DESIGN AND OPERATION OF TRASH SCREEN
APPENDIX F

WORKED EXAMPLE

INTRODUCTION

This worked example is primarily intended as an aid to identifying screen need and screen area design. It is not possible in the context of the hypothetical nature of the example to deal with all design criteria, particularly operation and maintenance aspects that will be particular to each operating authority.

The example follows the approach in the manual through its initial stages. The example is based on the following hypothetical data.

NOTES

The following data pertaining to an existing culvert and its hydrological area are provided;

1. Description

The responsible authority is examining the need to place a screen at this location following an incident earlier in the year when some large debris (mattress and tree branches) became stuck at the culvert change point. The blockage resulted in some minor flooding to a builders yard, 12 domestic properties and 2 shops upstream of the culvert entry. Fortunately the event was of short duration and the flood levels receded prior to further damage occurring. The debris was extracted via the culvert entrance.

2. Existing culvert

- Overall, length is 250m.
- The upstream section is of brick arch construction with a base width of 4.5m and a height of 3m. This section is 100m in length. The remaining 150m section to the outfall is within dual (2 number) pre cast concrete circular sections of 2m diameter.
- There is a public highway above the culvert at its upstream end. Downstream of the culvert are railway sidings and some light industry.
- The invert level at culvert entry is 20.00 m AOD and at the outfall is 18.00 m AOD.
- The brick arch is some 100 years old, the circular sections about 20 years.

3. Topography

- The watercourse immediately upstream runs for 1.6 km to a level control structure. The bed level at this point is 36m AOD. Bed level is 22m AOD at a point 160m upstream of the culvert and 33m AOD 1360 m upstream of the culvert.
- The first 500m upstream of the culvert passes through an urban area and above this is woodland and Public Park.

- There are two streams entering the main watercourse at about 1000m upstream of the culvert. These are both about 1.5km in length and run to high ground through open rural/wooded areas.
- The area immediately upstream of the culvert entry is steeply banked from the highway level

4. Hydraulic considerations

- The watercourses generally reach bank full state in the upper areas about 6 times a year.

STAGE 1 ASSESS SCREEN NEED

- **INVESTIGATE AREA HISTORY**

From the data given in the notes, it is concluded that there is risk at the culvert, in terms of both blockage, and unauthorised entry.

The operator should investigate the need to install a screen at this location.

- **RISK ASSESSMENT**

With reference to section 2.2 of the manual, the following constitutes an appropriate risk assessment

i) Culvert Blockage. Set of tables A:

Probability – Analysis of the recent problems on the culvert indicate that there is a fairly high risk of blockage. It may be that the debris causing that blockage arose from an infrequent fly tipping incident. Discussion with operations staff should confirm the incidence of fly tipping in the area. However, given the data available a score of **4** is determined.

Consequence – The data provided indicates that the likely result of a blockage would be between £100,000 and £1,000,000 and therefore a score of **4** is determined.

Thus, the total score for culvert blockage is **16**.

ii) Unauthorised Culvert Entry. Set of tables B

Probability – There are no reports of unauthorised access, although further checks should be made. The upstream face is in a non-secure area. A score of **2** is therefore determined.

Consequence – The culvert is long at 250m, therefore anyone in the culvert during high flows is likely to be washed through it for a substantial distance. There is no record of safe places/ledges in the culvert; there is a significant change in culvert section. It is concluded from the information provided that unauthorised culvert entry could result in serious injury to the party entering the culvert. A score of **4** is determined.

The total score for unauthorised entry is therefore **8**.

iii) Damage to Infrastructure. Set of tables C.

Probability – The information given does not give any details of services within the culvert, this will need a further check. The structure itself could sustain some damage especially at the change in section and therefore a score of **2** is determined.

Consequence – Given the nature of the existing structure and the likely location of damage within the culvert repair costs are likely to be above £10,000. A score of **3** is determined.

The total score for infrastructure is therefore **6**.

- **DECISION RULE**

From Section 2.3 of the manual the decision rule flow chart indicates that for the highest scoring area (16, Culvert Blockage) a screen installation is required at this location. Design of the installation should now proceed.

At this stage, the Engineer should ensure a peer review of the decision rule process. For the majority of promoting authorities a suitable project appraisal will then be required. The proceeding sections could be used as a basis of the necessary option appraisal. The decision rule has identified a particular problem; there may be a number of options for solving the problem including the installation of a trash screen. The outcome of the project appraisal will determine the need to install a screen. Alternatives to screening may include: culvert removal, watercourse diversion, providing a secure compound to the culvert entrance and taking measures upstream to ensure debris does not enter the culvert.

For the purpose of this example, it is assumed that a trash screen is deemed necessary.

STAGE 2 ASSESS CATCHMENT

Stage two involves the collection and appraisal of data that will be used for the basic screen design.

- **Identify site location**

All issues of location pertinent to the development of the installation should be detailed here, a detailed site survey should be undertaken. A services search should be instigated. Access requirements should be considered, are there rights of way in the area that may impact on the final design of the installation?

The production of a detailed site location drawing should be an output from this stage; it will include topographical detail, services and other constraints.

For this example, a suitable drawing is not provided.

- **Calculate different types of contributing area and length of watercourse in each**

In order to calculate the required screen size the lengths and types of contributing area should be calculated. Sufficient data has been provided to determine these parameters.

There are 4 stream lengths to be considered;

500m, urban
1100m woodland/park
1500m rural/wooded
1500m rural/wooded

Calculate S1085

The S1085 provide for an average catchment gradient

The level at 85% stream length is 33.00 m AOD
The level at 10% stream length is 22.00 m AOD
The length between these two points is 1200m
The design gradient is therefore 0.009167, or 1 in 109.

- Calculate basic Da figure

In order to calculate the Amount of Debris (Da) refer to Figure 3.3 in the manual and using the figures calculated above, thus.

500m, urban	= 50 m^3/yr
1100m woodland/park	= 40 m^3/yr
1500m rural/wooded	= 60 m^3/yr
1500m rural/wooded	= 60 m^3/yr
TOTAL	**= 210 m^3/yr**

This figure is then factored in accordance with table 3.3.2 of the manual. In this case, the gradient is fairly steep and the Design Debris Amount is un-factored Da i.e. 210 m^3/yr.

In cases where good records exist of debris amounts then these should be used. Otherwise, where it is believed appropriate to obtain accurate data then systems can be put in place at or near the potential screen site to collect and measure the volume of debris. This will be a time consuming task and it is important that any temporary installation does not increase flood risk.

STAGE 3 SCREEN SIZE DERIVATION

Section 3.3.4 of the manual provides guidance on determining screen size, firstly using knowledge of debris amounts in channel and secondly using an empirical formula based on culvert size.

Using the screen sizing formula.

Design Debris Amount	= 210 m^3/yr
Number of significant event and	= 6 , this equates to the number of bank full events annually is given in the data provided. *To obtain the figure then some research will be required into the history of this watercourse or other similar watercourses near by..*
Blinded depth factor.	= 0.63, this figure is believed the most suitable for the description given, the majority of the catchment being woodland area.

Using the equation

$$\text{Screen size} = \frac{\text{Design Debris Amount}}{\text{Number of events x Blinded depth factor}}$$

Therefore

Screen size = $\frac{210}{6 \times 0.63}$

Screen size = **<u>55m²</u>**

Using the empirical method

The table given in the manual provides advice based on three categories of debris amount; large, medium and small. In this example, the **'large'** classification is most appropriate. Thus the screen size should be **$12m^2$** or 9 times the culvert area.

9 times the culvert area in this instance will be 9 times the smallest cross section of the culvert over its full length, i. e. the 2 number 2m diameter culverts. This equates to **$56m^2$**

In this particular case, the values derived from the two approaches are similar, which is unlikely to be the norm. The designer should use the result from the screen sizing formula unless he believes there are serious deficiencies in the original data, in which case he must re evaluate it and perhaps obtain further data.

STAGE 4 – SCREEN ARRANGEMENT

The screen arrangement will be based on an effective area requirement of $55m^2$.

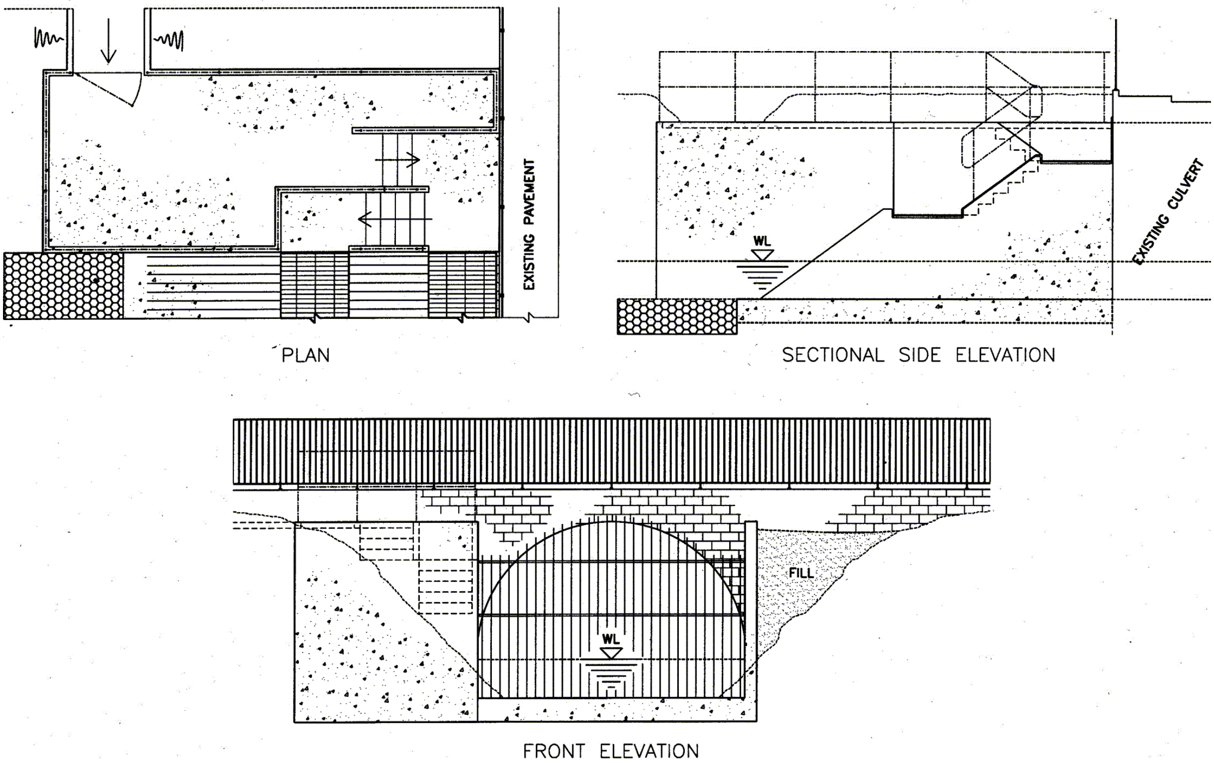
The designer is referred to section 3.4 of the manual that highlights those factors that must be considered in developing the screen arrangement.

Figures 1 to 3 show possible arrangements, the following notes refer to each figure.

Figure 1

- The screen is designed to be manually raked, for clearance in both routine and non-routine events. However, a grab lorry can be parked adjacent to the structure for removal of debris.
- The arrangement is a simple 2-stage with horizontal areas providing part of the effective screen area.
- The raking screens are set at an angle of 45^0.
- The steel super structure is contained within a reinforced concrete sub-structure that forms a new channel bed and full height sidewalls that retain fill placed to the previous embankment.
- A concrete hard standing is provided on the left bank abutting the new structure. This area is for storage of debris and possible parking of vehicles. As the installation is adjacent to the public highway, the operating authority should seek a way-leave for parking.
- The hard standing area should drain to the watercourse, avoiding the possibility of eroding the earth embankment.
- The hard standing should be set at a level so as not to cause a trip hazard when accessing or egressing the screen super structure.
- Access to the two working platforms is by steps cast into the sub structure; Ladders could be used but are inherently less safe.
- Hand railing is provided to the perimeter of the structure and hard standing with suitable lockable gates. Hand railing is also installed between the hard standing and the screen.

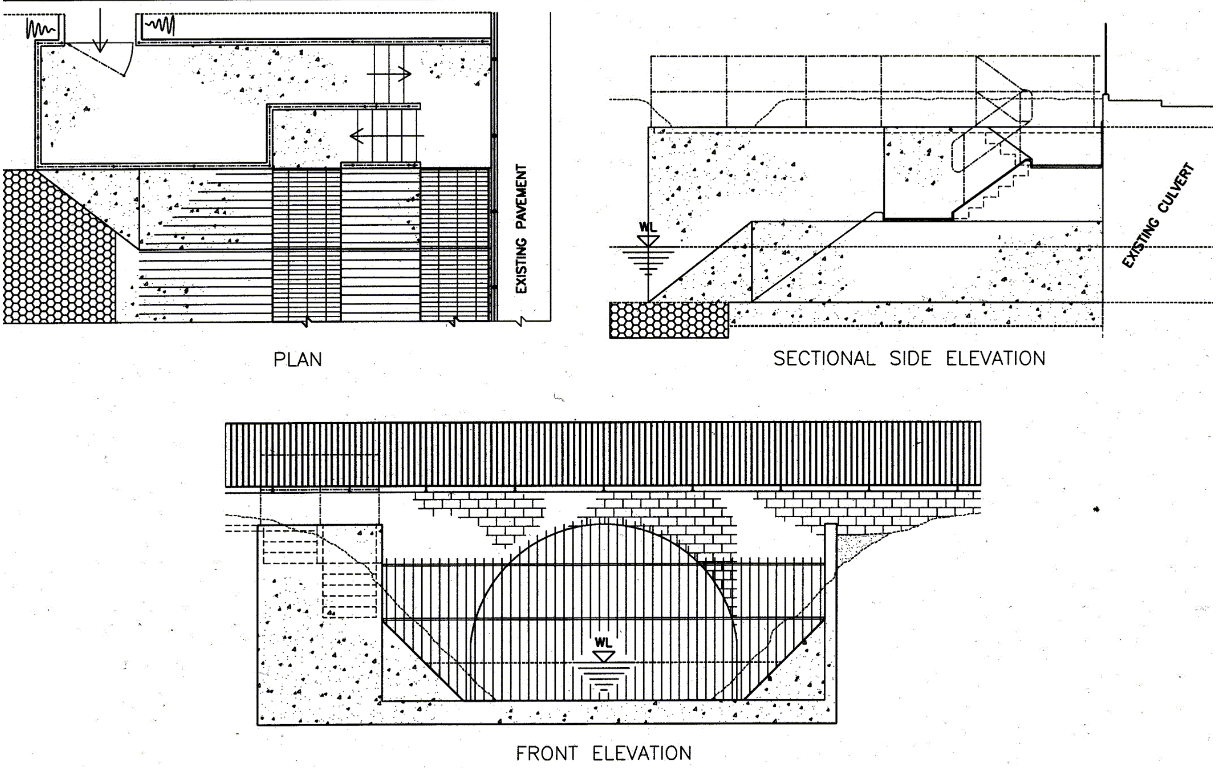
- Access to the culvert is provided via an access hatch in the upper working platform, with a ladder to the channel bed.



<u>Figure 1 - Worked Example Appendix F</u>

Figure 2

In this arrangement, the width of the sub structure has been increased to provide a greater screen area. All other features are the same as Figure 1. It is not the intention in this example to show detailed dimensional properties, as the case is hypothetical.



<u>Figure 2 - Worked Example Appendix F</u>

Figure 3

In this arrangement, the screen has been placed on the left-hand bank of the watercourse. The length of the screen along the channel determines the screen area. It is noted that a better arrangement would be to angle the screen to flow in order to retain a greater volume of trash.

For the three arrangements given it would be useful for the designer to undertake detailed hydraulic analysis, perhaps through the use of computer modelling techniques.

The three arrangements shown are for illustrative purposes only; there are many other possible arrangements.

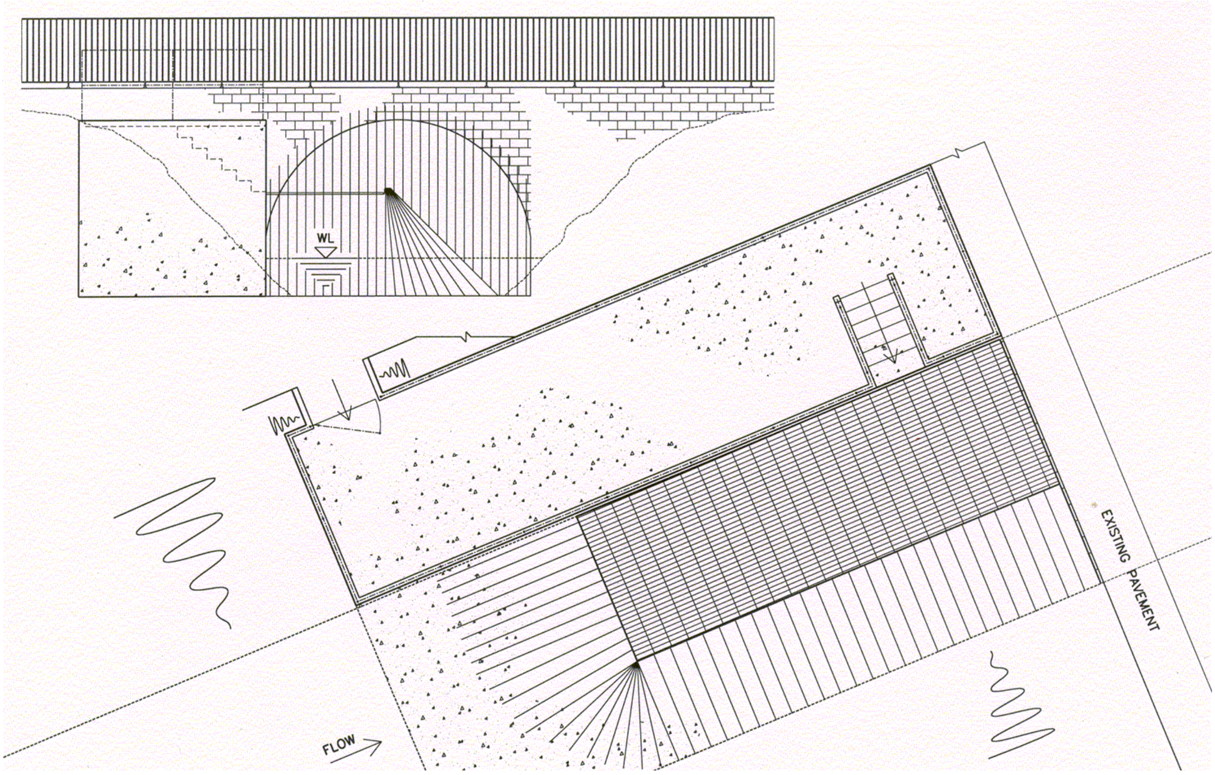


Figure 3 - Worked Example Appendix F

DEVELOPMENT

Having compared various options, the designer will be required to undertake some detailed design work to prove a preferred feasible option. This will involve a critical element appraisal as detailed in section 3.3 of the manual.

It is not possible to demonstrate an appraisal for this hypothetical case, however the intention is to investigate each element and prioritise the features required to provide best screen functionality. The final design must attempt to balance all these features.

The final design must incorporate the operational and maintenance requirements of the installation in the form of draft procedures.

The design manual does not release designers, contractors and promoters from their normal duties under CDM, environmental requirements etc.