Integrated Urban Drainage Modelling Guide

Appendix D

Topographic Surveys

CIWEM Chartered Institution of Water and Environmental Management

D1. Introduction

This appendix should be read in conjunction with the current version of the Environment Agency (EA) National Standard Technical Specification for Surveying Services which provides detailed guidance on the commissioning of geospatial surveys. The EA recommend that anyone commissioning survey work on behalf of the EA should follow the guidance and where appropriate adapt to suit their needs. This appendix serves to supplement the EA specification for the purpose of urban drainage modelling requirements. In consideration of urban drainage modelling, this commentary is concerned primarily with the surveying of smaller watercourses, lakes and ponds rather than main river surveys. These smaller surveys would be those potentially carried out by the Lead Local Flood Authority or services that may be procured locally by approved survey companies. When choosing survey firms, guidance should be sought from the EA / Royal Institution of Chartered Surveyors or The Survey Association, all of whom can offer independent information about which firms would have the appropriate experience and technical expertise to execute and deliver the surveys.

D2. Scoping the survey

The scope for the urban drainage survey should predominantly cover the two types of measured surveys:-

Channel Surveys which include cross section profiles both open channel and structures. Structures can include bridges, culverts, sluices and weirs. Drawings are presented as sections and structure elevations. Digital data can be delivered in a variety of formats to suit the preferred modelling application.

Topographical Surveys which include planimetric details showing annotated level information and cartographical features such as tops and bottoms of banks, street furniture and spot levels. Drawings are presented as topographical plans either as 3d elements or 2d with annotated levels. Digital data can be delivered in a variety of formats to suit the preferred modelling application.

Critical to the successful scoping of the survey should be the initial site walkover. This would ideally involve the modelling team and the field surveyors who will be capturing the data. Initially, the section positions would be defined as a desktop exercise to allow outlined survey costs to be assessed. The purpose of the site walkover however is to establish the optimised locations where the cross sections should be taken to improve the reliability of the model and if required inform where additional sections are needed if at all. Simultaneously, a site risk assessment should be carried to identify specific hazards within the survey area and establish control measures to mitigate any hazards. This assessment may also influence the choice of survey method as some non-contact methods can offer significant safety benefits.

D3. Channel Surveys

D3.1 Survey Control

Within the identified survey extents, permanent control stations should be located along the watercourse at the suggested interval identified in the survey brief. (i.e. at a maximum of 1km). Any existing survey control that has been identified should be checked or updated depending on the purpose of the survey or the geoid model previously used. New control stations should then be installed to supplement the existing survey control. Any newly established control stations should have good sky coverage and be installed in appropriate concrete structures (i.e. pads, parapets or retaining walls).

Control for the survey should be derived using Global Navigation Satellite Systems (GNSS) utilising either Network Real-Time Kinematic (RTK) or Static GNSS survey methods in accordance with The Survey Association (TSA) guidance. A digital proforma shall be created for each permanent control station and projected onto the Ordnance Survey National Grid using the latest transformation parameters currently OSTN15 and OSGM15. Where appropriate, these control stations should be checked daily by the surveyor. This is to ensure that there is no gross error in the initial establishment of the control, as well as in the daily usage of the GNSS receiver. Where 3D control (Easting, Northing & Height) is not possible due to poor sky coverage, level only control should be installed from nearby 3D stations.

For the majority of channel surveys, a minimum of two temporary control stations can then be installed where necessary utilising Network RTK survey method. These reference stations are then used to triangulate the position of the Total Station before any radial detail is observed.

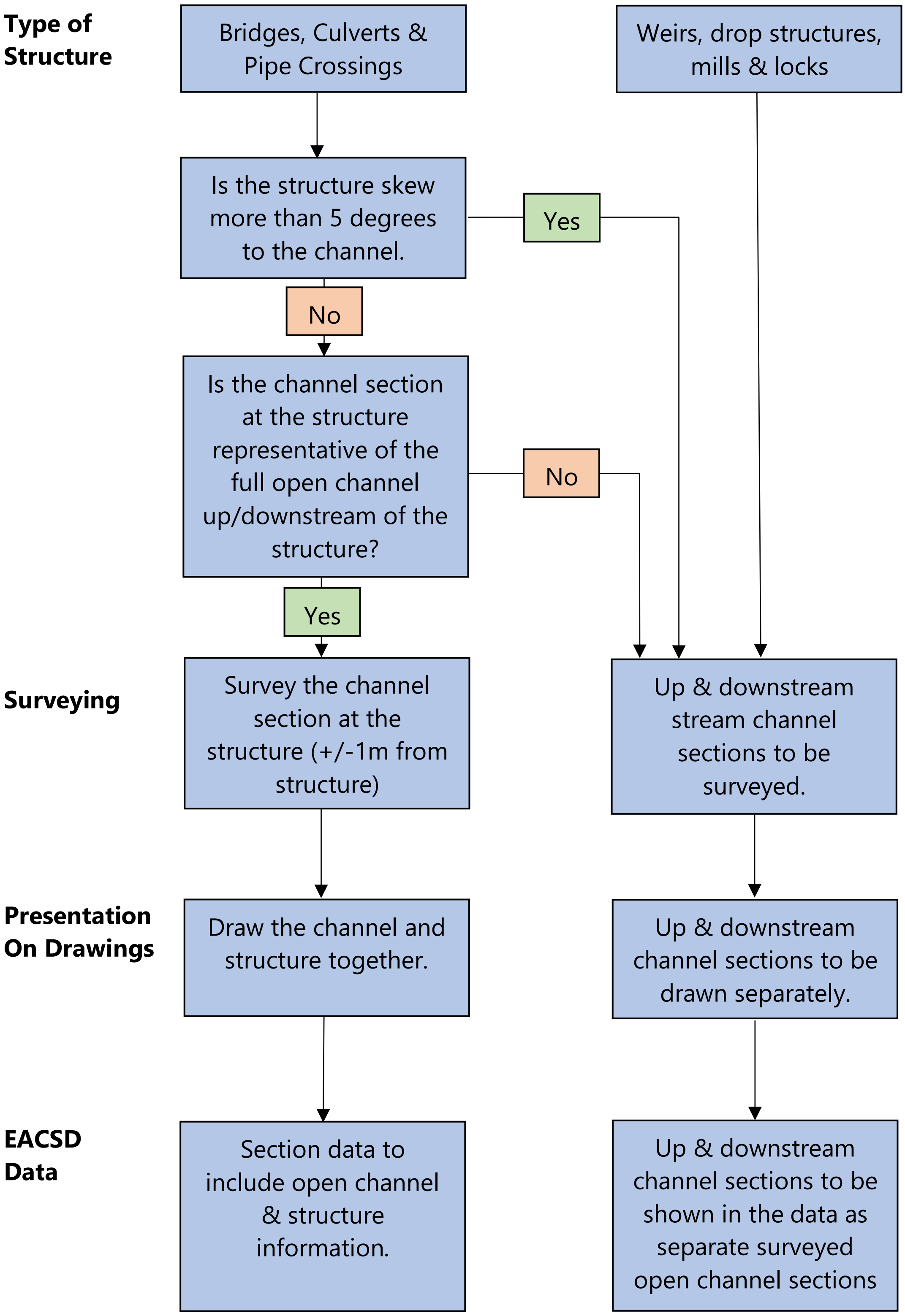
D3.2 Cross-sections

Cross-sections are to be surveyed perpendicular to the watercourse at the interval specified within the survey brief. Within urban environments, it is generally considered that the maximum spacing of cross sections is 50m along smaller open watercourses. Each cross-section should capture the bed profile & adjoining bank levels as well as the water level at each location. Each should give a good representation of the general channel profile which may include avoiding areas like bends where scouring may cause the channel to be locally distorted. Water levels are observed at each cross section as a gross error check on the GPS data and establish if any user error can be identified.

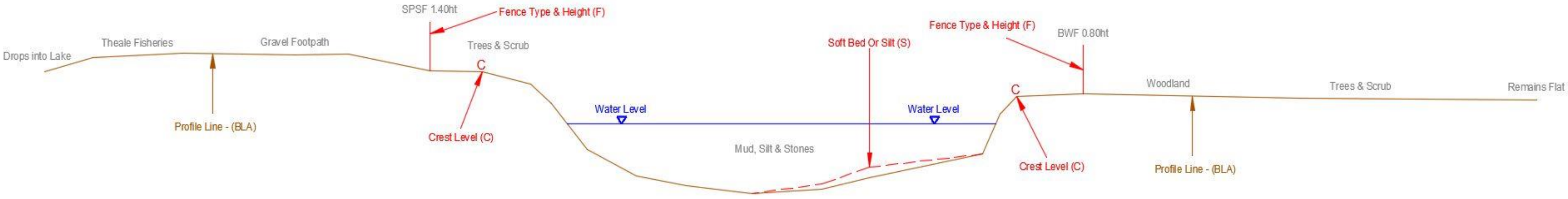
As well as open channel cross-sections, a comprehensive survey will require cross-sections to be observed at the following:

- Any major obstructions to the flow of water, such as culverts and bridges, including pipe crossings.
- Any major weirs or drop structures (both natural & man-made).
- Any changes in the shape/width of the watercourse that could affect the flow.
- At any gauging stations where information is available for calibration purposes.
- At the confluence with any tributaries entering the main watercourse.

Where structures are located along the extent of the watercourse, it may be necessary to include additional cross sections to show the natural channel shape. The following decision tree should be adopted by the surveyor when identifying the need for additional cross-sections:



Example: *What a typical Open Channel cross-section should look like:*



Required Photos:

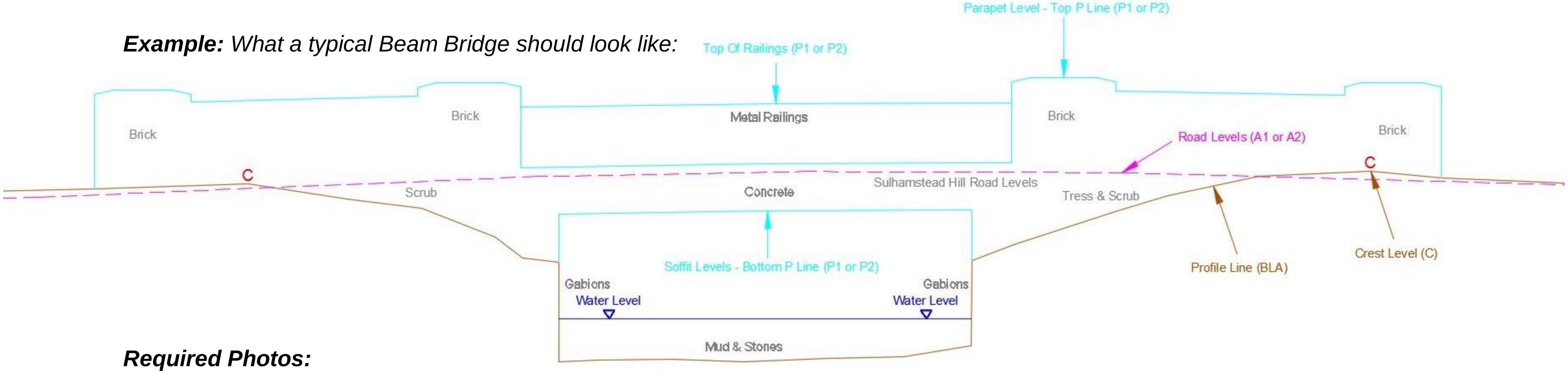
Downstream

Upstream

Left Bank

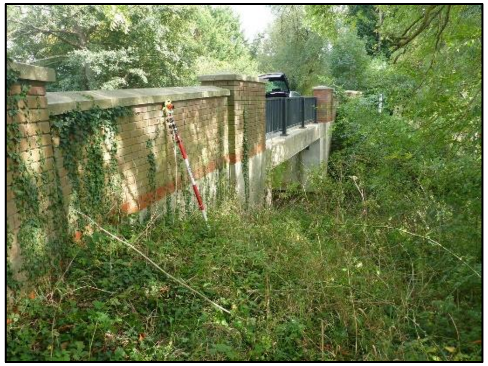
Right Bank

Example: *What a typical Beam Bridge should look like:*



Required Photos:

Downstream Face



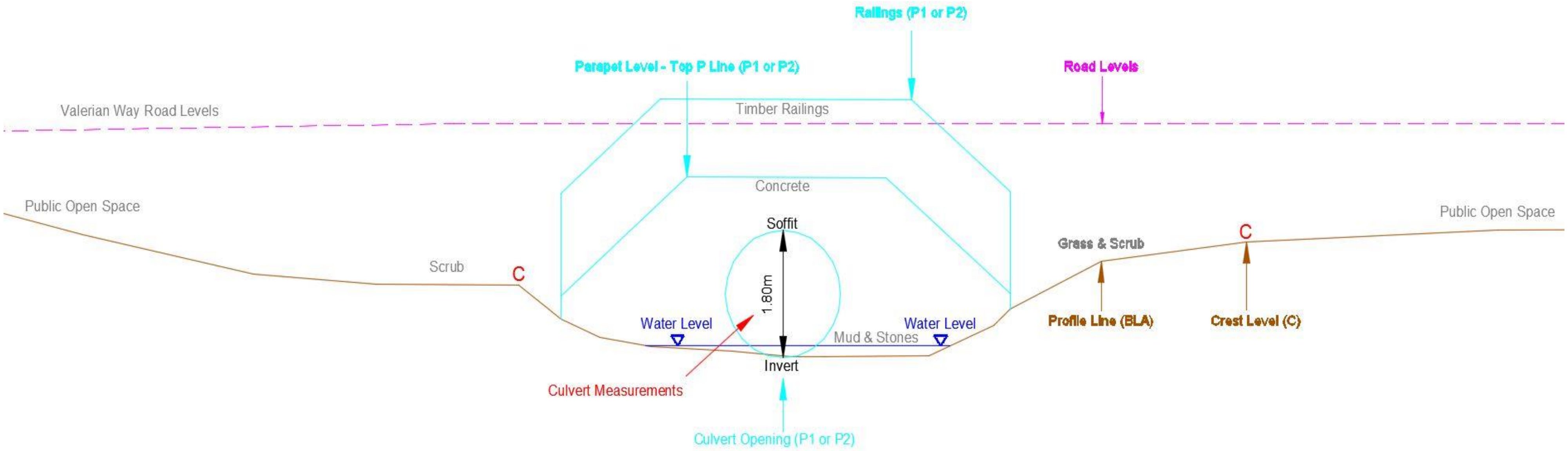
Upstream Face (Close)

Upstream Face (Whole)

Left Bank

Right Bank

Example: *A typical Circular or Pipe Culvert*



A **Circular or Pipe Culvert** Requires the surveyor to:

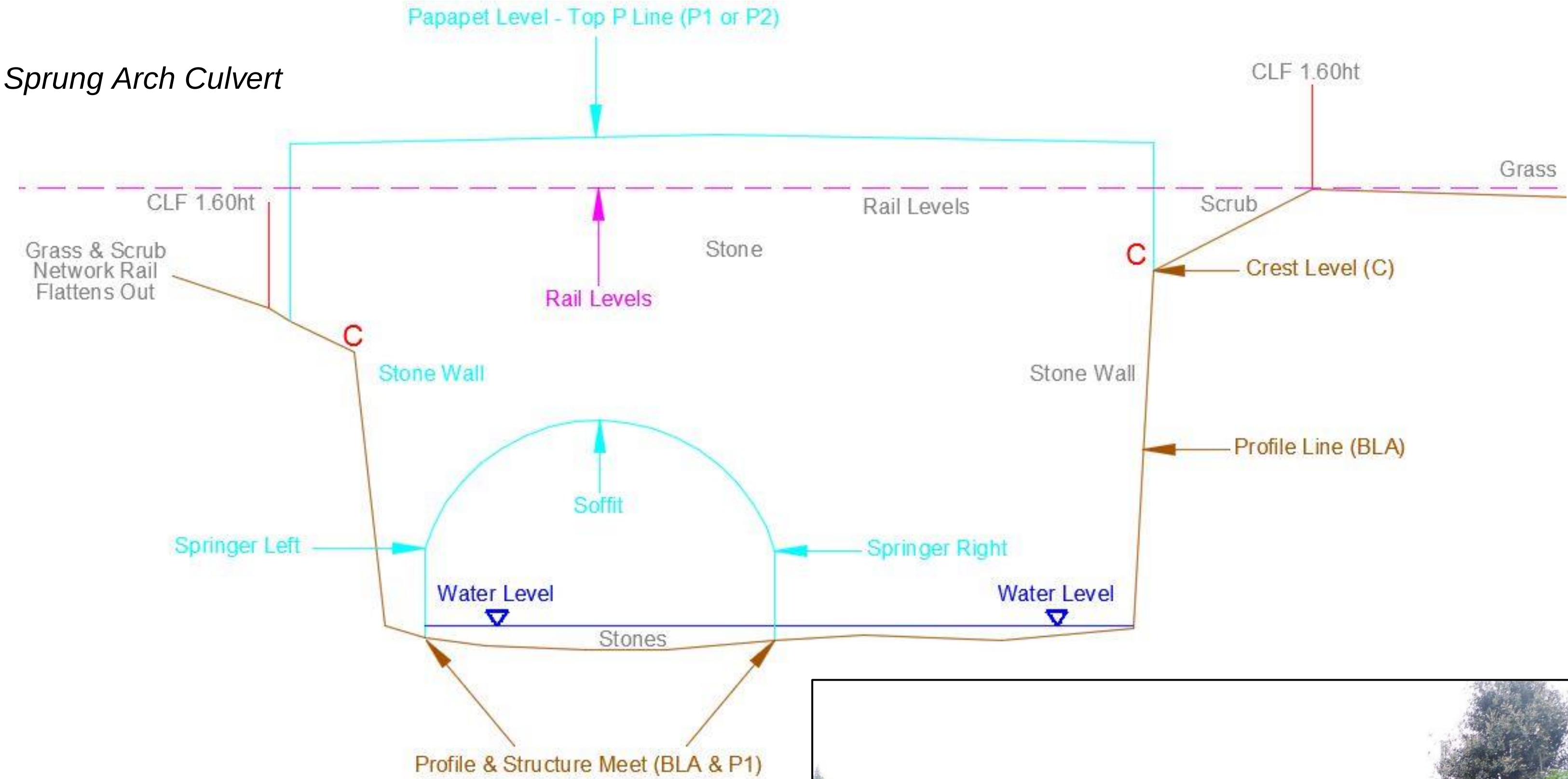
- Measure two internal points on the pipe. One at the top - *Soffit* & one at the bottom – *Invert*

(Total Station Code: P1 or P2).

- Measure Pipe diameter & note down all measurements on the relevant cross section

sheets.

Example: *A typical Sprung Arch Culvert*

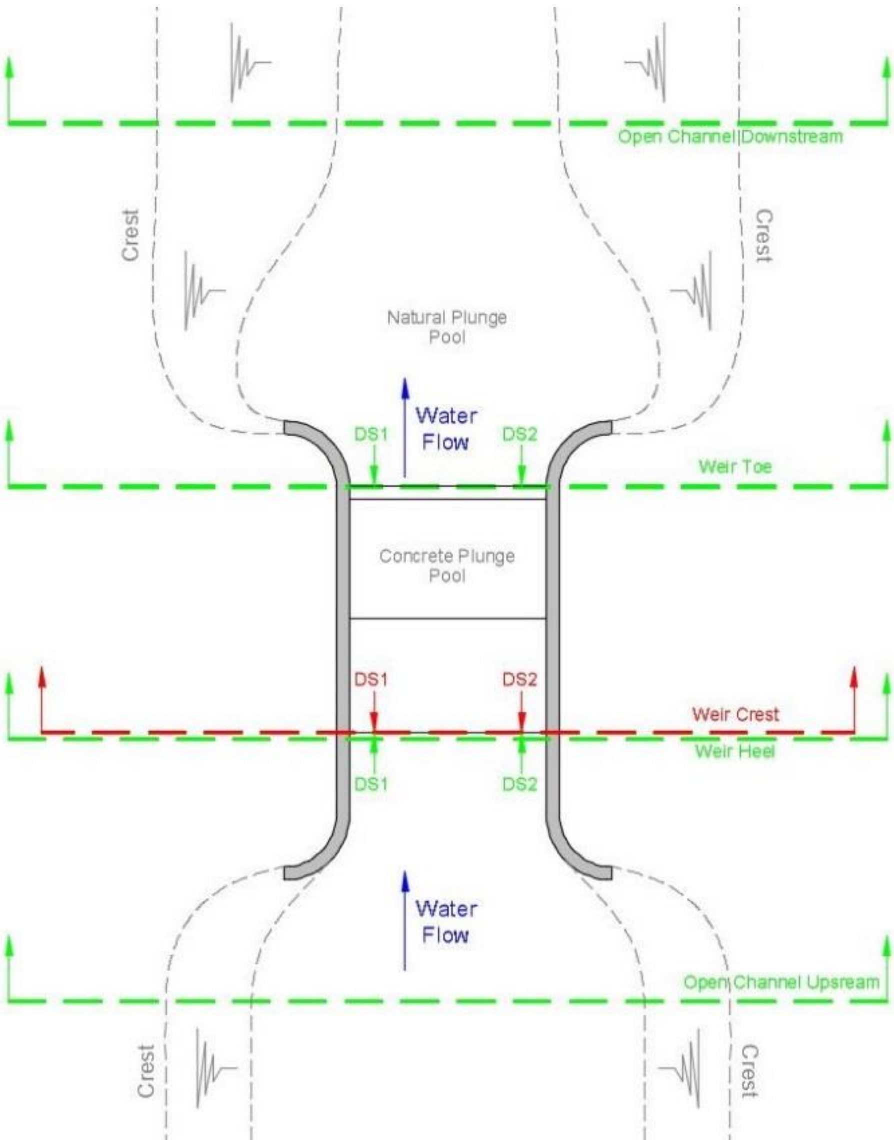


A **Sprung Arch Culvert** Requires the surveyor to:

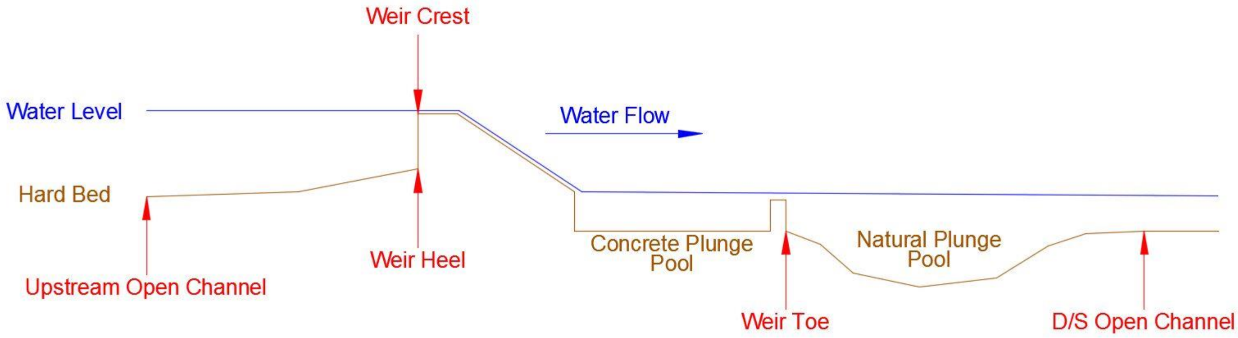
- Measure a point on each side where the structure meets the bed profile (Total Station Code: BLA & P1/P2).
- Measure five internal points on the Arch. Left Springer Right Springer, Soffit Level & two additional splitting the three

(Total Station Code: P1 or P2).

Example: *A Broad Crested Weir with retaining walls*



Typical Cross Section Location Plan for a Broad Crested Weir with additional cross sections.



Typical Through Section for a Broad Crested Weir with additional cross sections.

D3.3 Longitudinal Sections

Along the extent of the watercourse, the following detail is required:

- Incoming pipe invert levels and diameters
- Incoming culverts; noting the size and shape.
- Any pipe or structural crossings not deemed necessary for a full cross section as per the survey brief.
- Any overhead wires that cross the watercourse within the extent of the survey.
- Any tributaries or spillways.
- Any other low points or significant changes along the top of bank.

D3.4 Threshold Levels

Within urban environments, it may be necessary to undertake a property threshold level survey to determine whether properties are at risk from flooding. When conducting a threshold survey, the surveyor should ensure that the levelling is completed from the nearest or most appropriate permanent control station. The following detail should be obtained as a minimum:

- Ground Level
- Property Threshold - *Front door, lowest/multiple if the owner allows.*
- Lowest air brick - *if available*
- Damp Proof Course (DPC)
- Finished Floor Level - *if the owner allows.*

D4. Topographical Surveys

D4.1 Definition of a topographical survey

A topographical survey can be described as a collection of measurements used to define the spatial relationship of both natural and man-made features on the ground in order to produce a topographical plan or map. They generally show features such as buildings, fences, trees, roads, watercourses, tops/bottoms of banks and will often show contours at suitable vertical intervals to define the relief of the of the ground terrain. They are used by many disciplines including Architects, Consulting Engineers and Developers in order to inform design or development proposals, calculate areas and volumes as well as form the basis for flood planning and modelling within the urban water environment.

D4.2 Methods of data collection

A topographical survey can be collected using a variety of methods including:

- Total Station (Combined distance and angular measurement)
- Terrestrial Laser Scanning
- Global Navigation Satellite System (GNSS)
- Aerial Photography / Photogrammetry
- Airborne Lidar (Light Direction and Ranging)
- Remote Sensing

The first three methods are normally associated with topographical plans where they represent data at scales of larger than 1:500 i.e. 1:200, 1:100 and 1:50 whereas the last three methods would be associated with topographical mapping at small scales from 1:1250 to 1:10,000. Only the first three methods will be discussed within this appendix as they are directly measured as opposed to being derived from other sources of data capture such as aerial photography.

D4.3 Topographical plan presentation

Topographical plans can be represented on stable film, paper but most commonly and ethically they are now presented only in digital format some of which are outlined below:

- 2d AutoCAD / Bentley Microstation
- 3d AutoCAD / Bentley Microstation
- Moss Genio
- Revit / AECOsim / ArchiCAD
- GIS formats including ESRI/KML/TAB etc.

- XYZ (Ascii / Excel)

The transfer of digital data from between consultants will predominantly be via email although for larger data sets proprietary secure data hosting / transfer services are often used.

D4.4 Specifying a Topographical Survey

The key factors to be considered when specifying a topographical survey are:

- The extents of the area to be surveyed
- Safe access to the site / area including treatment of areas of vegetation.
- The scale and accuracy required
- The level of detail to be shown (can be influenced by seasonal vegetation)
- The grid and datum to be adhered to
- Model requirements 2d / 3d
- Data presentation / Digital Outputs.

There are several recognised documents available to help in scoping and specifying a topographical survey. These include documents published by the Royal Institution of Chartered Surveyors (RICS), Environment Agency (EA), The Survey Association (TSA) and English Heritage.

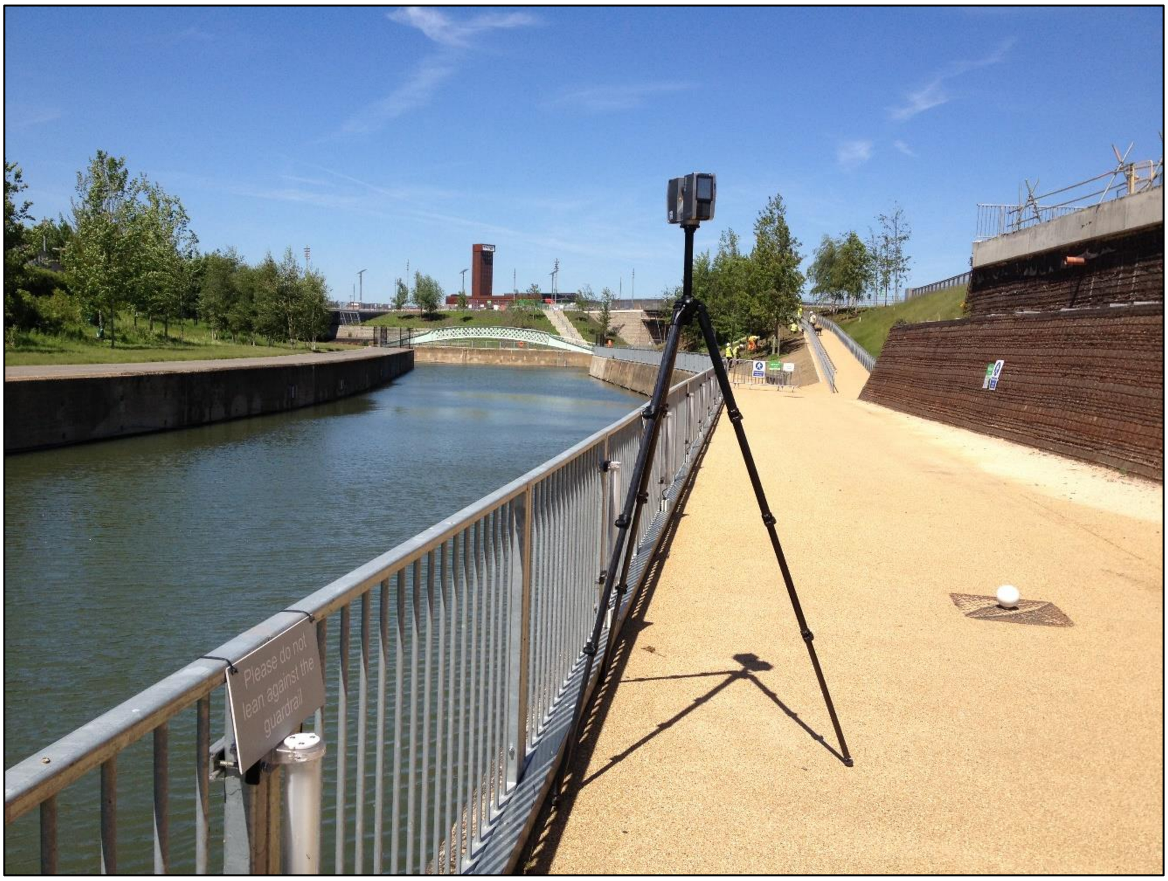
- RICS professional guidance, Measured surveys of land, buildings and utilities 3rd edition.
- EA National Standard Technical Specifications for Surveying Services (V4.01)
- TSA Client Guide - Topographical Surveys_Issue 3_HR
- Metric Survey Specifications for Cultural Heritage (English Heritage)

D4.5 Surveying with a Total Station

A Total Station is the name given to an electronic/optical device used in surveying and construction. It is a combination of a theodolite and electromagnetic distance measurement in one unit. Most modern Total Stations additionally have the ability to measure non-contact distances to surfaces without the need for a prism. Accuracies for total stations used for topographical surveys are generally +/-2mm or better and distances can be measured up to 1km. Most distances measured from an individual survey control station would be less than 150m before adjacent control stations would be used. Beyond this distance the accuracy of trigonometric heighting points is reduced. Detail observations are recorded to discrete points using either a prism mounted on a detail pole or by use of non-contact measurement to a surface. Feature strings, coded point features and spot levels are observed on the ground. These are recorded directly on the total station allowing for a digital terrain model (DTM) to be created very quickly in the office using DTM software. Accuracy of ground level information is unambiguous as it is obtained by direct surface measurement using a detail pole.

D4.6 Surveying with Terrestrial Laser Scanner

Use of Terrestrial Laser Scanners is now becoming commonplace in all forms of geospatial mapping and surveying. A Terrestrial Laser Scanner uses light detection and ranging (LiDAR) to measure distances to surfaces and objects. These devices are able to capture hundreds of thousands of points every second to generate a very rich data set referred to as a point cloud. The scanner is set up at multiple locations to capture the scene. Following the data capture on site, scan registration is the process whereby each scan setup is geometrically referenced to adjacent setups using targeted or cloud to cloud techniques. Total Station control points are generally supplemented to relate the registered scans to a common control framework. The resultant point cloud can be referenced in most CAD software to form the source from which digital drawings or models can be produced. The data can also be extracted to form a digital terrain model at very close grid spacings ; this can be very useful when analysing detailed drainage run offs. Accuracy of level information on soft detail can sometimes be ambiguous as the true ground level may not always be discernible. There are significant safety benefits utilising this method as large amounts of data can be captured without physical access to the points being observed. Most proprietary scanning software vendors now allow the ability for online point cloud viewing and interrogation from a web browser negating the need for client end software and large data storage capacities.



D4.7 Surveying with GNSS

Current RICS Practice guidelines explain that Global Navigation Satellite Systems (GNSS) has been used extensively by land surveyors since the late 1980s, primarily for geodetic control networks and for photo control. As systems have become more compact, more technologically advanced, easier to use and with a full complement of satellites enabling 24-hour usage, the diversity of surveying applications has increased significantly. GNSS systems are now available for many surveying and mapping tasks, including establishing control, topographical survey, setting out, real-time deformation monitoring, on-board camera positioning for aerial photography; the list is continually growing.

The most common use for detailed topographical surveying is referred to as Network RTK which enables an operator with a single receiver and appropriate subscription to get real-time corrections from continuously broadcasting OS Net stations. Typical accuracies achievable range from around 10-20mm in plan and 20-40mm in height.

Network RTK is particularly economical for establishing spot height information but does rely on good sky coverage vertically within 10 degrees of the ground surface so that many satellites are in view of the receiver. Large expansive areas such as flood plains and exposed open riverbanks are ideal topography to be surveyed using GNSS. Urban and densely wooded areas do not lend themselves to GNSS as the satellite signals are distorted by the local environment. Network RTK can be mounted on a vehicle or quad bike to enable rapid data capture in open terrain.

D4.8 Calibration

Irrespective of the method of data capture all instrumentation used should be in good adjustment. All survey equipment should be calibrated at least annually on a certified baseline and a certificate of conformance issued. On site vertical and horizontal collimation checks should be carried out on survey instruments prior to the commencement of each project and periodically throughout longer projects.

All processes involved with surveying should have an element of redundant information captured for the purpose of validating observations. All ancillary equipment including tribrach's, details poles, tripods and levelling staffs should be in good working order and level bubbles checked frequently and adjusted as appropriate.