**Lower Moors SSSI**

**Hydrological Monitoring: Technical Brief**



**July 2016**

# Report Details

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| **Project Name:** | Lower Moors SSSI |
| **Report Title:** | Hydrological Monitoring: Technical Brief |
| **Project Number:** | 16\_0502 |
| **Client:** | Council of the Isles of Scilly |
| **Version:** | V2.1 |
| **Author:** | D.J. Mould |
| **Date:** | 8th July 2016 |
| **Status:** | Final. Addition of analysis and management plan update |
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# Introduction and Objectives

Lower Moors is a wetland site on the island of St. Mary’s, lying within the archipelago of the Isles of Scilly. In Spring 2016, Milestone Environmental completed a scoping study assessing the requirements for increasing understanding of the surface water hydrology. This is with a view to alleviating surface water issues including flooding of the adjacent industrial site; potential water quality issues originating from the waste site; and saline intrusion. A primary recommendation was the installation of a structured network of hydrological monitoring to increase the understanding of surface water dynamics at the site, and thus facilitate improved site management. Note that a concurrent project is being instigated to complete a topographic survey which will complement the output from hydrological monitoring.

The current document is a brief for the hydrological monitoring, outlining the scope and technical requirement for these works. It includes a brief introduction to the site for context in Section 2. Section 3 outlines the detailed technical requirements of the survey work, and Section 3 outlines the deliverables required by the project.

The monitoring will comprise a network of shallow surface water dipwells and in-stream stilling wells. The output from the monitoring programme will be used to derive the following:

* Hydraulic gradients (and in conjunction with a theoretical rating, water transfers) relative to surface topography;
  + Along the central ditch;
  + Through the eastern and western ring ditches;
  + Through other minor ditches;
* Surface water storage across the wetland site, and subsurface hydraulic gradients;
* Inflows from the industrial and waste sites;
* Other minor flow pathways through the wetland, including associated water quality issues;
* Outflows from the wetland through the culvert outlet;
* Extent of saline intrusion across the site, during different seasons; and
* Assess the impact of management regime changes, including the recommended seasonal use of the stop plank structure at the downstream end of the site boundary or the potential for installation of additional stop plank structures at other locations across the site.

Note that deeper groundwater monitoring is **not** considered necessary: as the groundwater interactions are considered to be sufficiently well characterised and not thought to be as changeable to prevailing conditions as the surface water hydrology. Also, theoretical ratings are considered to be most appropriate to derive flows in surface channels: velocities will be approaching zero for much of the time given the low topographic gradients, and thus too low for flow meters to detect.

The dipwells will all be sampled monthly at a minimum to provide information on seasonal changes. Data will be logged at high temporal resolution at critical monitoring locations. This will provide information on the response of the wetland to rainfall events, allowing an increased understanding of the flood hydrology of the site. This would be enhanced by acquiring logged rainfall data. Although this is available from the airport, provision of this data from the Met Office *may* be prohibitively expensive.

Data may, if required, be used to calibrate a dynamic model of the site, which can in turn be used to test potential management scenarios before implementation.

It is envisaged that monitoring should continue for a period of 24 months to allow observation of both seasonal and annual variations in condition and hydrological behaviour. If possible an element of logging should also continue past 24 months to provide a long term dataset at key locations to monitor longer term changes, including that induced from sea level rise and associated salt water intrusion.

Water quality parameters should also be monitored to assist with determining flow pathways. It is considered that this sampling would be infrequent (twice per year), and be using a handheld analyser if not through logging instruments.

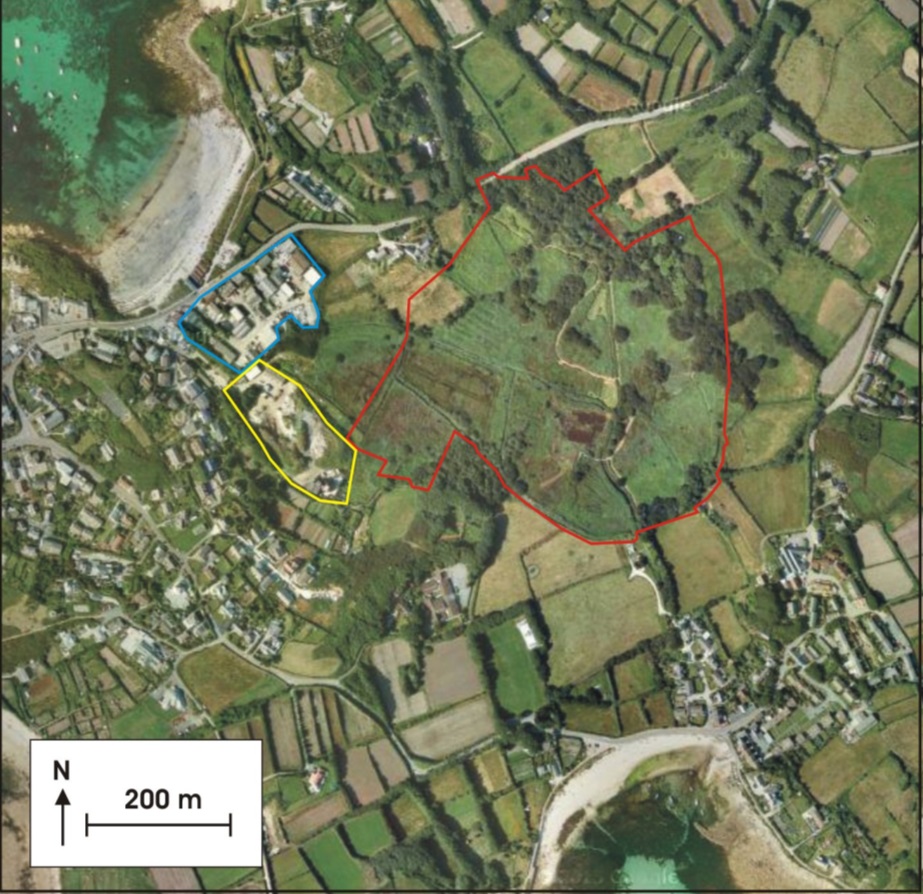
Data will be analysed and interpreted to develop the understanding of the surface water hydrology of the site and the hydro-ecological interactions critical to the wetland. This in turn will inform an update to the site’s management plan, to be developed in collaboration with all stakeholders.

# Site Introduction

## Description

The Lower Moors wetland site is a designated a Site of Special Scientific Interest (SSSI; Natural England, 1976). It lies immediately to the east of Hugh Town on the island of St Mary’s, on the Isles of Scilly. It is 10.2 ha in extent, and the entire site lies at less than 5 maOD. The western boundary is the extent of Hugh Town, buffered only by the island’s waste site. To the northeast, a small industrial estate drains towards the site, beyond which lies Porth Mellon beach. Small areas of pasture lie to the southern fringes, becoming more extensive to the east and northeast. The site boundary is shown in Figure 1, together with the industrial and waste sites. A view of the site from Hugh Town is shown in Figure 2.

The wetland has formed in the ‘bowl’-shaped enclosure formed at the base of the surrounding hillslopes. The drainage from Lower Moors is naturally restricted, and the entire site drains south to the sea at Old Town.



**Figure 1– Satellite image of the site, with site boundary marked in red, industrial site in blue and the waste site in yellow. Map data © 2016Google; approximate site boundary taken from Natural England (2016)**



**Figure 2–The northern extent of wetland site, looking east from Hugh Town**

## Site Ownership and Responsibilities

The leasehold of the land is held by the Duchy of Cornwall, and the site is leased to and managed by IoSWT. The local unitary authority, CIoS, has responsibility for permitting development and flood management, and thus has a vested interest in effective management; the wetland also lies entirely within the AONB, for which CIoS are responsible. Natural England enforces the protection of designated sites, and thus gives consent for changing management activities. Milestone Environmental have written a scoping study of the surface water management requirements of the site, including completion of a site survey; they have also written the brief for the topographic survey given the knowledge of the site and adjacent areas.

## Access

Vegetation coverage can be dense and thus prevent access: this is considered to be most restrictive in Spring and summer months: overhead vegetation cover may also restrict GPS coverage through the year. A high proportion of the site is likely to be saturated, again making access difficult. This is likely to be least problematic in the late summer.

The exact positioning of dipwells will be influenced by ease of access (including regards vegetation density), security/discretion and applicability of the substrate for augering well holes.

Given that the wells are to be included in the topographic survey, installation should be completed first.

# Hydrological Monitoring Technical Requirement

## Output

Prior to installation of the monitoring network, the following should be provided:

* Risk assessment outlining perceived operational risks and appropriate mitigation. Known site risks include:
  + Open water;
  + Overhead high voltage power lines;
* Method statement required *before* commencing work, outlining a planned technical approach and logistics.

Upon completion, delivery should be provided of the following within one calendar month:

* Short report detailing the installation, including:
  + Site conditions;
  + Access problems;
  + Installation network locations
    - Map;
    - NGR/GPS coordinates;
    - Elevation of well heads;
    - Elevation of surface at the well locations;
  + Depths of dipwells;
  + First set of readings;
  + Photos of wells including locations;
  + Any other relevant information;
* Field sheet for manual dip well readings, to also include:
  + Instructions for manual measurements;
  + Map of well locations;
  + Instructions for downloading logging instruments.

## Dipwell Installations

Shallow surface dipwells are slotted tubes inserted into the soil profile enabling the depth from ground surface to water level to be monitored. Water level is usually below the ground surface, but in wetland environments is frequently at or above the surface also. A convention is thus required for measurement above and below ground to avoid confusion in measurement.

Discretion of installations is of benefit to avoid third parties interfering with the installations. However, protrusion above the surface is of benefit in that wells can be found when the site is inundated. Well caps can be made secure to prevent interference if found by third parties, this is usually limited to those wells containing data loggers, and only where interference is expected.

## Logging Details

Data logging is possible using compact pressure transducer instruments integrated with a battery and data recorder. These are placed inside the dipwells and can be configured to record water level measurements at fixed intervals. It is recommended that a data interval of at least hourly is used: in some instances 15 minute data can be useful but this depends on the chosen logger system. For those wells that contain data loggers, manual measurements are also required to verify logged output is accurate.

## Monitoring Points Required

This section outlines the locations of wells required. The technical specification is outlined in Table 1, and is structured with increasing complexity of network, allowing increasingly dense monitoring should funding allow. A more dense network provides increased understanding of the site hydrology, filling gaps that might otherwise be missed. Also, a higher number of loggers within the monitoring network provide substantially more information on the hydrological response: many nuances of the hydrological regime will be missed if readings are only taken monthly, whereas a full picture is provided with hourly observations that are not possible with manual measurements.

As such, options 1 through 9 provided below are in order of priority, as highlighted during the previous scoping study: understanding the response of the north-south transect is critical and so is item 1. Options for increasing network and logging density are also given, with increasing complexity from a through to c. It is anticipated that ‘upgrades’ through options would be chosen together: e.g. all of the ‘b’ options. This decision will be dictated by cost considerations at the time of tender.

For the north-south central ditch monitoring (1), option 1a comprises in-channel stilling wells and allows an increased understanding of the inflows from the upstream catchment north of Telegraph Road, and central ditch response lower down the wetland. Options 1b and 1c also allow subsurface dipwell transects through the wetland site.

Second is the flow of water west to east through the site (2), especially given the potential water quality problems originating from the waste site. It should be noted that the north-south monitoring locations will also feed into the east-west dataset, as all data allow a more full understanding of site hydrology.

The open water monitoring location (3) includes the recommendation for the installation of a stageboard visible from the bird hides. This will allow reading of water levels without disturbing the birds (and so the members of the public). Visible stageboards often act to engage the public to increase their understanding of the water regime, and allow an opportunity to educate the public on the ongoing wetland management project.

The outlet culvert at Trench Road (4) is critical as this may limit the outflow from the wetland site. A water level monitoring station upstream of this will enable a theoretical rating (converting water level to flow) to be defined, so enabling quantification of the outflow. Access and permissions to install monitoring equipment are to be confirmed at this location, as this is outside of the SSSI boundary.

The stop plank structure (5) at the downstream edge of the site boundary is approximately 100 m upstream of the culvert outlet. The channel bed is thought to have a topographic high point, and thus works in conjunction with the outlet culvert (see above) to limit outflows. The structure facilitates fixing of a stageboard, which can be directly compared to that at the open water structure, which in turn can elucidate the impact of using stop planks to hold up water outflow at this location.

Flow pathways in the minor ditches (6) may contribute a significant amount to the total flow through the wetland system. Wells located at carefully chosen locations, to be determined at the time of installation, would help identify those flow pathways.

Water quality monitoring (7) will help fill the gaps regards both salt water intrusion and potential pollution at the site. Guidance should be taken from the Site Warden as to where salt water intrusion and pollution is thought to be occurring, along with information from the concurrent topographic survey. Conductivity measurements will identify salt water flow pathways: it is recommended that this is undertaken during the installation at the very least using a basic hand-held electrical conductivity meter, and ideally in different seasons to identify how salt water intrusion varies through the year. Water quality sampling can be completed at any location, not being restricted to dipwell locations. Logging water quality samplers would need fixed installations.

Regards the potential pollution, expert advice should form part of a contractor’s tender, including advice on particular determinands that are likely to be indicators, but these are likely to include heavy metals. For pollutants, samples will need to be taken for laboratory analysis.

Ecological surveys (8) should ideally be interwoven with an increased hydrological monitoring programme, given the close links between hydrology and ecology. The best approach is considered to be for expert advice to accompany the installation visit, such that the hydrological installation design can respond to any interesting or unexpected ecological occurrences, and *vice versa*. Ecological surveys at least annually will enable improvements (as a result of surface water management improvements) to be recorded.

Raingauge information (9) is useful for calibrating a dynamic model to investigate hydrological response to different management scenarios. It is known that data is collected at St. Mary’s Airport (this is a Met Office station): CIoS should investigate obtaining this from the airport, as obtaining high temporal resolution data via the Met Office can be prohibitively expensive (substantially less than a logging tipping bucket raingauge deployed at the outset of the data collection programme).

Table 1 outlines the recommended options for hydrological monitoring installations, water quality monitoring and ecological survey.

At the very minimum, it is considered that the basic requirements (stated in Table 1) of the monitoring (considered level ‘a’) is implemented for each of the elements. Thus, the north-south (1a) and east-west (2a) basic transects; open water level (3); outlet culvert (4); stop plank structure (5; if use of this structure is initiated); minor ditch intersections (6a); water quality sampling during major hydrological site visits (7a); and ecological surveying (8) should be implemented, with further enhancements where budgets allow. Level ‘a’ options have basic logging coverage. Also included in the basic requirement should be the topographic survey, as specified separately.

## Data Analysis and Interpretation

At the completion of the period of data collection, the data will be subject to analysis and interpretation. This will be completed to increase the understanding of the site’s surface water flow pathways and mechanisms, developing and quantifying the current conceptual model. This will be undertaken in conjunction with the information provided by the topographic survey to determine hydraulic flow pathways. Specific requirements will be to:

* Analyse water levels from the monitoring programme and infer flow rates under different conditions in the central ditch and minor ditches across the site;
* Analyse water storage and movement via the wetland surface (including areas of open water) and shallow subsurface profile using the data from the network of dipwells arranged in north-south and east-west transects;
* Develop a theoretical rating for the stop plank structure, enabling flow to be estimated from upstream water level at the point of monitoring;
* Develop a theoretical rating for the outlet culvert, enabling outflow to be estimated from upstream water level at the point of monitoring;
* Assess the likely flow pathways originating from the waste site and the industrial site, with implications for pollution distribution across the wetland site, noting the potable water abstraction borehole site;
* In collaboration with any available runoff calculations, develop an assessment of runoff contribution from the industrial and waste sites, and implications for flooding;
* In conjunction with botanical and water quality surveying, assess the hydro-ecological interactions across the wetland site, including saltwater intrusion points; and
* Develop and update the site management plan in collaboration with all stakeholders, using the development of hydro-ecological understanding and to include assessing the effectiveness of potential management options.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Item** |  | **Name** | **No. Transects** | **No. Stageboards** | **No. Dipwells** | **No. Logging wells** | **Basic req.** | **Notes** |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | a | North-south transects | 1 | 0 | 2 | 2 | \* | Centre Ditch |
| b |  | 3 | 0 | 9 | 4 |  | Centre ditch + east and west side transects |
| c |  | 3 | 0 | 9 | 6 |  | Increasing logging capabilities |
|  |  |  |  |  |  |  |  |  |
| 2 | a | East-west transects | 2 | 0 | 4 | 2 | \* | Northern and southern transects across site |
| b |  | 2 | 0 | 6 | 4 |  | Increasing density, to include potable abstraction borehole |
| c |  | 2 | 0 | 6 | 6 |  | Increasing logging capabilities, including at saltwater problem areas, and potable abstraction locations |
|  |  |  |  |  |  |  |  |  |
| 3 | - | Open water | 0 | 1 | 1 | 1 | \* | To include stage board installation |
| 4 | - | Outletculvert | 0 | 0 | 1 | 1 | \* | Upstream of structure. |
| 5 | - | Stop plank structure | 0 | 1 | 1 | 1 | \* | Upstream of structure. If recommendation to experiment with use of stop planks is planned to be implemented |
|  |  |  |  |  |  |  |  |  |
| 6 | a | Minor ditches | 0 | 0 | 2 | 1 | \* | Logging at western ring ditch intersection |
| b |  | 0 | 0 | 4 | 2 |  |  |
| c |  | 0 | 0 | 4 | 4 |  | Enhancing logging capabilities |
|  |  |  |  |  |  |  |  |  |
| 7 | a | Water quality monitoring | 0 | 0 | 0 | 0 | \* | Basic sampling at site visits |
| b |  | 0 | 0 | 0 | 3 |  | Logging |
| c |  | 0 | 0 | 0 | 3 |  | Laboratory analyses |
| 8 | - | Ecological (botanical) Survey |  |  |  |  | \* | Same time as hydrological installations. |
| 9 | - | Raingauge |  |  |  |  |  | If not available from the airport met site |

Table 1 - Hydrological monitoring requirements; see text for details of basic requirements