Technical Advisory Group on the Water Framework Directive (2008). UK Environmental Standards and Conditions (Phase 2), Final (SR1 – 2007), March 2008
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