

# DESIGN AND OPERATION OF TRASH SCREENS CASE STUDY

## LEEN SYPHON

### 1. SCREEN REQUIREMENT

#### 1.1 The Site

The site is situated on the River Leen at Lenton in the city of Nottingham where the River Leen passes under the Beeston Canal in a syphon. The River Leen channel upstream of the syphon consists of a straight trapezoidal grass bank channel. Before entering the syphon the river passes through a transition zone which consists initially of steel sheet piles with reinforced concrete capping beam and then a reinforced concrete flume. The flume is divided into two chambers by a central reinforced concrete wall.

The channel and syphon were constructed in the late 1970's as part of the River Leen flood alleviation strategy.



**Figure 1.1 View of the canalised river looking directly upstream. The access road is on the left of the river.**

#### 1.2 Reasons for Installation

The placing of the syphon on the river at this location presented a particular hazard to both public health and safety and potential blockage, (*Manual, Sections 2.1.2 and 2.1.3 provide guidance with regard to culvert blockage*). The screen therefore was built as part of the original flood alleviation strategy.

The potential risk of blockage to the syphon was a primary design concern. The alleviation scheme had been promoted as a consequence of historical flooding in the area and therefore the probability and consequence of flooding was well known at this location.

Syphons of this nature do have a high risk of blocking and the decision to construct a screen was taken at an early stage, (*Manual, Section 2.2 indicates that blockage probability and consequence would be high*). No guidance was available for the design of trash screens at this time.

Blockage of the syphon would lead to flooding of the upstream area of the River Leen including domestic dwellings, businesses, public highway and various amenities. In addition

there would be a high probability of water spilling over the embankment adjacent to the canal and into the canal itself.

Should a person become trapped in the syphon during flood flows there would be very little chance of escape. There was therefore a clear reason to install a screen at this location.

### 1.3 Decision Process

The screen formed an integral part of the flood alleviation scheme, which went through a formal project appraisal and design process. Planning permission was required for the installation.

### 1.4 Consultation

Consultation was undertaken as part of the flood alleviation scheme. It is not known if the screen was highlighted as a particular issue.

## 2 DESIGN

### 2.1 The Designer

The designer of the flood alleviation scheme was a river engineering consultant who was also responsible for part of the trash screen installation. However, a sub-contractor and supplier designed the mechanical clearance system, and upstream section of the screen.

The sub-contractor was well known as an expert in the field of pumping station screens and the installation is therefore one that would normally be associated with pumping stations.

### 2.2 Design Parameters

The parameters used to establish the design are not known and it is believed that no particular guidance on trash screen size was used. The flood alleviation scheme itself considered, in detail, the hydrology and hydraulics of the proposals.

### 2.3 Screen Area

The total screen area is approximately 60m<sup>2</sup>. The twin syphon area is 16.82m<sup>2</sup>.

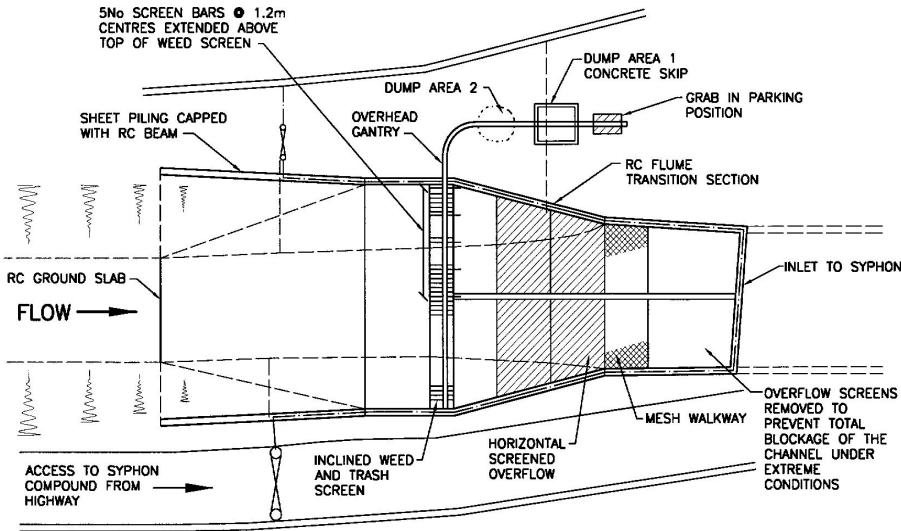


Figure 2.3 Screen Layout

The screen face is some 29m<sup>2</sup> and set at an angle of 73 degrees to the horizontal. The plan above shows the horizontal layout of the screen, which is regarded as the overflow area. (*Manual, Section 3.3.4 details screen sizing*).

It is not known how the screen area was actually derived, however it is, in total, over three times the culvert area. This would comply with the Interim Guidance Note requirement if small trash amounts were to be expected at this site.

## 2.4 Particular Features

To the rear of the screen and across the flume channel there exists a horizontal screened overflow grill and a removable open mesh walkway. The flume channel has been left uncovered to the rear, between the walkway and the entrance to the syphon culverts. This is to ensure the flow of water and small debris during extreme flood conditions which could otherwise lead to complete blockage of the screen and screened overflow, resulting in flooding upstream of the site.



**Figure 2.4 View on the horizontal screen area looking downstream.  
Note that the area at the rear is now open.**

## 2.5 Access Arrangements

Access to the screen is straightforward and consists of a narrow vehicular path/lane some 200m in length along the upstream right bank of the river from the public highway in central Nottingham. The access leads into a relatively large site compound. During extreme conditions this can become flooded which may hinder access to and from the site. (*Manual, Section 3.4.1 provides guidance on access arrangements*).

The access route is constrained between the river and local housing.



**Figure 2.5 View on the screen from the access road, up-stream, note the gantry arrangement. Also note the security fencing to prevent access to the screen compound and moving plant.**

### **3.0 OPERATION**

#### **3.1 Development**

The clearance of the screen is outside the recommendations of the IGN, (Interim Guidance Notes), in so much as the mode of clearance is by a mechanically operated grab suspended from an overhead gantry.

The system is based on weed screen clearance at pumping stations with the addition of a large horizontal area behind to provide an increased effective area to the screen.

A telemetry system records the water levels upstream and downstream of the screen and automatically triggers the grab cleaning cycle following a differential reading of 0.5 metres. The grab can also be operated manually from location on site. In the event that the system registers a fault or power failure occurs, the screen has to be cleaned manually. This is a particularly hazardous operation and a careful, assessment of flow conditions are required before operatives venture anywhere near the screen.



**Figure 3.1 The extended guide bars are clearly visible here as is the ultrasonic level gauge near the bottom of the gantry pots.**

### **3.2 Clearance Process**

As mentioned above the weed screen is cleaned automatically by grab suspended from an overhead gantry system. The control system for the automatic grab is located in a secure brick control building, and contains 3 No. operational settings and 3 No. dumping settings. The operational settings control the cleaning cycle of the screen and not the triggering mechanism.

For any particular operational setting the grab will be triggered automatically twice a day and will carry out a full cleaning cycle relevant to the particular chosen setting. During times of weed build up or heavy rainfall the grab will again be automatically triggered following a differential reading of 0.5 metres between upstream and downstream water levels. During this time the grab will continue to carryout full cleaning cycles for a particular setting until such a time as the differential falls below 0.5 metres. The three operational settings are as follows:

- 1) Extended Screen Bar Cycle. Cycle consists of a cleaning run across half of the screen, closest to the dumping area.
- 2) Full Screen Cycle consists of a cleaning run across the full width of the screen.
- 3) Extended Screen Bar and Cycle consists of a cleaning run across half Full Screen Cycle of the screen closest to the dumping area, followed by a cleaning run across the full width of the screen.

Agency operations personnel have stated that they favour setting No. 3. This is mainly because a full screen cycle takes a considerable length of time to complete and during big events weed will build up quickly. With setting No. 3 one half of the screen is cleaned twice as often as the other preventing a build up of debris/weed along that section of the screen. During particularly extreme events this cycle setting may also prove inefficient and at such times operation staff manually operate the grab in order to concentrate even more specifically on the region of the screen closest to the dumping area or to remove large obstructions from the screen.

The dump setting controls the location at which the grab releases the debris and weed to await removal from site. The 3 No. dump settings are as follows:

- 1) Dump 1 - concrete skip.
- 2) Dump 2 - area of hardstanding adjacent to the concrete skip.
- 3) Dump 1 and 2 - Both of the above.

The location of each of the dump sites is shown on the general arrangement plan.

### **3.3 Response Procedures**

A set of documented emergency response procedures exists for the River Leen and the Leen Syphon weed screen. These procedures must be undertaken in response to activated alarms which are triggered by the telemetry system on site. The alarms may activate for a number of reasons which include:

- High River Levels (>2m, Amber; >2.9m, Red)

- High screen water differential (>0.5m, Red)
- Automatic weedscreen system failure/fault (Red)
- Site mains power failure (Red)

In each case the Flood Defence Duty Personnel must be called out to site and the appropriate responses undertaken for the particular alarm activated.

As an example the following set of responses are documented in relation to the alarm for a high screen water differential:

- Ensure that the auto-weed screen cleaner is operating correctly and auto set on full and ½ cycle (No. 3)
- Check grab is not propped open by debris
- Operate manually if grab performance is inadequate to reduce levels
- Check debris bins are not overfull and there is spare capacity
- Change to No. 2 dump area if necessary.

Recorded call-outs to this site per year are on average very infrequent, at some 2 or 3 times.

There is a log book held on site and weekly visits ensure that the condition of the installation are well known to the operators. It is not known what formal reporting procedures exist within the Agency for addressing any problems found during visits.

#### **4.0 MAINTENANCE**

##### **4.1 Inspections**

The mechanical equipment requires regular maintenance and written procedures exist for this work.

#### **5.0 PERFORMANCE**

##### **5.1 Flood Events**

During flood events in July and August 1992 serious failings in the original design were brought to light and subsequently a number of modifications had to be made.



**Figure 5.1 Flooding drowned out the installation. Panels in the horizontal platform had to be removed.**

- A new screen with wider bar spacing
- The removal of two horizontal screened overflow panels to the rear of the screen between the open mesh walkway and the entrance to the syphon culverts.
- Installation of a new heavier grab.
- The extension of a number of the weed screen bars above the top of the screen, over half of the screen closest to the dumping ground.

The following problems with the original screen were noted during this event and prompted the above changes.

- 1) The weed screen was found to block very quickly beyond the capabilities of the automatic cleaner, resulting in a rapid build up of water level in the upstream channel. This was considered to be due to the fine bar spacing which prevented the passage of very fine flood debris. Whilst screens of this nature are required to prevent the blockage of culverts by a build up of debris, it is acceptable to allow fine debris to pass as this is unlikely to cause a blockage in the culvert without the aid of larger obstructions. This problem was addressed by replacing the original screen with a new one, containing wider bar spacing.
- 2) Following complete blockage of the front of the weed screen, water and debris began to flow over the screen and onto the overflow grills behind. Initially water was successfully able to flow through these grills, however as more debris built up on the surface of these grills the passage of water was increasingly impeded resulting in a further increase in water levels upstream.

Operating staff realised this to be a significant problem during the July 1992 event and removed the rear two overflow panels, close to the culvert, to prevent further build up of debris and hence total blockage of the screen. It was therefore considered that to alleviate this problem in the future these panels should not be replaced.

- 3) The original grab was noted to be incapable of coping with the flood and debris conditions. The grab was not capable of penetrating the dense weed build up on the screen but instead would hit the weed and fall away from the screen resulting in little to no removal of debris. It is considered that this problem was an additional factor in the rapid build up of weed on the trash screen. In addition to this as the debris and water levels built up to the top of the screen the grab was noted to be washed over the screen by the high water velocities, further impeding the removal of debris.

This problem was addressed by two modifications. Firstly the existing grab was replaced by a larger heavier grab, to assist in penetration of the weed and give greater resistance to river flow. Secondly a number of the raked bars on the new weed screen were extended above the top level of the screen over half of the screen close to the dumping ground. These extended bars were spaced along the screen such that two are located behind the grab at each of its drop positions for the cleaning cycle No. 1. It was considered that these bars would prevent the grab from being washed over the screen during times of high flow and in effect guide the grab to its required cleaning position.

## 5.2 Mechanical Grab System

On numerous occasions the automatic grab “trips out” and the overall control system registers a fault for which an alarm is activated and Agency staff are called out. There are a number of reasons why the grab “trips out”, or the system registers a fault. Some of them can be addressed and others simply require regular maintenance to limit the frequency and severity of the problems. By the term “trips out” we simply mean inoperable. The following are reasons why the grab has, or might “trip out”.

On occasions the grab has overrun or skidded past the end sensor on the gantry that indicates its parking position. This results in a fault registering on the system that requires re-setting on site before the grab will work automatically again. This problem is noted to occur more frequently during wet, foggy or frosty conditions. The overall system works on a series of magnets which seem to be affected during these times.

In addition during cleaning operations, the grab can become covered with weed which adds substantially to the overall weight. The operations staff consider this to be an additional factor which could result in it skidding during wet conditions.

Removal of heavy objects off the screen has resulted in the grab becoming inoperable. Under such circumstances the grab tends to breakdown over the screen leaving retrieval extremely difficult. This usually requires bringing a mobile crane /excavator to site for removal purposes. This is time consuming and could prove severe in terms of flooding, as it is most likely that the grab will experience this problem during flooding conditions when large debris can be transported within the river system. Records indicate that on one occasion the grab broke down while trying to remove a fridge.

On a number of occasions one of the cables, by which the grab is lowered, has snapped leaving the grab hanging by one cable. When a cable breaks the whole grab and carriage system becomes inoperable. As with heavy loads, this usually occurs over the screen and requires mobilising plant to site such that it can be retrieved and repaired. The operations staff suggest this is down to general wear and tear rather than the removal of a heavy load, although it is more likely to occur as a combination of both.



**Figure 5.2.1 The mechanical grab has to run on guides that come above the screen area. Originally, these were not in place.**



**Figure 5.2.2 Grab in operation during high flow.**



As stated earlier, one modification was undertaken in 1992. This was the extension of raked bars on the screen to guide the grab into position during high flows.

Despite this modification problems still occur with the grab becoming caught on the concrete plinth to which the screen is fixed. High water levels and strong currents cause the grab to tilt as it enters the water, which pushes the back teeth over the plinth. As a consequence the grab cannot be lowered successfully to remove trapped weed. Operations staff have on occasions physically guided the grab to prevent this from happening. This in itself gives rise to a number of health and safety issues.

Should the site mains power fail, there is at present no on site back up facilities. Should a power failure coincide with a critical flood event, then rapid blockage of the screen could occur, followed by extensive flooding. As part of the emergency response procedures, an alarm will activate should a power failure occur with the cause and likely duration being investigated with the East Midlands Electricity Board. In order to prevent a lengthy duration of failure at critical times it would be prudent to provide facilities for connecting a mobile generator to supply 415V 3ph 50 Hz Motor Power 0.75 kw.