

Feasibility Study on Rehabilitation of Yuen Long Nullahs in Hong Kong

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Annotation

This paper presents the Study on rehabilitation and water quality improvements to an urban nullah in Hong Kong. Yuen Long nullahs are about 12km long with sizes ranging from 7 to 70m wide and 3 to 4m deep. Local residents have expressed increasing aspirations for a better environment associated with this concrete lined nullah, as well as resolution of the odour issues resulting from illegal discharges. The purpose of the Study is to examine various options and produce specific proposals to make the best use of both the nullahs and the space they occupy by developing them as local amenities or other uses more beneficial to the community. The biggest challenge for rehabilitating the nullahs is to address constraints such as maintaining the flood protection standard, improving water quality, ensuring an adequate quantity and quality of scenic water, and concerns for public safety. These constraints need to be balanced against the local aspirations, project cost, and programme for implementing the works. Taking into consideration the above factors, a strategy to improve the nullahs has been developed.

Keywords

Rehabilitation, Drainage Capacity, Flood Protection, Scenic Water, Water Quality, Hydraulic Modelling, Minimum Baseflow

INTRODUCTION

The nullahs in Yuen Long Town are part of the oldest drainage systems in the territory, constructed in the early 1960's to alleviate flooding. Many of the nullahs originated from natural watercourses, which over the years have been straightened and provided with concrete beds and walls. Figure 1 shows the Yuen Long Town nullahs.

As the Yuen Long Town has developed and urbanised, the nullahs have increasingly become polluted by expedient connections, urban runoff, and rural runoff from farms upstream. In addition, drainage improvements such as Yuen Long Bypass Floodway project have diverted part of the flow from the upper catchment, leaving some parts of the nullahs with minimal baseflow.

Local residents and the District Council have increasingly requested that the nullahs be rehabilitated to improve the local environment, enhance the ecology of the watercourses, and reduce the nuisance caused by the baseflow. In addition, the nullahs represent an untapped resource where additional green space or recreational facilities could be provided in this densely urbanised community.

In view of this, Black & Veatch Hong Kong Ltd (B&V) was commissioned by the Drainage Services Department (DSD) of the Government of the HKSAR in January 2007 to carry out a feasibility study of the Project, "Rehabilitation of Yuen Long Town Nullahs". The purpose of the Study is to examine various options and produce specific proposals to make the best use of both the nullahs and the space they occupy by developing them as local amenities or other uses more beneficial to the community. The proposals must also take into account the existing constraints, as well as planned and committed developments adjacent to the nullahs.

The biggest challenge for rehabilitating the nullahs is to address constraints such as maintaining the flood protection standard, improving water quality, identifying a source of scenic water, ensuring an adequate quantity and quality of scenic water, and concerns for public safety. These constraints need

to be addressed with respect to the local aspirations, project cost, and programme for implementing the works.

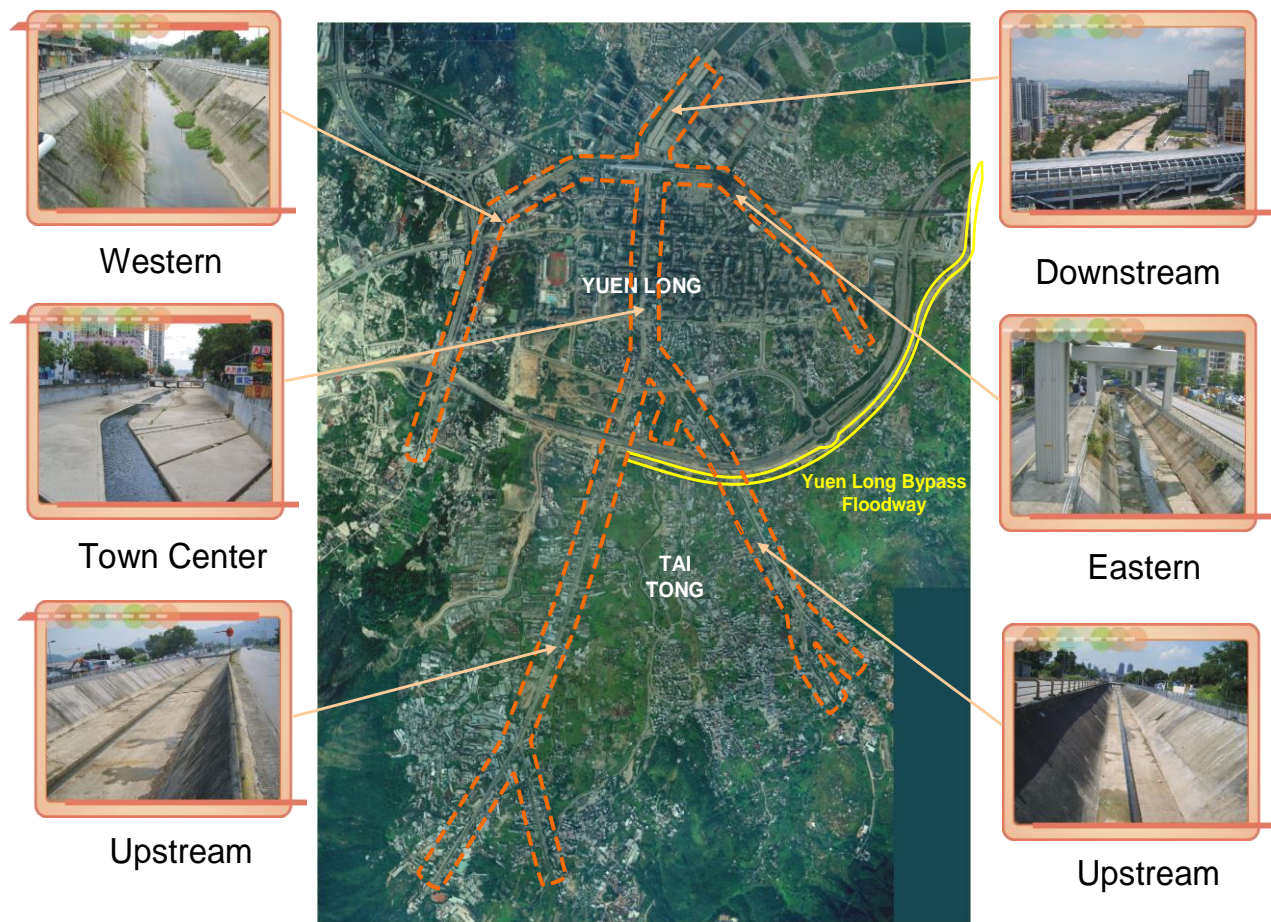


Figure 1 – Yuen Long Town nullahs at present

Taking into consideration the above factors, the strategy to beautify and improve the nullahs has been developed on the basis of maintaining the nullahs' flood protection requirement, while enhancing the landscape, recreation and ecological functions and improving the water quality.

INVESTIGATIONS

Background

The Study was undertaken in two key phases. With a first phase focused on understanding the nature and conditions of the nullahs and a second phase focused on determining appropriate options which could rehabilitate the nullahs while addressing the various constraints. Up-to-date information in connection with this Study and data from other studies were collected, including those on drainage improvement works, past flooding records, existing utility installations, existing land status, planned land use, and on-going and proposed projects in the vicinity of the Yuen Long nullahs. This phase included an extensive review of data and literature including previous water quality studies, expedient connection studies, and reviews of water quality objectives.

In addition, a number of investigations were undertaken during this phase to assess the hydraulic performance of the nullahs and the nature and extent of the pollution problem. These surveys included flow surveys, CCTV and man-entry surveys, and water quality surveys. Pilot trials of a

number of potential remediation options were also undertaken to understand the effectiveness of each option in dealing with the pollution and resultant odour issues in the Yuen Long nullahs.

Definition of the problem also required a programme of consultation with the local community and stakeholders to ensure that the rehabilitation of the nullah would address their concerns and was consistent with their aspirations for the area.

Public Aspirations and Public Safety

Since the nullahs in Yuen Long Town run through the town centre and are an important feature to local residents, it is important to recognize and understand the aspirations and requirements of these stakeholders. Other stakeholder groups such as the local District Councillors, green advocacy groups, and local universities were also consulted. A series of public consultation activities were undertaken with stakeholders to collect their views and opinions.

The public expressed four major areas of concern and provided a number of suggested options for dealing with these areas of concern, including: water quality, flood protection, enhancement of public amenities and recreational areas, and improvement of aesthetics.

Suggestions for improvements to water quality such as decking of the nullahs to conceal the existing pollution and provide additional surface area for public amenities; diversion and treatment of the polluted waters; and treating pollution at source were proposed.

For flood defence, the stakeholders expressed the need to maintain the existing standard of flood protection. Recognising that decking of the nullahs or rehabilitation schemes within the nullahs would impact on the drainage capacity of the nullah, the stakeholders suggested options such as widening and deepening the nullah channel, raising the height of the nullah walls, and rehabilitating a diversion channel to discharge overflows directly into Deep Bay.

For the enhancement of public amenities and recreational areas, there were two options proposed. The local community expressed a desire for decking of the nullahs to provide areas for public amenities as well as additional space to expand congested roads and walkways. Another option, supported by the green groups, was to naturalize and green the nullahs to provide recreational space and enhance the aquatic habitats.

As the Yuen Long nullahs are in the heart of the town centre, its rehabilitation is a critical element in revitalizing the surrounding environment. Suggestions on improving the aesthetics included removing existing overpasses and reconstructing roads and walkways at grade, and greening and naturalizing the nullahs. The Cheonggyecheon Stream Restoration Project in Seoul was cited as an example.

These suggestions had to be balanced against the need for public safety. The key aspects of public safety which needed to be investigated were public contact with the water and the risks associated with sudden flooding during Hong Kong's intense rainstorms. The investigations concluded that the rehabilitation options should limit the public access into the nullahs and public contact with water.

Flood Protection

As noted by the public consultation exercise, a key aim was to ensure that the current standard of flood protection was maintained. To this end, hydraulic modelling of the watercourses was undertaken to establish the current standard of flood protection and the impact of the various rehabilitation options. Hydraulic modelling required careful consideration of the fluvial-tidal interactions within the Yuen Long basin.

The current nullahs are mainly constructed with concrete, which has a low hydraulic roughness coefficient. If the current nullah channel is transformed into a landscaped area, the hydraulic roughness would increase and therefore the drainage capacity would be greatly reduced. The hydraulic modelling indicated that while in some sections there was scope for naturalizing and greening the nullah, however -in the town centre section, the current flow capacity needed to be maintained. As this area is densely developed and is under tidal influence, there is very little scope to either widen or deepen this section. The construction of walkways above the nullahs could also greatly reduce the drainage capacity of the nullahs, as these would restrict the runoff flow path.

Water Quality

The current water quality in the whole of the Yuen Long nullahs is known to be unsatisfactory. In addition to the odour concern from the public, results of water quality tests and audits of upstream farms have shown that the water quality fails to meet the minimum standards set by the government for amenity purposes. To further understand the nature of the problem, this Study included investigations to determine the sources of the pollution and to define the chemical and biological contamination of the water.

To determine the sources of the expedient connections and to assess their structural condition, CCTV and man-entry surveys were carried out under dry weather conditions. From the results, a total of 17 manholes were suspected as possible pollution sources within the survey boundary.

Water quality surveys were undertaken to better characterise the nature of the problem. Various in-situ and laboratory test parameters, including Dissolved Oxygen (DO), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), E.coli and Chemical Oxygen Demand (COD) were measured and evaluated. The survey result indicated that the water quality conditions varied between fair and very poor, with the better water quality associated with the Upstream and Western nullah sections and the poorer water quality through the Town Centre and Downstream. In general, the water quality did not meet established criteria for human contact.

The livestock farms and expedient connections were found to be the major contributing sources of this water quality problem. Based on these findings, it was determined that the water quality improvement options should be targeted to those areas which most contributed to the pollution of the watercourses. In addition, the rehabilitation solutions should restrict human contact with the untreated water within the nullahs.

Enhancing water quality is one of the most important considerations which will lead to the success of the rehabilitation works. Therefore, various pilot trials for enhancement of the water quality in Yuen Long nullahs were carried out during the course of the Study for evaluation of possible treatment/mitigation measures. These trial works included:

- In-situ filters;
- mitigation for expedient connections;
- Bioremediation;
- artificial rip-rap at nullah base;
- Constructed Rapid Infiltration™ (CRI) system.

The applicability and constraints for each type of pilot trial option is summarized in Table 1. The trial options were evaluated based on their effectiveness at removing pollutants, cost effectiveness, maintenance requirements and required time for implementation. By comparing the pollutant removal results with other pilot trials, the diversion and subsequent treatment of expedient

connection (i.e. mitigation for expedient connections) were the most effective measure to reduce pollutant load through the Town Centre Section and into downstream receiving catchments.

By diverting the expedient connections, the removal rate of TSS, BOD, COD, nutrients (Total Nitrogen (TN) and Total Phosphorous (TP)), and E. coli was 69%, 66%, 65%, 51%-55% and 55% respectively. The analysis was carried out during the dry season, when the influent water quality and pollutant load were very stable.

| Option | Implications | |
|--|---|--|
| | Applicability | Constraints |
| Bioremediation | Satisfactory in BOD, COD, TP and TN removal. | Effectiveness greatly affected by quality of inlet water; difficult removal if base flow water quality was bad. |
| CRI | Extra land not needed for trial size; can be adopted with other system such as artificial wetland; relatively low cost for construction & operation than traditional system. | Requires power supply and great manpower input for maintenance. |
| In-situ Filter | Reasonable performance in the removal of TSS, BOD and COD; no extra land required; relatively low cost for construction; no need of power supply. | Recurring cost may be high for the frequently desilting; limited effectiveness for removal of organic pollutants and tiny particles. |
| Rip-Rap | System performance could be more effective with absence of livestock wastes and obstacles. | Effectiveness and performance greatly affected by presence of livestock wastes and rubbish; limited water quality (e.g. increase of DO) improvement shown by trial works. |
| Expedient Connection Mitigation | Effective as a preventive measure to prevent illegal discharges and pollutions into the nullahs; short time for construction and simplicity for monitoring; low social and environmental impact; improvement can be readily observed. | Cannot be used to remove pollutants already in the base flow; expensive if no existing sewage system nearby; land resumption and long implementation time maybe required if new sewerage system construction are required. |

Table 1 – Summary of Pilot Trial Options

Scenic Water

Key to the successful implementation of improving/beautifying the nullah is the availability of good quality clean scenic water resources to provide a minimum baseflow within the nullahs. To ensure an aesthetically attractive view, sufficient water flow must be maintained within the nullahs at all times. The Study therefore looked at identifying appropriate sources for this water and identifying the necessary quantity of water required to achieve this aim. The quantity of this scenic water was determined through literature review and hydraulic modelling. An estimated water depth of about 100 to 300mm along the low flow channel of the rehabilitated nullahs was determined to meet the aesthetic and environmental requirements. This equates to a minimum steady supply requirement of 8,000 m³/day.

RESULTS AND DISCUSSION

Based on the results of the first phase investigations, a clearer understanding of the nature of the problem was established and appropriate options which balanced the various constraints and aspirations for the rehabilitation of the nullahs were defined. The possible impacts brought by the proposed rehabilitation works were analyzed and assessment reports were issued accordingly. These assessment reports include a Flood Risk Assessment Report, Environmental Review, Preliminary Geotechnical Appraisal, Traffic Review, and Land Requirement Report.

The primary options investigated included naturalizing and greening the nullah, providing decking over all or part of the nullah with localised landscaping improvements. Some of the options for

rehabilitating the nullah were shown to reduce the flow capacity of the nullah, such as landscaping within the nullah. As such, extensive hydraulic modelling was undertaken to assess the feasibility of options which would enable these options to be pursued and maintain the existing flood protection standard to Yuen Long Town. These options included constructing an upstream storage reservoir, widening the flood drainage waterway, and diverting the excess flood water to the Yuen Long Bypass Floodway. However these options were shown to be either not technically feasible or very costly and would require major construction works. As such, it was identified that the proposed scheme should avoid excessive landscaping changes within those sections where there was insufficient drainage capacity.

The Environmental Assessment investigated a number of options to address the water quality issues and associated odour concern. These included various in-situ and off-site options such as sewage interceptors, on-site sewage treatment, construction of a wetland, and evaluation of the various pilot trial options. While the most effective method of dealing with the pollution would be to treat it at source, it was recognised that this could not be achieved within ~~the required project a reasonable~~ timeframescales. As such, the most cost effective and timely method was determined to intercept the expedient connection and divert the polluted flow to the Yuen Long Sewage Treatment Works (YLSTW) for treatment. This option in conjunction with providing a new source of water to ensure a minimum baseflow would reduce the pollutant load within the Yuen Long nullahs and downstream waters.

The key to the successful implementation of improving/beautifying the nullah is the availability of a minimum baseflow for environmental improvement and to provide a scenic watercourse. Various possible scenic water sources were considered. Three options were considered to be most viable in consideration of the quantity provided and maintenance required. These options were: utilization of effluent treated from the existing YLSTW; utilization of effluent treated by a proposed on-site treatment plant built next to Yuen Long Highway; and installation of a stormwater re-circulation system along the Town Centre Section with a wetland built next to Yuen Long Highway.

The plan area of both the on-site treatment plant in Option (ii) and wetland in option (iii) above are 15,000m² each. It undoubtedly poses a drawback as the land resumption and clearance of temporary structures is a very costly and time-consuming process. On the other hand, for the option of using effluent from YLSTW requires relatively small structures which would not require any land resumption. These structures include a pumping station within the YLSTW and a treated effluent storage tank upstream of the Town Centre section. The current effluent flow rate from the YLSTW is in excess of 15,000m³/day and is expected to increase as additional areas are to be connected to the plant. As such, the plant can provide the estimated 8,000m³/day required for a minimum baseflow for the rehabilitated nullah.

Yuen Long is a developing area with many areas undergoing further developments. The recommendations to beautify Yuen Long nullahs need to be matched with other developments in the area. The project options were therefore considered against other development proposals to minimise any conflicts. With the developments of the region, and the continuous growth of traffic in Yuen Long Town, the option selected must also recognise that effort should be made to seek opportunities for expansion of the existing roadway or building new roadways to alleviate the burden on the existing road network. Proposals to beautify the nullah that combine traffic improvement measures will provide a more beneficial solution for Yuen Long residents.

After collecting and analyzing data on the various sections of the nullah and surrounding environment, rehabilitation proposals were drawn up for five sections of the Yuen Long nullah. The proposed solutions were adapted for each area to best meet the balance between constraints and

opportunities. The key features of the proposed solutions were discussed with and supported by the Yuen Long District Council and included: the interception of polluted flow at the Town Centre Section, treatment of this intercepted polluted flow prior to discharge, and the use of treated effluent to provide a minimum baseflow within the Town Centre nullah.

Town Centre Section

The main objective is to improve the water quality, resolve the odour concern and beautify this section of the nullah. The key components of the rehabilitation works included:

Dry Weather Flow Interceptors – Box culverts would be constructed along both sides of the nullah to intercept the dry weather flow (DWF) and convey it to the YLSTW for treatment. The maximum DWF to the YLSTW would be about 15,000 m³ per day, and the average flow would be about 10,000m³/day.

Pumping Station for DWF – A new pumping station would be constructed at a site in the Yuen Long industrial area adjacent to Shan Pui Chung Hau Tsuen to transfer the DWF to the YLSTW.

Pumping Station at YLSTW – A new pumping station would be constructed within the existing YLSTW to pump treated effluent via rising mains to a storage compound to the south of Yuen Long.

Effluent Storage Compound – A storage compound would be constructed at Kiu Hing Road adjacent to the area beneath Yuen Long Highway.

Beautification Works – The river course would be reconstructed to include deepening the bottom of the existing concrete nullah and constructing an 800m long, 5 to 10m wide channel with natural landscaping. The bottom of the nullah would be paved with pebble stones while small cascades, pebbles and rapid current would be provided. Other measures to beautify the nullah include building gently sloped lawns or orderly arrangement of quarry stones and art work such as murals and patterns on both the retaining wall and nullah bed. Figure 2 presents an indicative option for rehabilitating the town centre nullah.

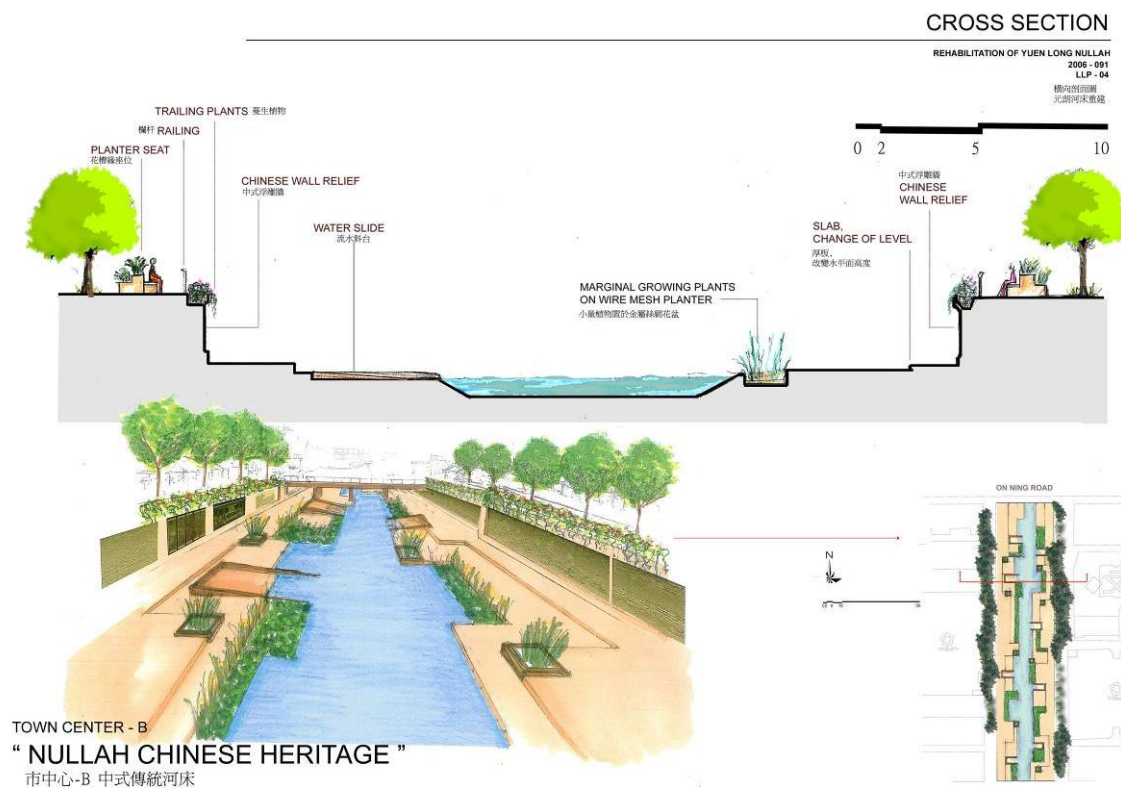


Figure 2 – Example of Rehabilitation Option for Town Centre

Downstream, Eastern and Western Sections

Along these sections, there are fewer constraints associated with flood risk and water quality. Accordingly, section of the river bed will be changed into straw bales or crushed stone and shallow

water ponds to enhance the natural scenery and restore the watercourse's ecosystem. Other sections will be transformed into green space, allowing greater public access while other areas will be decked to improve traffic conditions and increase landscaping area.

Comparison with Overseas Experience

As part of the Study, a literature review of 28 overseas rehabilitation projects and studies relevant to this Study was conducted. The three main categories of overseas experience reviewed included: (1) rehabilitation of deteriorated urban streams and drainage channels; (2) stormwater management approaches; and (3) recreation or beneficial use of water and drainage systems.

The overseas experience is similar to Hong Kong in that traditionally “hard” structural approaches have been used extensively for stream and stormwater management in the past. As more negative impacts associated with most traditional “hard” approaches have been identified, there is an increasing trend of using “soft” bioengineering approaches for stream restoration and stormwater management. While the overseas experience does have some applicability to the rehabilitation of the nullahs in Yuen Long, it is important to keep in mind that local, site specific constraints must be taken into consideration when determining the most appropriate solution. Nevertheless, the experience to date from Yuen Long and from review of these overseas cases points to some common key criteria for the success of a rehabilitation project. These include:

- **Define project goals, objectives and priorities early on based on parameters such as funding availability, public opinion, local regulations and land availability.** This will help to formulate a project scope suitable to the site. In addition, some project scopes may need to be scaled down to correspond with what is achievable in the short term, and then followed up in the future to achieve the full restoration potential at the site.
- **Understand the importance of early planning.** It is important to take advantage of study, modelling or pilot testing prior to implementation if possible.
- **Consider and manage public and stakeholders inputs.** A well planned public consultation and education program or strategy is a critical element for success.
- **Understand local constraints to the project.** For example, physical (e.g. channel alignment) and hydraulic characteristics (e.g. storm frequency, climate) are specific to the location. Political and local government regulations also vary from location to location, which may pose constraints on one project but not on another.
- **Post-project and continual monitoring and maintenance are important elements for long term success.**
- **The value of a project may be more than just an engineering solution.** Public education opportunities for protecting our environment from pollution and other damages are also of good value, as problem prevention is always the best solution.

CONCLUSIONS

The Study has indicated that rehabilitation of a nullah within a densely urbanised area is feasible, although there are a number of factors which need to be balanced against each other in order to develop an appropriate solution which is based on the following principles: sustainable water source; energy efficiency; increasing ecological value of the nullah; durability; minimum restriction to future development; and public aspiration. In deciding which option is the most appropriate, the costs of construction, operation and maintenance need to be consistent with the requirements for cost effectiveness and sustainable development.

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