Surface Water Management in Humanitarian Contexts

Practical guidance on surface water management & drainage for field practitioners

Version released 22nd January 2019

GUIDANCE BACKGROUND

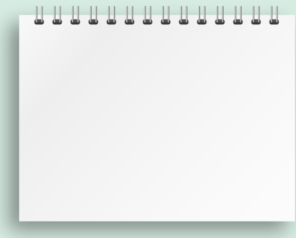
This project has been funded as part of the Humanitarian Innovation Fund's (HIF) 'Surface Water Drainage in Emergencies - Knowledge Access Challenge'. The project first undertook a scoping study in 2017 which identified the surface water management issues practitioners currently experience in the field. This insight was then used to deliver this guidance document. This project looks to align with HIF's overall Surface Water Challenge aims and fill a gap identified in the Gap Analysis in Emergency Water, Sanitation and Hygiene Promotion report.

This project is supported by Elhra's Humanitarian Innovation Fund programme, a grant making facility supporting organisations and individuals to identify, nurture and share innovative and scalable solutions to the most pressing challenges facing effective humanitarian assistance. The HIF is funded by aid from the UK Government and the Swedish International Development Agency (SIDA). Visit http://www.elhra.org for more information about Elhra's work to improve humanitarian outcomes through research, innovation and partnership.

INTERACTIVE PDF PRINTING RECOMMENDATIONS

This document has been designed to be primarily used as a pdf on a laptop or tablet. There are many interactive boxes so the document is best used as an interactive pdf. It may also be used on a smart phone or as a printed copy.

It is recommended that the document is printed landscape on A4 and bound at the top and may be printed double-sided (flip on long-edge).



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FEEDBACK LOOP

We need help to improve this guidance for future users:

- What aspects of this guidance, content and/or structure, could be improved?
- Do you have any innovative ideas about managing surface water in humanitarian contexts? Can you help develop what good looks like?
- Do you have any case-studies which you could share with us and the wider humanitarian community?

If yes, please get in touch through the following mechanisms:

Contact us on our dedicated email address:
drainage.camps@arup.com

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CONTENTS

ICONOGRAPHY

Information Boxes

- i Key information
- i Information management information
- ! Remember
- C Case study
- A Activity

Approx cost

- $ Low cost
- $$ Mid range cost
- $$$ High cost

Basic budget advice given as this varies significantly from site to site. Labour, materials and resources are considered throughout.

Techniques (see p.68)

Prevent, Use, Treat, Infiltrate, Store, Slow, Convey

GUIDANCE SUMMARY
HUMANITARIAN SURFACE WATER MANAGEMENT

WHY?

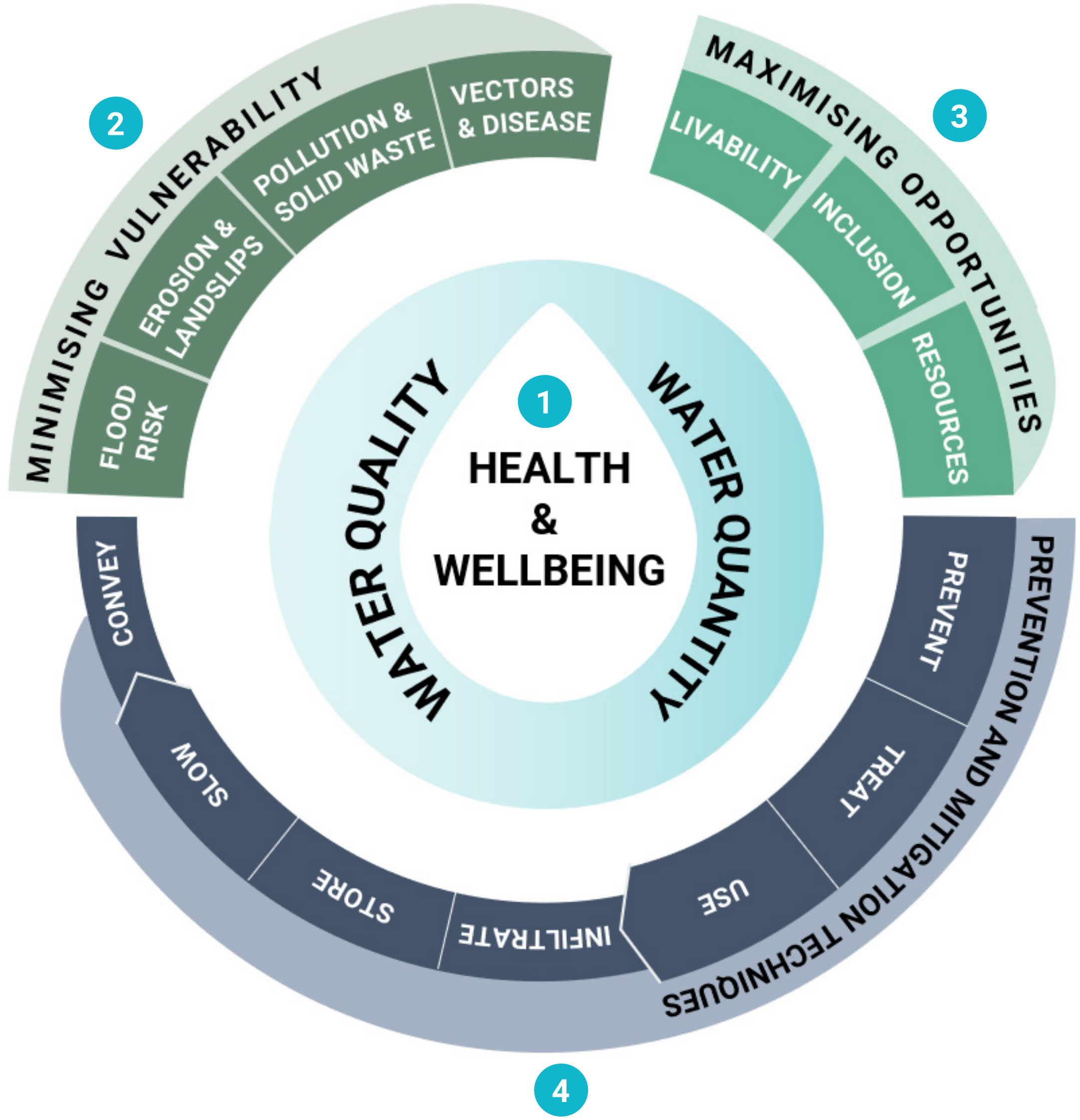
Appropriate and adequate surface water management is essential to humanitarian response. To date, there has been limited guidance available to practitioners summarised as follows:

- i Little information beyond basic assessment of flood risk and implications of standing water on a site.
- ii Limited guidance on surface water quality with most of the information focussing on the management of water quantity; and
- iii Few mitigation techniques and their suitable use have been widely publicised.

WHAT?

This guidance seeks to address this by:

1. Focussing the outcome of good surface water management on health and wellbeing of people and the environment, through considering both water quality and quantity;
2. Minimising a variety of closely linked vulnerabilities;
3. Maximising opportunities available, to provide wider benefits to each site; and
4. Promoting seven prevention and mitigation techniques to try to manage surface water as close as possible to the point where it enters the system whilst also considering the wider catchment. These seven techniques relate to eleven components listed in the guide.



GUIDANCE STAGES

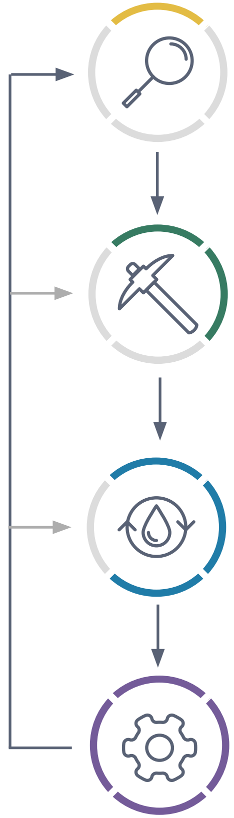
The main chapters of the guidance are are shown on this page. Readers may start at any point in the guidance. It is recommended that the guidance is used as follows:

1. All users should read the summary (p.4) and awareness section (p.6-13).
2. The guidance is not designed to be read chronologically users may start at any point and hyperlinks will redirect users to the most relevant sections.
3. Stages should be revisited during the development of a site to gain further information and adapt to changes in the site.

AWARENESS

Explains the key information relating to surface water management and cross-cutting aspects including stakeholder engagement, gender and vulnerable groups.

This section supports all the following sections.



SITE ASSESSMENT & PLANNING

Helps gather data and information to make appropriate decisions.

DESIGN & IMPLEMENTATION

Explains techniques and the design of components considering the site context.

OPERATE & MAINTAIN

Aids maintenance activities and day-to-day operation of surface water management.

REVIEW & ADJUST

Helps troubleshoot surface water management issues occurring in new or existing sites.

KEY INFORMATION

Surface water management has the potential to impact on all of the UN Sustainable Development Goals (SDGs) and is likely to have a direct impact on the targets highlighted (see right).

SDG	Targets
1	1.5
2	2.4
3	3.3
4	
5	
6	6.5 \ 6.6 6.a \ 6.b
7	
8	
9	9.1
10	
11	11.3
12	12.2
13	13.1
14	
15	15.1
16	
17	17.17

! REMEMBER - The management of surface water should be an **iterative process**. Although the chapters are arranged chronologically, as more information on the site is gained, previous parts may need to be revisited and repeated. Sites should ideally be managed pro-actively, starting from site assessment and planning rather than reactively starting at 'review and adjust'.

AWARENESS

WHY IS SURFACE WATER MANAGEMENT IMPORTANT?

If left unmanaged, surface water has the potential to significantly negatively impact everyone, affecting health and wellbeing, site and living conditions. If managed well, surface water can help create opportunities to improve safety and quality of life, see page 4.

> *"Everyone has the right to a standard of living adequate for the health and wellbeing"*
>
> [Universal Declaration of Human Rights 1948; Articles 25]

> *"Enhance people's safety, dignity and rights and avoid exposing them to further harm"*
>
> [Sphere Association, 2018]

WHO IS THE GUIDANCE AUDIENCE?

Many individuals and organisations have a role in supporting good surface water management. Therefore, this section has been written for a wide audience to support this. The main audiences that this guide is written for are as follows:

- **Primary audience -** The main audience for the guidance are international actors and local government staff with a lead role in camps/settlements, who have a technical/engineering focus and may be involved in Shelter, Site Planning and WASH. These staff are most likely to coordinate resources and stakeholders to achieve good surface water management.

- **Secondary audience -** National government and other agencies that have an oversight and budget responsibility. In some situations, namely where the international community takes a lead role in establishing camps, these personnel may be from organisations such as the UN and NGOs. Public health and environmental practitioners may also use the guidance.

In all situations, it is recommended that appropriately skilled and qualified personnel should be appointed to support the process.

WHERE IS THIS GUIDANCE APPLICABLE?

Typically in humanitarian contexts there has been limited resource and time available for surface water management. This guidance has been written to support appropriate management of surface water in refugee/internally displaced people (IDP) camps and settlements. The guidance intention is to both reduce negative impacts of surface water and promote sustainable surface water management in both new and retrofit situations. Although it is not the focus of the guidance, some of the information may also be used in other contexts, for example informal settlements and transit camps.

Some sites may be completely or partially unsuitable for supporting an adequate standard of living and avoiding exposure to further harm. Some sites, or areas of sites, may have significant surface water management challenges where steep slopes, impermeable ground, cross-contamination of surface waters and/or significant quantities of water make land use unsuitable due to risk of flooding, unstable ground and/or pollution. These sites would need to be rapidly declared unsuitable for humanitarian habitation in the short and medium term and highlighted to Government or UN planning officials, as making arrangements for new sites is invariably a complex undertaking.

For sites or part of sites that are suitable in the immediate or medium term, if left unmanaged, surface water still has the potential to cause physical harm, impact on the health and wellbeing of inhabitants and damage infrastructure.

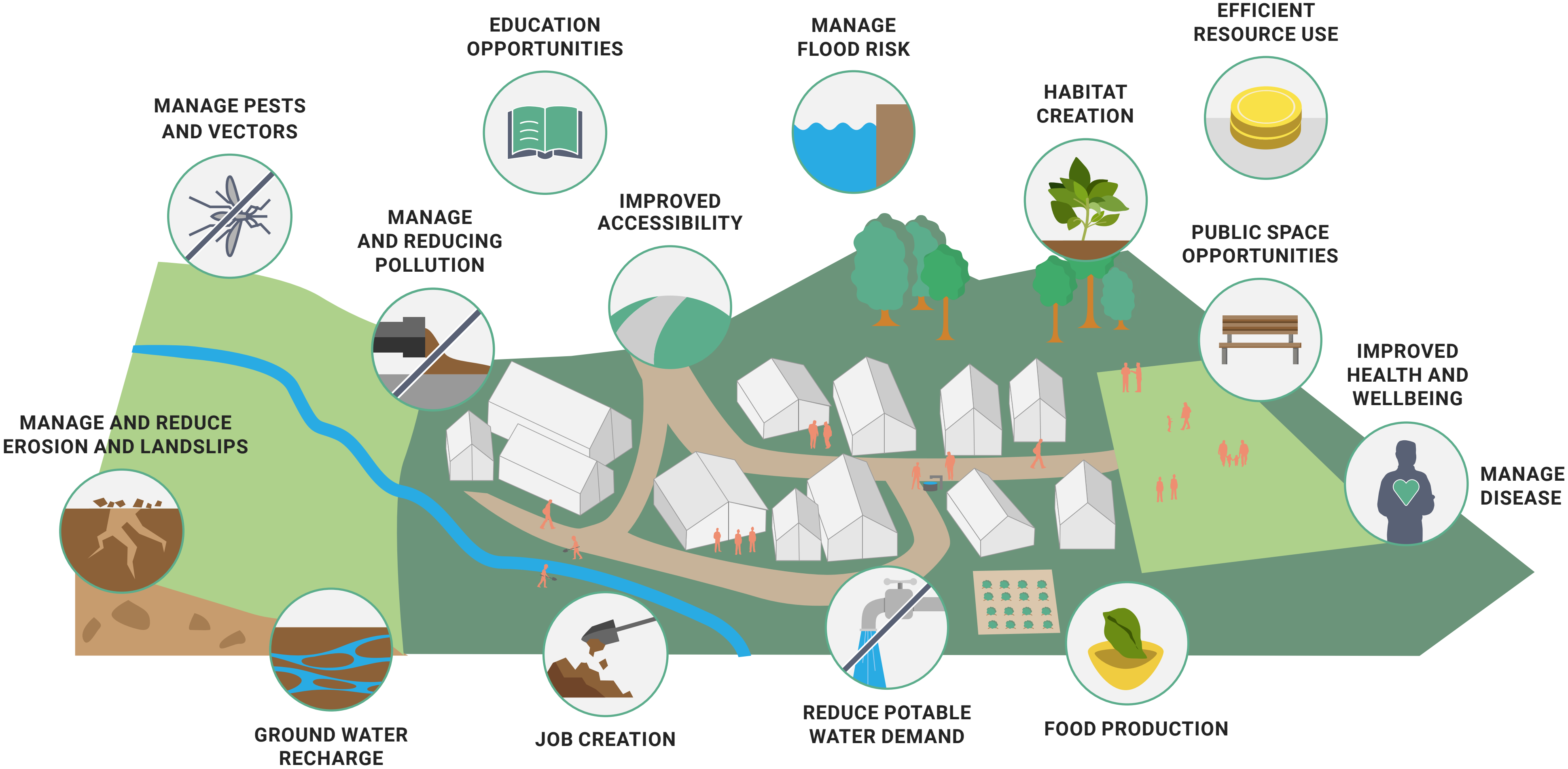
WHERE - GUIDANCE RELEVANCE AND ROLES IN DIFFERENT CONTEXTS

These classifications in the table below are based upon typical patterns and it is recognised that interventions and key actors may vary from place to place. This categorisation should not be considered predictive or prescriptive.

SITUATION/CONTEXT	EMERGENCY TYPE	SURFACE WATER MANAGEMENT INTERVENTIONS	KEY ACTORS AND STAKEHOLDERS RESPONSIBLE	RELEVANCE OF THIS GUIDANCE
A) Temporary displaced camp like situations, which may well evolve into medium, perhaps longer-term settlements where there is no immediate prospect of people affected returning to their homes for months or even years.	1. Conflict-related refugee and IDP responses for camp type situations. 2. Large-scale emergency e.g. tsunami, war, tidal surge and category 5 storms.	Construction of water management systems on a temporary basis. These are likely to require upgrading over months and even years. The prospect of upgrading to introduce permanency/ semi permanency will depend upon time people will remain, political will, and funds.	A mix of government and UN/Red Cross/ NGOs. Where government budgets and capacity are very limited, international actors often play a very significant role leading design, build and operation. Where there is a dedicated site /settlement capacity sector they will lead. In the absence of this it may fall between Shelter and WASH, and there can be gaps in roles, capacity and budget in such situations.	The guidelines are primarily targeted at these situations. Reference to the phases of emergency are made in the design section but it is expected that the entire process will be repeated and improved iteratively to better reflect the phase of emergency and contextual changes.
B) Situations in which people remain in situ in their house & settlements, and/or are displaced for days or a few weeks, such that any camps will not exist for long so emphasis will likely be on longer term in situ solutions.	1. Acute/widespread disease outbreak such as cholera, dengue, 'flu pandemics. 2. Cyclone, flooding, urban violence, droughts, de-development, chronic poverty/violence.	Surface water management will typically work with existing systems (whatever their limitations) and often focus on cleaning operations and minor repairs/upgrades to secure quick wins. Though perhaps less common, in some cases this may lead to work with local government actors and others to upgrade & redesign systems which should consider sustainable drainage. In all cases it is suggested that a site appraisal is completed to make sure that people do not remain in or are not placed in unsafe areas.	In urban areas, the municipality will play a strong role, even it is limited to oversight. There needs to be strong links with solid waste management actors, especially where cleaning operations are required. International actors typically play a complementary /supplementary role in support of local government.	The guidance has some applicability (particularly in the 'site assessment' and 'review and adjust' sections) but given its starting point is creation of new temporary systems and building from there, it may have limited applicability although the 'design and implementation' section may be a good starting point for considering sustainable surface water management approaches and drainage components.
C) Surge of displaced populations into pre-existing and somewhat functional settlements.	1. Conflict-related refugee, IDP responses, along with displacement due to natural disaster housing/settlement damage, with displaced populations dispersed within host populations, particularly in urban areas.	The pre-existing "permanent" surface water management systems may well have been inadequate before the crisis and will often be overloaded with the population surge through upgrading to cope with the surge. However, retrofitting where existing system capacity is exceeded may be complex. Work will therefore be predominantly based upon interventions for Category B.	See above for Category B.	See above for Category B.

WHY - HEALTH AND WELLBEING

Some of the benefits of good surface water management can be seen in the figure below. Benefits will vary from site-to-site and good stakeholder engagement is needed to maximise opportunities. Ultimately, by managing surface water quantity and quality, these benefits can all improve health, wellbeing and protection of people and the environment. These outcomes relate to the summary on page 4 and is summarised in the design criteria (management of flood risk, erosion and landslips, pollution and solid waste, disease and vectors, livability, inclusion and resources).

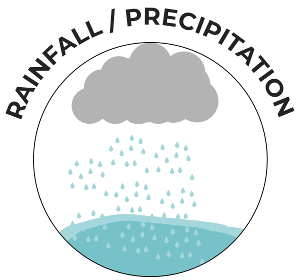


CONT.

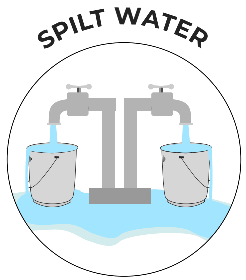
WATER QUALITY AND QUANTITY

Surface water management (see page 4) involves reducing the risks of flooding and ponding of water originating from runoff from the land, small watercourses, pipes and groundwater following periods of heavy rainfall/precipitation. This water should be characterised by both its water quantity (too little or too much water) and water quality (the chemical, physical and biologic characterists of water).

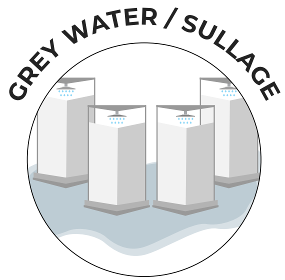
Pollution of surface water is frequent. Good surface water management allows water that lands on the ground to be used if the water quality is adequate helping to optimise water resources. Water quality can also be improved for the benefit of humans and the local ecosystem. In this guidance, rainwater, greywater and spilt water are considered to be the three main categories of surface water sources (see below).



Precipitation is any product of the condensation of atmospheric water vapour that falls under gravity this includes rain and snow.



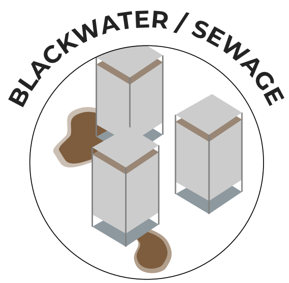
Clean/treated; water that might be spilt on the site Water that is accidentally spilt this could be at a tapstand, by a water truck.



Water that has been used for washing, bathing, laundry or cooking etc. and is contaminated but, unlike sewage (or black water), contains little faecal matter and solid waste; and has very low % or no faecal matter

BLACKWATER/ SEWAGE

Water that is polluted with a high proportion of faecal matter and solid waste. Blackwater management is not covered by this guidance, but it is recognised that keeping surface water and blackwater separate can be difficult, as misconnections, overflows and leaks occur . When this does occur, systems should be investigated to locate the cause of the issue and mitigation measures established (e.g. where appropriate, raising pit latrines slightly to avoid surface water entering the latrine and minimising open defecation).



KEY INFORMATION

WHY?
Greywater and spilt water are included in the definition of surface water as:

- it causes similar impacts
- it is often widespread
- the water often follows the same drainage route; and
- there is frequently a lack of separation at policy level.

WHAT IS DRAINAGE?
Drainage is part of surface water management. In this guidance, drainage refers to the structures or processes used to connect surface water from its source (for example rainfall) to a discharge point (for example groundwater, watercourse etc.).

REMEMBER

Surface water management does not include sewage or blackwater, which contains faecal matter. This is highly contaminated water and needs to be managed separately using different measures mostly by dry, on-plot facilities but this is beyond the scope of this guidance. For more information on this subject refer to SuSanA's Sanitation Library.

In some locations surface water may also come from **groundwater** through springs or saline intrusion. Further advice should be obtained if this is an issue on the site.

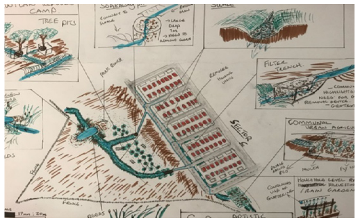
WHAT DOES GOOD SURFACE WATER MANAGEMENT LOOK LIKE?

C CASE STUDY - GAWILAN REFUGEE CAMP, DOHUK GOVERNORATE, IRAQ

The project intervention was designed to address surface water flooding in a micro-catchment as part of a pilot study into the efficacy of such systems in humanitarian settlements. The project takes an adaptive co-management approach, which is entirely participatory.

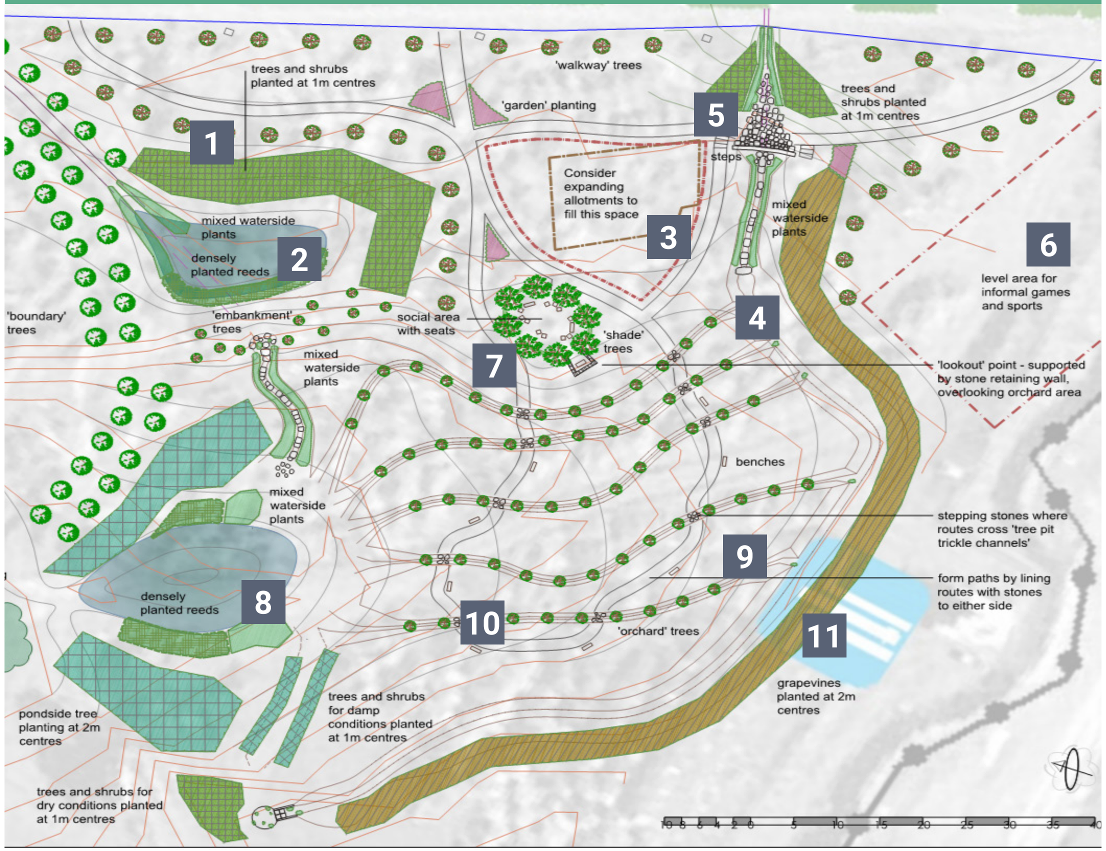
A participatory design and planning workshop was held with the SuDs management committee, from the sector nearest to the proposed intervention area. More information on *p.64*.

Site walkover with UNHCR WASH Associate, management and women from the SuDS community committee. camp. Site assessment information can be found on *page 65.*



More information on design, implementation, O&M on *page 66-67*.

PARK LANDSCAPE DESIGN



1. *Trees to stabilise steeper banks.*
2. *Pond/ wetland at the end of concrete greywater channel to address water quality issues.*
3. *Residents had already begun gardening - space for expansion.*
4. *Footpaths requested by the community with shade and stepping stones across channels.*
5. *Gravel/ aggregate 'broken pavement' to catch oil, fat and grease entering from concrete greywater channel. Periodic maintenance and cleaning required.*
6. *Recreation provision for sport, but could be used for temporary stormwater storage.*
7. *Community space requested by the residents for meetings etc.*
8. *Low lying wet areas left as ponds. Vegetation already present.*
9. *Community requested benches, these will have to be provided by the camp.*
10. *Tree pit trickle trenches to encourage water to infiltrate. Nutrients will be taken up by the trees- fruit trees could be used here.*
11. *More potential here to grow food, but also provide shade and greening.*

Case study information courtesy of the Centre for Agroecology, Water and Resilience Coventry University; Board of Relief and Humanitarian Affairs, Dohuk Governorate; UNHCR, Iraq; French Red Cross, Iraq; Lemon Tree Trust, Middle East Branch. The project was funded by the HIF.

STAKEHOLDER ENGAGEMENT

WHY?

It is important to consider how surface water management affects the different stakeholders and how stakeholders might be able to support activities on the site. As stated in Sphere Association (2018, p.109), it is important to 'establish an overall drainage plan in coordination with site planners, the shelter sector and/or municipal authorities.' By mapping and managing stakeholders, resources may be used more efficiently and an integrated approach achieved.

There are usually two distinct boundaries to humanitarian surface water management issues
i) the site boundary/ management system; and
ii) the catchment.

Water does not follow (i) the site boundary so catchment-wide information and stakeholders should be sought whilst remembering that infrastructure (e.g. roads/shelter drainage) may disrupt the natural catchment by directing runoff in or out.

STAKEHOLDER COLLABORATION

An activity should be undertaken to understand the different stakeholders local to the site (see right), this may need to be adapted to the context and local governance structure. A case study is shown on page 64. The activity aims are to:

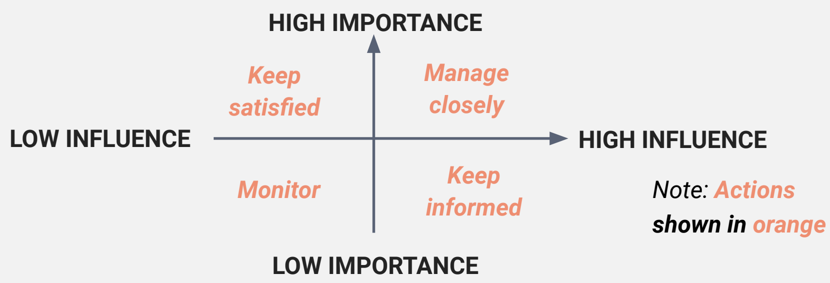
- Know which stakeholders relate to surface water locally and understand their skills, capacity and resources. Develop a coordination method if this is not happening through an established system.
- Understand where the gaps exist in the management of surface water and discuss who can fulfil this role and what the risks are if they are not managed (see risk management section).
- Think about when they need to be involved and, where required, how they may be empowered.

> *Close coordination and collaboration with other sectors and coordination with local authorities and other responding agencies helps ensure that needs are met, that efforts are not duplicated.* [Sphere Association, 2018 p.94]

A

ACTIVITY 1: BASIC STAKEHOLDER MAPPING
Identify stakeholders related to surface water. It is recommended stakeholders are identified first before prioritising them (see activity 2). Refer to the aims of the activity (see left) to improve the quality of the discussion.

ACTIVITY 2: BASIC PRIORITISATION OF STAKEHOLDERS
Classify them according to their importance and influence in surface water management and consider when they might be involved.



REMEMBER
Stakeholder engagement should be continued throughout the project. Working with stakeholders to understand the context may take time and not all of the activities listed on this page will be achieved concurrently. At the beginning of a crisis, surface water management may appear to be a long-term activity and therefore the affected population may be unwilling to engage if they think that they will be living in the site for a short time. Equally if stakeholders have not been or do not perceive to be impacted they may not take an interest. Further and advice on coordination should be sought for the context as this page contains basic advice. Additional guidance is given in: https://emergency.unhcr.org/ and CARE A Landscape Approach for DRR in 7 Steps'

COMMUNITY ENGAGEMENT

Adequate time should be allowed for the host community and affected population to participate in surface water management at all stages. The community are a key stakeholders for an integrated surface water management approach from participatory planning to reviewing/adjusting techniques.

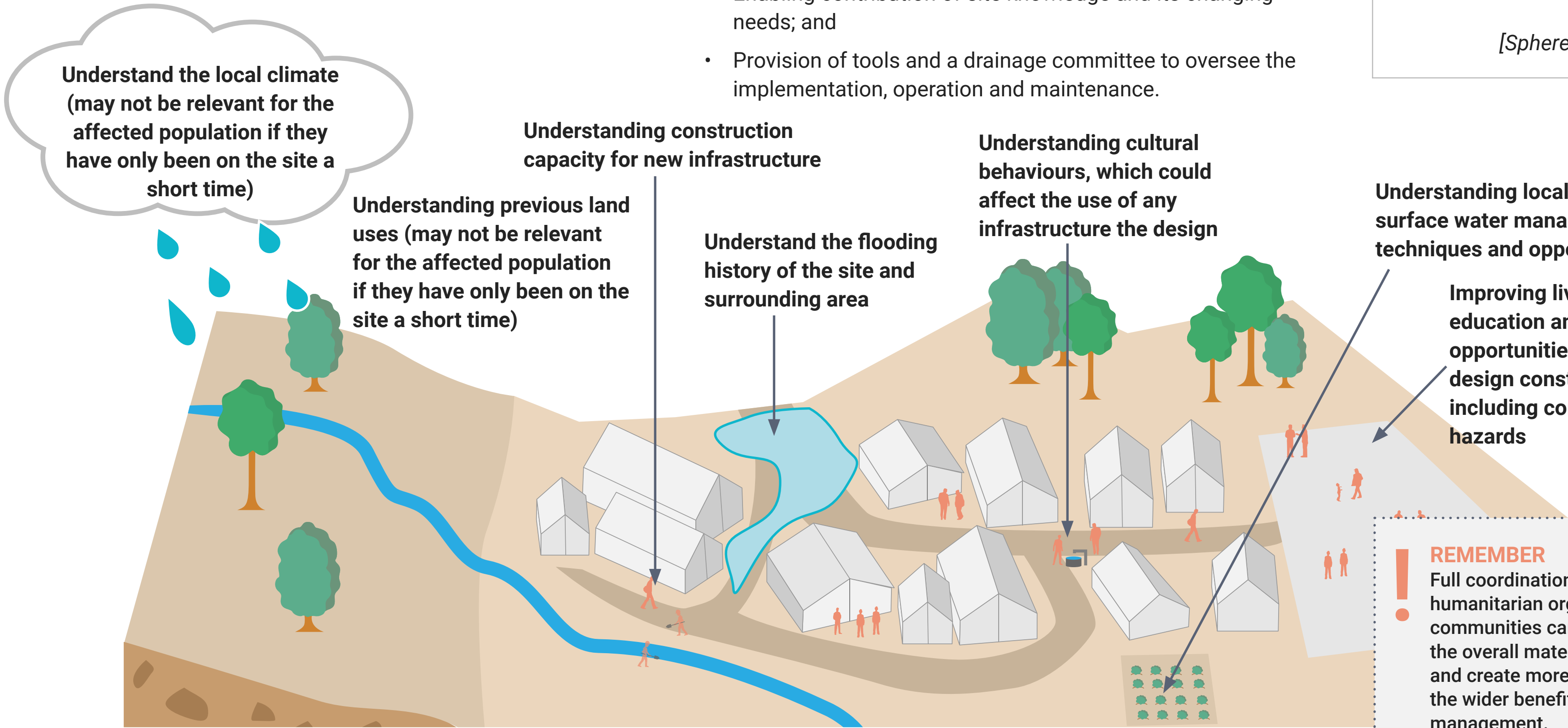
There are a number of benefits, in both the short and long-term that may be achieved through effective engagement with the host community and affected population, some of these are displayed below. The case study on p.10 is a good example of community engagement in practice.

ENGAGEMENT METHODS

Engagement methods are dependent on the surface water management activities and context. It is appreciated that engagement may vary from site to site and intermediaries may be needed. Initial ideas include:

- Workshops, education events and training programmes;
- Information sharing exercises;
- Enabling contribution of skills that may contribute to developing management of surface water on the site;
- Enabling contribution of site knowledge and its changing needs; and
- Provision of tools and a drainage committee to oversee the implementation, operation and maintenance.

> *Community engagement... is a dynamic process connecting the community and other stakeholders so that people have more control over the response and the impact it has on them. It goes beyond risk identification and needs assessments. Effective engagement links communities and response teams to maximise community influence to reduce public health risks, provide appropriate, accessible services, improve programme quality and establish accountability*
>
> *[Sphere Association, 2018]*



This page contains basic information, further information and advice is available here: UNHCR, 2018d. Communication with communities.

REMEMBER
Full coordination between humanitarian organisations and local communities can help to reduce the overall materials, cost and work and create more opportunities for the wider benefits of surface water management.

GENDER & VULNERABLE GROUPS

The distribution of drainage across a site must be equitable. Women, girls, children and vulnerable members of the community are more affected by unmanaged surface water, and the negative impacts it can create, more than others. As part of the engagement with the community, identifying the views of women/girls and that of the vulnerable groups in the community and take specific action to reduce their risk, whilst taking care to prevent stigmatisation. This might include:

- Giving special attention to areas used by women, girls and vulnerable groups and either:
  i) Provide surface water management based on a site and risk assessments; or/and
  ii)Provide a greater level of surface water management in these areas.
- Making sure that measures used on the site (e.g. drainage channels) do not obstruct or cause increased danger to these specific groups and that abandoned structures are removed to prevent injury and misuse.
- Looking for opportunities to enhance the environment for vulnerable groups for example consider using drainage as a way of giving clear visual indications of the walkway boundaries of the walkways, or reducing vector breeding sites locally through improved surface water management - see COM2 Guidance notes, Sphere Handbook (2018).
- If there are opportunities for participation, provide appropriate tools for these groups to safely participate in operation and maintenance (see p.52) activities. For example, women sometimes prefer head-pans for earthmoving whilst men may prefer wheelbarrows. Wherever possible consult the users as to their preferred tools.
- Mitigation methods should be planned, designed, implemented, reviewed and adjusted collaboratively with the community members including women children and other vulnerable groups and with specialist practitioners where possible.

1. SITE ASSESSMENT AND PLANNING

Identify and involve the community including women/girls and other vulnerable groups in the assessment, this may include:

- Focus-group discussions (FGD), for example this could be with an existing social group;
- Separate FGD with women and girls community members;
- One-on-one interviews or/and group safety audits;
- Discuss how surface water management might be implemented;
- Discuss future involvement in the management of surface water.
- Discuss with vulnerable groups whether other community activities can be supported through space allocation at the edges of the camp. This may include livelihood enterprises, or vegetable gardens.

2. DESIGN AND IMPLEMENTATION

Review designs with stakeholders and mitigate any unforeseen issues. Seek implementation involvement where possible. Discuss the impact of the designs, for example:

- Positively: provide meeting places, enterprises and private areas
- Negatively: deep drainage might block exits and thick vegetation may inhibit sight lines.

3. OPERATION AND MAINTENANCE

Seek support from groups with maintenance responsibility and involve the community including women and other vulnerable groups in operation and maintenance.

4. REVIEW AND ADAPT

Review processes with stakeholders and adjust to accommodate their needs. Revert back to site assessment stage if more information is needed.

KEY INFORMATION

GENDER CONSIDERATION

Women in particular can be effected by poor surface water management. The perspectives, views and involvement of girls and women in the community should be sought at all stages of the surface water management process. It is recommended that advice is sought from gender specialists throughout the process of surface water management.

> *Adapted and inclusive programming is essential to avoid discrimination, reduce potential risks and improve usage or quality of services. ... Engaging individuals and communities in all stages of the response can further help incorporate protection considerations...*
>
> [Sphere Handbook, 2018]

Further information and advice is available here: IOM, 2018a (2018) and https://emergency.unhcr.org/

SITE ASSESSMENT & PLANNING

This stage covers site assessment and planning and helps to gather, and improve the data, needed to make appropriate decisions for design and implementation' and understand the site context with regards to surface water.

This section includes risk assessment which will help identify where surface water management interventions are most needed. This will help:
i) identify suitable sites; and/or
ii) prioritise areas of sites so that resources and time are spent on critical interventions that will make the greatest impact.
This will vary depending on whether it is a new or existing site. Basic information on risk assessment is covered in:

- Understanding risk;
- Risk assessment;
- Influencing site location and layout/ activity (including advocating for safer sites); and
- Quick test.

In addition this information, will help choose the type and location of surface water management components and techniques (p.36).

Prior to understanding risk, a good understanding of the site is needed and the earlier part of this chapter addresses this by looking at a wide range of areas:

- Site levels/topography (p.17)
- Ground profile and soil type (p.18)
- Ground conditions - soil and rock strength (p.19)
- Ground conditions - infiltration (p.20)
- Rainfall (p.21)
- Water quality (p.22)
- Planting/Vegetation (p.23)
- Site walkover or observation walk (p.24)

Site assessment information should be clearly recorded as assumptions will be made from this information (e.g. infiltration rates and vegetation choices). If problems occur during operation it will be important to verify and potentially improve this information when reviewing and adjusting systems.

A site assessment checklist contains a list information that needs to be collected as part of a site assessment.

It is important that the Awareness section is read prior to this stage so that key themes and cross-cutting issues are understood.

CHAPTER CHECKLIST

CONT.

SITE ASSESSMENT LIST (1/2)

A list of information that should be collected is shown on this and the following page. Hyperlinks and page numbers connect to additional information.

NATIONAL, REGIONAL OR LOCAL GUIDANCE

Where it exists national, regional and local guidance should be used instead of the advice given in this guidance unless an appropriately qualified person suggests otherwise.

- ◻ Existing technical standards
- ◻ Government guidance and regulations including environmental regulations, local advice and standards
- ◻ Local catchment / integrated water management (IWM) plans, flood authorities and flood maps.

SOCIAL INFORMATION

- ◻ Refer to p.11-13 on stakeholder engagement
- ◻ Identify most used areas and mobility routes
- ◻ Identify escape or evacuation routes
- ◻ Current and future population predictions
- ◻ Grazing animals and local wildlife that may impact management of surface water on the site
- ◻ Solid waste management plans (refer to Sphere Handbook (2018) Solid Waste section).

Further advice is given in: https://emergency.unhcr.org/

SOURCES OF SURFACE WATER

Find the location, quantity and quality of the following:

- ◻ Rainfall data , glacier melt, snow melt, groundwater/springs and other natural sources including those upstream
- ◻ Extent of typical flooding on flood plains. Existing catchments, runoff and drainage systems. Understand the human/social impacts of previous flood events including water levels and damage extent.
- ◻ Existing sources of water pollution (e.g. latrine overflow)
- ◻ Greywater sources e.g. bathing, laundry, cooking/eating
- ◻ Potable water spills – including locations of tapstand.
- ◻ What sources of surface water pollution exist? What pathways and receptors exist on the site (refer to p.33).

DISCHARGE LOCATIONS

- ◻ Watercourses - rivers, streams, lakes etc. (including information on their size and fluctuation during the year).
- ◻ Groundwater
- ◻ Sea
- ◻ Evaporation
- ◻ Can discharge be avoided through water use locally?
- ◻ Who owns, operates and maintains local sewerage and water treatment infrastructure. Are there opportunities to use this? Where is it located and how big is the network?
- ◻ How does surface water discharging from the site impacts downstream areas – e.g. increased flooding or reduced water resources for irrigation.

THIS LIST CONTINUES ON PAGE 16

! **REMEMBER**

- **It is essential to familiarise yourself with the site before starting the site assessment. This can be done remotely via satellite imagery and topographical data but it if possible it is best this is done in the field. Try to compare information with at least one other reference to check consistency.**
- **Take care if the site is draining to or near the sea. Tides and sea surge may be an issue. Seek appropriately experienced personnel.**
- **Seek appropriately experienced personnel to understand flooding from rivers (fluvial flood risk). River flooding/hydrology is not covered in this guide.**
- **Consider how the sources change in seasonal or extreme weather events.**
- **Where possible, familiarise yourself with the site before starting the site assessment.**
- **Appropriately qualified means that a person should meet an officially recognised standard.**

i Clearly record the information the found, indicating the source and links and contact details. Try to share existing and new information with relevant stakeholders.

SITE ASSESSMENT LIST (2/2)

This part of the site assessment helps gather data and information on the site. Hyperlinks and page numbers connect to additional information. Make sure that the information on p.15 is also reviewed as this page continues the list of information and considerations for site assessment.

KEY SURVEYS

The following resources might be held by local government, district engineers and/or other NGOs, online resources and national surveys. If appropriately experienced personnel think that the existing surveys do not give enough information links to pages in this document to help gather further information and undertake surveys are referenced.

- ☐ Existing maps, site surveys and satellite images
- ☐ Topographical surveys (p.17)
- ☐ Geological maps and groundwater information (refer to p. 18-20). Soil maps, soil tests/ground investigations – information on ground conditions including soil type, strength and infiltration characteristics (refer to p.18-20)
- ☐ Site walkover (p.24)
- ☐ Ground water/aquifer/hydrogeological information
- ☐ Water sources and local waterbody surveys (rivers, lakes etc.)
- ☐ Hazard maps, historical flood and landslide information including water marks or trash lines and frequency. Information on other local hazards that may cause further risk.
- ☐ Historic, existing and proposed infrastructure (roads, electrical cables, sewerage infrastructure) including sanitary surveys, surface water studies and Flood Risk Assessments (FRA).
- ☐ Historic, existing, proposed land use changes - including impacts on ground/soil conditions (e.g. landfill sites). This may be obtained by a digital surface model/aerial photos.
- ☐ Information on extreme temperatures and possible impacts.
- ☐ Natural areas (e.g. woodland, wetlands etc.), vegetation surveys (see p.23) and extent of previous natural areas.

BUDGETS, PHASING & RESOURCES

- ☐ Existing budgets for drainage (capital and operation costs)
- ☐ Opportunities for multi-functional infrastructure – for example roads with drainage
- ☐ Understand funding impacts on phasing and prioritisation of surface water management . Including consideration of the duration that the surface water management and associated drainage components are needed.
- ☐ Locate potential materials – pipes, concrete, wood, bamboo etc.
- ☐ Understand local labour, skills, tools/machinery available and the capabilities of users/beneficiaries including local vernacular surface water management techniques.

DISEASE, VECTORS AND PESTS

Consider how these might vary due to seasonal or extreme weather events. Refer to Vector Control in the Sphere Association (2018) p.121.

- ☐ Understand if and how diseases, vectors and pests that impact humans are affected by surface water.
- ☐ As stated in the Sphere Handbook (2018), ' ...base decisions about vector control responses on an assessment of potential disease and other risks, as well as on epidemiological and clinical evidence of vector-borne disease problems.'

! **REMEMBER**

- Try to compare information with at least one other reference to check consistency.
- It is essential to familiarise yourself with the site before starting the site assessment. This can be done remotely via satellite imagery and topographical data but it if possible it is best this is done in the field.
- Consider how the vectors may change due to seasonal or extreme weather events.

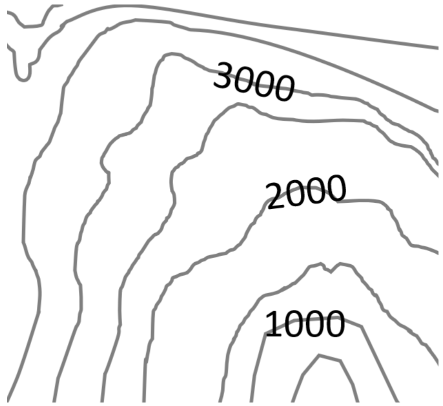
i

- **Clearly record information including the source and the date information was recorded.**
- **Try to share existing and new information with relevant stakeholders.**

SITE LEVELS/ TOPOGRAPHY

WHY?

Designing with site levels helps make the techniques used more efficient and may allow avoidance of unexpected costs during construction particularly due to earthworks. The chosen method depends on the accuracy needed, the area covered and the resources available. The costs of these surveys may vary considerably in different locations.



Example of a contour plan at 500mm contours, needed for drawing and understanding flow paths

Large area

DRONE SURVEY

A drone topographical survey can be procured. The output should be given in reference to a known level and a digital elevation model (DEM) generated from the point cloud.
Consider the impact of drone surveys on the local community before using drones and consult with stakeholders. Care should be taken to understand anomalies in the data through post-processing, it is possible that the levels of features (e.g. buildings and trees) may disrupt the survey. Useful information on can be found here.

TOPOGRAPHICAL SURVEY

Get a local survey contractor to complete a topographical survey either by hand or electronically at ideally 500mm contours. This survey should relate to a clearly indicated and known level/marker.

Use a local survey company.

ONLINE MAPPING TOOLS

Local hard copy or online maps can generally indicate elevation contours.
For example Google Maps: locate the site -> next to the location search bar click -> select 'Terrain' -> zoom in
Note, the accuracy may vary from location to location and a site walk-over should be undertaken to confirm findings

LOCAL LIDAR DATA

Public topographical data (also known as LiDAR data) from online or local authorities. If accessible, use GIS (Geographic Information Systems) software to import and review the data.

Small area

VISUAL CHECK

Undertake a site walkover - this is a particularly useful exercise following a rainfall event to understand water pathways. Note down the natural direction of runoff from rainfall or existing drainage or surface water management infrastructure, and areas of ponding or standing water. Identify areas of slopes greater than 1:3 - it will be important not to cause slope instability problems in these areas.

SIMPLE SURVEYING TECHNIQUES

Refer to Engineering in Emergencies (2002) or/and Building Roads by Hand (1990).

! REMEMBER

- Contours indicate points of equal elevation of ground levels. Try to compare more than one source of data to check accuracy
- Try to compare information with at least one other reference to check consistency. Visual assessment can be a very useful way to quickly check assumptions.
- The population density and frequency of changes in levels should help determine the grid required for the survey. A hilly, densely populated small site should have more levels taken than a sparsely populated large, flat site. Ideally request contours as these are easier to work with.

GROUND PROFILE AND SOIL TYPE

WHY?

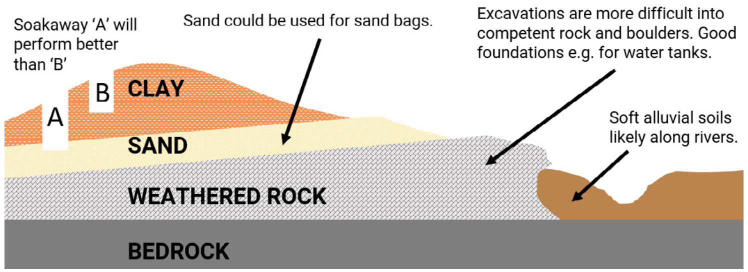
The ground profile refers to the type and sequence of soil and rock layers that lie below the site. The ground profile can directly affect the ground surface conditions, and therefore the pathway of surface water, in many ways:

- Clays and silty soils (loamy) may soften when saturated through rainfall, flooding, groundwater rise and surface water ponding;
- Human and vehicle trafficking over softened soils leads to fast deterioration of the route;
- Clays and finer silts are less permeable than coarser grained sands and gravels and infiltration of surface water through soakaways less feasible;
- Silts and fine sands are more susceptible to landslips and liquefaction (from ground shaking during earthquakes) particularly when on steep ground / impacted by flows; and
- Sands and gravel can be useful materials for sand bags, concrete and road construction;
- Bedrock found at or near the surface will make excavations for drainage channels and soakaways more difficult, although will be better for supporting structures like water tanks.

A series of trial pits excavated at locations around the site will help to better understand the ground profile and improve the sighting of facilities and infrastructure, as well as identifying local materials for construction. The deeper the pits the better, but limited by the ground conditions, water table and pit stability. At least 1 to 1.5 m deep though. The number of pits depends on the camp size, topography and ground conditions but more pits will be required in areas of 'problem' soils / ground. This might be where there is:

- Made ground (particularly if contaminated);
- Black cotton soils and other expansive clays;
- Soft organic soils;
- Steeply sloping ground;
- Shallow groundwater table; and
- Active erosion / gullying.

Geotechnical expertise on ground hazards and ground investigation should be sought for more difficult sites.



- Sand areas less likely to be affected by flooding. However, water quality and water scarcity may be an issue
- Weathered rock fragments and gravels may be a good source of aggregates for other uses.

Example soil profile

FIELD ASSESSMENT	SOIL TYPE					
	CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDERS
	Fine grained ('cohesive') soils		Coarse grained ('granular') soils		Very coarse soils	
PARTICLE SIZE [to UK /European standards]	< 0.002 mm Not visible by eye	0.002 – 0.063 mm Not visible by eye	0.063 – 2 mm	2 – 63 mm	63 – 200 mm	> 200 mm
Plasticity	Can roll thin threads (~3mm Ø) with moist soil, then remould and re-roll to a thread again, without breaking.	Rolling to a thin thread more difficult and ruptures on re-rolling.	Non-plastic. May stick together when wet but cannot roll or remould. Falls apart when dry.	N/A	N/A	N/A
Feel	Smooth. Can form shiny surfaces when rubbed. Sticky when wet.	Grainy or silky		N/A	N/A	N/A
Behaviour on handling	Dries slowly on the hand and sticks to fingers. Can crack when dried.	Dries quickly on the hand and can be dusted off.	Wet sand may stick to hand but falls off on drying.	N/A	N/A	N/A
DRY STRENGTH Push between thumb and forefinger	Dried lumps can be broken but not powders.	dried lumps can be powders	very low, if any	N/A	N/A	N/A
Disintegration of dry lump in water	Falls apart slowly (hours)	Faster than clays (minutes)	Immediate, if dry lump still intact	N/A	N/A	N/A

! **REMEMBER**

- Note areas of made-ground (i.e. ground filled with man-made material or impacted by previous infrastructure.)
- Make sure samples are taken below the level of made-ground.
- Before testing, review local hazards (see Appendix 1) this may include contaminated ground and unstable ground.

GROUND CONDITIONS – SOIL AND ROCK STRENGTH

WHY?

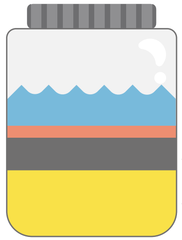
The site geology and ground conditions have a direct influence on the soil strength, which influences implementation of surface water techniques including acceptable slope gradients and need for erosion protection. Generally, the stiffer or denser the material the less susceptible to erosion/landslips it will be.

Soil strength is more accurately determined by either laboratory tests on undisturbed soil samples or through in-situ (on site) testing in boreholes, or with other testing equipment. However, although less accurate, more simple field assessments of strength can be made in hand-dug trial pits. These should be at least 1m deep, but preferably deeper if it is safe to excavate without side wall collapse.

The field tests for fine grained soils assume that the ground is moist and will not apply in arid locations or during the dry season. Soils which appear to be strong or hard when dry can soften during the wet season or when local flooding occurs. If it is possible to soak the ground before the trial pit is excavated this will provide a more accurate assessment of the likely soil strength in the wet.

Lumps of hard dry soil can be placed in jars of water to observe how quickly they soften or fall apart and layers of different soil types can be observed.

Geotechnical expertise on ground hazards and ground investigation should be sought for more detailed analysis.



Jar test showing 60% sand, 30% silt and 10% clay

FINE GRAINED SOILS (CLAYS AND SILTS)

CONSISTENCY	INDENTATION	MOULDING
Very soft	Finger easily pushed in up to 25 mm	Exudes between fingers when soil lump is squeezed.
Soft	Finger pushed in up to 10 mm	Lump of soil can be easily moulded by light finger pressure.
Firm	Can easily make impression with thumb	Lump of soil cannot be moulded by fingers but can roll in the hand to a thread without breaking.
Stiff	Can indent slightly with thumb	Sample crumbles when rolling to a 3 mm thread, but can then be remoulded.
Very stiff	Can indent only with thumb nail	Cannot be moulded.

From BS 5930:2015

COARSE GRAINED SOILS (SANDS AND GRAVELS)

CONSISTENCY	INDENTATION	PENETRATION with pick by pushing
Very loose	Very easy to excavate with a spade / hoe.	~75 – 100 mm
Loose	Can excavate with a spade / hoe or penetrate by crowbar / pick.	~25 – 75 mm
Medium dense	Difficult to excavate with a spade / hoe or penetrate with a crowbar.	~10 – 25 mm
Dense	Requires a pick to excavate.	~2 – 10 mm
Very dense	Difficult to excavate by pick.	< 2 mm

From BS 5930:2015

REMEMBER

- Note areas of made-ground (i.e. ground filled with man-made material or impacted by previous infrastructure.)
- Make sure samples are taken below the level of made-ground, the organic/top soil layer or fractured/desiccated ground.
- If the water table level is reached it may be very difficult to infiltrate and may be prone to contamination.
- Before testing local hazards should be reviewed (see Appendix 1) this may include contaminated ground, unstable ground and ground water.
- Locations should be representative of the areas where surface water management techniques are being implemented. The more areas tested the more confident you can be that the network is not over or under designed and resources are used effectively.

GROUND CONDITIONS - INFILTRATION

WHY?

The site geology and ground conditions have a direct influence on the sub-surface drainage characteristics of a site.

The infiltration coefficient or permeability is a measure of the rate at which water drains through the ground. This will dictate whether infiltration solutions are possible or if outfalls are needed. The infiltration rate is usually expressed by the depth of the water layer that can drain through the soil per hour (also written as mm/hr).

Soakaway tests can be carried out in test pits located across the site. The test pits should be located in the places where an infiltration component is planned. The more areas tested the more confidence there can be in the likely drainage capacity, but this should be balanced with the resources available and the consequence of that infrastructure failing.

HIGHER PRECISION / LOWER UNCERTAINTY

Robust Method

INFILTRATION TEST

Ask an appropriately qualified person to conduct an infiltration test following BRE Digest 365. This test should be conducted and sized relative to ground conditions and the likely depth of the soakaway/infiltration component. If several infiltration components are to be used on the site, consider undertaking multiple tests to understand how the infiltration rate changes across the site.

Improved Method

BASIC INFILTRATION TEST (AS SHOWN IN APPENDIX 2)

This test should be conducted and sized relative to ground conditions and the likely depth of the soakaway. The minimum depth, width or length of the pit should be greater than 0.3m. The test location should be close to the anticipated infiltration point.

Tests may be conducted first at shallow depths. If infiltration rates are insufficient, the test may be repeated locally at deeper depths. If several infiltration devices are to be used on the site, consider undertaking multiple tests to understand how the infiltration rate changes on the site.

Basic Method

APPROXIMATE INFILTRATION RATE BASED ON SOIL TYPE

Review local ground condition information (see p.15-17) and complete exercises on soil type (p.18).
Based on the above information choose infiltration rate below that is representative of the soil type on the site or specific area of the site.

Good infiltration → **Poor Infiltration**

SOIL TYPE	SANDS/ GRAVELS	SANDY LOAM	SILT	CLAY
Infiltration rate (mm/hr)	30-80	20-30	10-20	1-10

Verify with site observation/walkover. Does water typically pond on site or quickly drain away? (p.24)

HIGHER UNCERTAINTY / LOWER PRECISION

KEY INFORMATION

Make sure good records of infiltration test results are kept for future reference.

Use the infiltration rate to size infiltration devices/soakaways see p.40.

REMEMBER

- Verify the rate using more than one reference.
- Before testing, review local hazards (see Appendix 1) this may include contaminated ground, unstable ground and ground water.
- Note descriptions of made-ground and hazardous soils (see p.18) or areas impacted by previous infrastructure.
- It may be very difficult to drain if the water table is shallow. The infiltration device may also be prone to contamination.
- Consider groundwater protection water zones.
- Refer to Engineering in Emergencies (2002) p.677 and BRE Digest 365 for more info.

RAINFALL

WHY?

Understanding the climate and the pattern of rainfall (defined on p.9) on a site will support appropriate preparation for storm events in advance. This should be carefully considered to ensure that it does not lead to a significant over or undersizing of the surface water management components.

HIGHER PRECISION / LOWER UNCERTAINTY

HIGHER UNCERTAINTY / LOWER PRECISION

Robust Method

LOCAL RAINFALL DATA

In an ideal situation, rainfall intensity for a range of frequencies and durations would be determined using statistical analysis of historical data collected at local weather stations every 15 minutes or hour at a local weather station over 20 years or more. Longer duration data (e.g. daily) may also be used but may lead to less accurate results. Where possible, contact other local weather stations for data. The data from multiple stations can be pooled to improved the statistical accuracy, as long as the precipitation patterns are similar.

Improved Method

EXISTING IDF INFORMATION

There may be existing information on the rainfall intensities locally. Using the search terms including 'IDF curve' 'IFD curve', 'Intensity-Duration-Frequency rainfall curves', 'Space-time-frequency', 'depth –duration-frequency, or 'rainfall intensity' alongside the location, name of local weather stations, region or country. Check the reliability of the source, ideally the analysis should be based on observed gauge data rather than satellite or radar.

Basic Method

GLOBAL RAINFALL

If there is no local information, it is possible to find global rainfall data sets. There is a risk that these generalised climate zones may not pick up on local differences that should be considered but should give a reasonable estimate. Examples include: gauge data sets (e.g. CRU TS, GPCC, APHRODITE, PREC/L), satellite-only data sets (e.g., CHOMPS) and merged satellite-gauge products (e.g. GPCP, CMAP, TRMM 3B42). These may not be in readily usable forms but converters are freely available. The rainfall data can be statistically analysed so an IDF curve can be produced. Although less accurate, it is also possible to calculate the 95th or 99th percentile and use these values (maps of extreme hourly, daily and monthly rainfall for localised areas data may also be used).

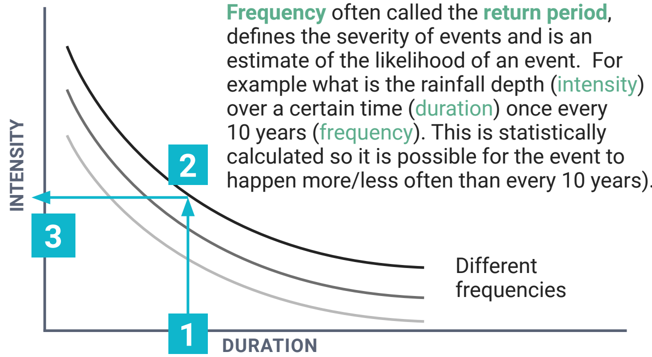
Seek assistance from a hydrology expert to analyse rainfall data and calculate the intensities for a range of different durations and frequencies. Many countries have specific approaches to defining IDF curves and the analysis should consider these methods. Digital models can be developed to understand the impact of rainfall events on infrastructure/buildings.

WHAT IS AN INTENSITY DURATION FREQUENCY (IDF) CURVE?

An Intensity-Duration-Frequency (IDF) curve describes rainfall intensity, or depth, as a function of duration to indicate extremity, expressed as a frequency or probability of exceedance (return period) curve. There are several key definitions to consider when investigating rainfall on the site (see figure below) these terms should be searched for locally to understand if there is locally applicable guidance. An example of an IDF curve is shown below (the axis may also be logarithmic).

Intensity
The rate of precipitation (its depth) over a unit period of time is needed for design. This varies depending on the frequency and duration of events. The units for intensity are usually in mm/hr. A millimetre of water equals a litre of water on a square meter.

Frequency often called the **return period**, defines the severity of events and is an estimate of the likelihood of an event. For example what is the rainfall depth (intensity) over a certain time (duration) once every 10 years (frequency). This is statistically calculated so it is possible for the event to happen more/less often than every 10 years).



Read an IDF curve
1. Choose duration
2. Choose frequency
3. Find the intensity.
Refer to p.35 to convert to a flow.

Duration - The length of time over which the rainfall occurred, dictated by when the peak flow (the greatest flow that will reach the infrastructure). The appropriate storm duration to be chosen will depend on the type of infrastructure designed. For the design of drainage infrastructure it is suggested to use a storm duration similar to the time of concentration, which is the time between the start of the storm and the peak flow.

REMEMBER

- Try to compare a few sources of rainfall data to see whether the data is similar. If the accuracy of the data is uncertain, try to find another local source to compare against.
- The 'frequency' is also called recurrence/repeat interval or annual exceedance probability.
- A suitable return period should be chosen for the site based on the impact caused by failure. Often this is 1 in 2 years (less than the median) of the annual maxima series for a surface water management network. Higher return periods can be used for critical infrastructure and local guidance should be followed on this where possible. Ideally for critical infrastructure/buildings flooding should not occur for a 1 in 100 year period. Refer to the 'risks' section on p.25.
- Complete research to find out if the impact of climate change on rainfall locally, it may both increase or decrease during the year.

WATER QUALITY

WHY?

Rainwater is likely to be unpolluted, but it is important to characterise greywater to help decide on its management. If surface water is heavily polluted or contaminated, it may be blackwater or sewage which needs to be managed differently. Water quality is likely to be linked to land use (e.g. highways, washing areas etc.). *Refer to surface water definitions p.8.*

HIGHER ACCURACY / LOWER UNCERTAINTY ↑

Robust Method

Tests (note samples should be taken in a sterile container)

- Coordinate with WASH to conduct water quality tests. For further advice refer to the EHS Guidelines or World Bank Group (1998) General Environmental Guidelines, Pollution Prevention and Abatement Handbook.

Improved Method

Sanitary survey and biotic index

- Complete a sanitary survey or find information from others who have completed this. Further information can be found in WEDC 'Sanitary Surveying' (2015)
- Use a biotic index (e.g. UNECE Guidance) to understand the environmental quality.

Basic Method

Tests

	Likely to need treatment
• Colour – is the sample coloured and/or non-transparent?	**Yes/No**
• Turbidity – is the water cloudy?	**Yes/No**
• Smell – is there a distinctive smell? What is the nature of the smell?)	**Yes/No**
• Algae – is there dense green algae in the water?	**Yes/No**
• Obvious sources of contamination (e.g. fats from kitchens or overspilling latrines).	**Yes/No**
• Refer to Sphere Association 2018, for example Appendix 6 p.150.	

LOW ACCURACY / HIGHER UNCERTAINTY

*If '**No**' it is likely to be surface water that does not need treatment. However, it is appreciated that this a complex topic so this is further addressed in the design and implementation section.*

KEY INFORMATION

A case study showing measurement of water quality can be seen in Appendix 3 p.65.

It is important to consider the current sanitation/solid waste management strategy and how this impacts surface water quality.

REMEMBER

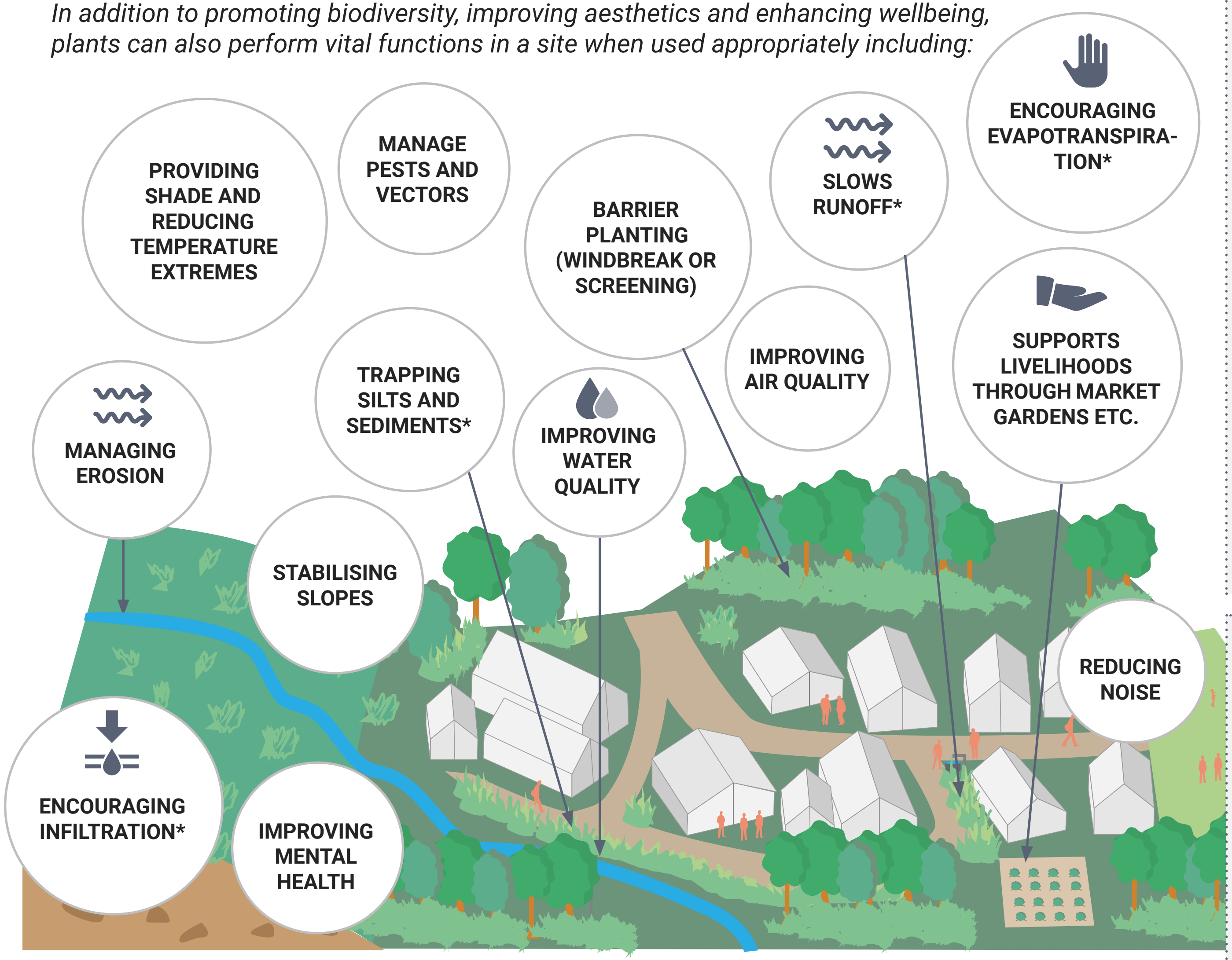
- It is recommended tests are regularly to see if the pollution varies and if interventions to manage pollution are working. Record carefully the location and measurements so thatlater results can be compared.
- Polluted water may be a risk to human health and should be managed carefully and kept separate from water supplies.
- Before testing local hazards should be reviewed (see Appendix 1) this may include contaminated ground, unstable ground and ground water.
- Locations should be representative of the areas where surface water management techniques are being implemented.
- The regularity of testing should be considered based on resources and the risk to human health and the environment. The testing regime should be planned and reviewed regularly.

Further advice is given in EHS Guidelines - https://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Sustainability-At-IFC/Policies-Standards/EHS-Guidelines/
and UN/ECE Guidance - https://www.unece.org/fileadmin/DAM/env/water/cwc/monit-assess/biological_assessment_methods.pdf

PLANTING / VEGETATION

WHY?

In addition to promoting biodiversity, improving aesthetics and enhancing wellbeing, plants can also perform vital functions in a site when used appropriately including:



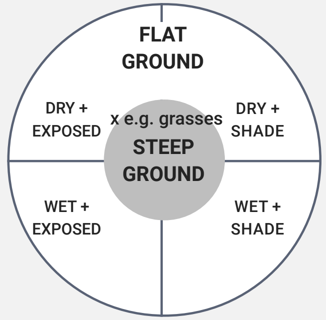
* - This helps to reduce the size of downstream features

Vegetation can be introduced into many different techniques and components to improve their performance as discussed in the design and implementation chapters. The design and implementation section often refers to the ability of plants for pollution/silt removal and erosion reduction. As shown in the figure, existing vegetation should be retained as far as possible.

Further advice is given in Sphere Association (2018) particularly p.272 also refer to the case study on p.38

A SITE APPRAISAL ACTIVITY

Look at local plants and plot them on the matrix below based on the local conditions where they are currently growing. This will become a useful reference when choosing plants during implementation. Some plants may sit in multiple categories (see example on the matrix). This matrix will form a 'tool box' used in component design.



Choose local plants as these are likely to be: low maintenance, rapidly colonising (fast growing), self-sustaining and can cope with local extreme weather conditions. Ideally vegetation should be planted in the soil that is already there. By planting local plants they are clearly already well adapted to the local environment.

! REMEMBER

When assessing vegetation for the site find information on:

- Identify local plant nurseries if applicable;
- Avoiding disruption of fire-breaks;
- Plants can have both a positive and negative impact on vectors/pests e.g. i) certain plants or their size may be disliked by species ii) some plants can provide a breeding medium for vectors/pests iii) other plants may encourage predators. The development of a balanced ecosystem that includes other invertebrates, insects, fish, birds and mammals will help maintain acceptable levels of vectors/pests.
- Constructing with nature may enable easier decommission if/when required.

SITE WALKOVER OR OBSERVATION WALK

WHY?

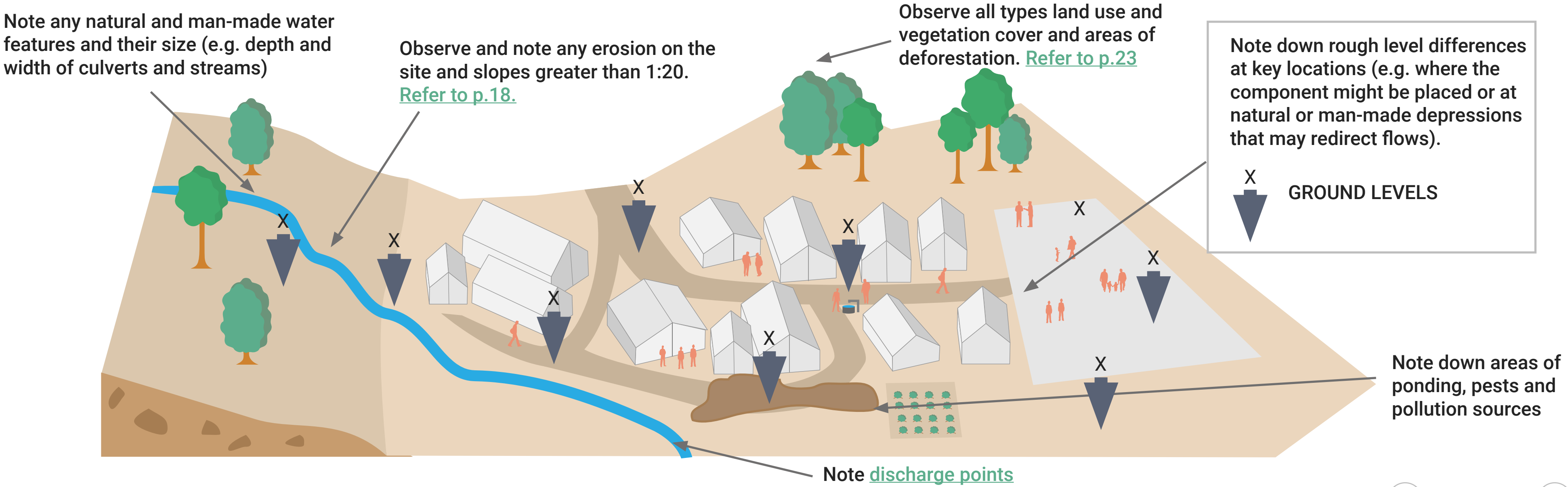
A site walkover is an essential activity, giving a clearer understanding of the site and verifying information obtained elsewhere as part of the site assessment.

If safe and respectful to do so, use plans obtained for the site to complete the following tasks:

- Plan a route through the site to include site boundaries, known natural and human water features (e.g. rivers, streams, pipes, ponds, springs, existing drainage infrastructure) and existing infrastructure (roads, power lines, tapstands etc.) Verify the size and location of this infrastructure. Use a GPS tracker/app to map the route.
- Sketch flow paths/natural flow routes (i.e. the direction that water might travel across the site). Note down rough level changes by eye. This will help gain an understanding runoff across the site (including areas where water might naturally pond or pool and to help plan the network layout in design. Identify overland flow paths draining in to or out of the site. Identify overland flow paths of water draining on to the site.
- Verify land uses, sources of surface water , vegetation types and material availability.
- Consider surface types and evaluate whether surface water is causing issues.
- Verify the natural drainage features on the satellite image or map and mark any differences. Note whether any of these differences could be seasonal.
- Take photos regularly, where possible, both at key points and to give an impression of the overall 'walkover' and note their location and direction of view.
- Look for water sources, overland flow routes and discharge points. Consider what happens if the rainfall cannot discharge or flow away from the site, and/or when a planned drainage system is overwhelmed (i.e. exceedance). Mark down the likely route this will take and whether it risks key infrastructure/overland flow paths.
- Note areas of erosion, pollution sources, debris, steep slopes and other potential hazards and then consider/ask why this is happening.

REMEMBER

- Ensure that at least one person who knows the area well is involved in the site walkover. Before the site walkover, local hazards should be reviewed (Appendix 1).
- Try to visit the area during or after a storm if safe to do so.
- It is recommended that a site walkover is done in groups of 2 or more.
- Ensure representatives of the affected population are present.



UNDERSTANDING RISK

WHY?

The risks due to surface water are not always obvious - they can effect different areas of a site over different timescales (e.g. seasons). Minor issues could worsen over time or the hazard may only be apparent in the future (i.e. during the rainy season). It is therefore important to be aware of potential surface water risks in advance and think about how to avoid and/ or reduce these impacts. This can save money and time in the future whilst delivering other benefits, for example identifying areas which could flood safely and therefore reduce the downstream impact.

REDUCING RISKS BY DESIGN

The best way to mitigate against the risk is by designing the risk out, by either eliminating it completely or reducing the risk. Therefore always consider risks, relevant to the site, throughout the design process. This will avoid the need to have specific measures to control risks or the need to warn people about them.

KEY CONSIDERATIONS

Detailed consideration should take place to understand what level of risk is acceptable and what mitigation is available or achievable. This can be achieved through appraising the site properly (through a risk assessment p.26), supported by engagement with local communities who have lived there or colleagues who have worked in the area previously. This will allow understanding of the potential severity of risks. This should include:

- Which site/system characteristics could be hazardous and when do these risks occur (either independently or together)?
- Consider the risk and impact of hazards all occurring at once.
- Consider the risk of poor performance and how ease of construction and O&M might be achieved to mitigate this.
- Who is impacted and to what extent? (relates to Stakeholder/ Community Engagement p.11-12)
- How acceptable is this (taking in to account the local context)?
- How can these risks be mitigated?
- Who already manages or who could manage these risks?
- When and who will review these risks?

CONSIDERING RESILIENCE

While resilience is related to risk, it should not be seen as the opposite of risk or vulnerability.

Resilience is complex, it is not a linear response to individual shocks and stresses but an integrated concept that ensures that a system remains functional when a shock or stress affects the system. Sites are complex systems that are constantly adapting to changing circumstances.

Resilience is often discussed in relation to multiple:

- SHOCKS - a sudden, acute event for a short time period but which can have a sever or long-term impact (e.g. a flash flood of an entire site or short-term cholera epidemic).
- STRESS - a long-term, chronic condition can can undermine health, wellbeing and quality of life (e.g. poor road and path conditions).

One shock may lead to another, one stress may compound another or the gradual accumulation of stresses can result in a sudden shock.

To improve resilience, consider the following elements when planning, designing, operating and reviewing surface water management:

- REVIEW AND ADAPT - Is there the ability to learn? Are the resources available to act when needed?
- ROBUST, REDUNDANT, FLEXIBLE - Can the techniques withstand shocks? Can alternative systems be used? For example, does overflow of swales bypass critical infrastructure?
- INCLUSION - Are site-wide needs considered?
- INTEGRATION - Is there coordinated action?

KEY INFORMATION

Using the site assessment information and risk assessment information it is important to prioritise what type of intervention is needed and where, in relation to site selection, stakeholders/community engagement, implementing surface water management techniques, operation and maintenance,

This will vary considerably if it is a new or existing site.

REMEMBER

Hazard: is something that can potentially cause harm or danger to anyone or anything.
Risk: is the hazard x the likelihood of it happening
Resilience: the ability of systems, in this case those related to a site, to withstand shocks and stresses.

For further advice refer to https://emergency.unhcr.org/entry/253298/risk-analysis-and-monitoring-multihazard-iasc
Risks may also be mapped using GIS either quantitatively or semi-quantitatively, to help visualise the issue.

RISK ASSESSMENT

This basic activity helps assess surface water management specific hazards and helps their prioritisation for the site.

A

ACTIVITY: BASIC RISK ASSESSMENT

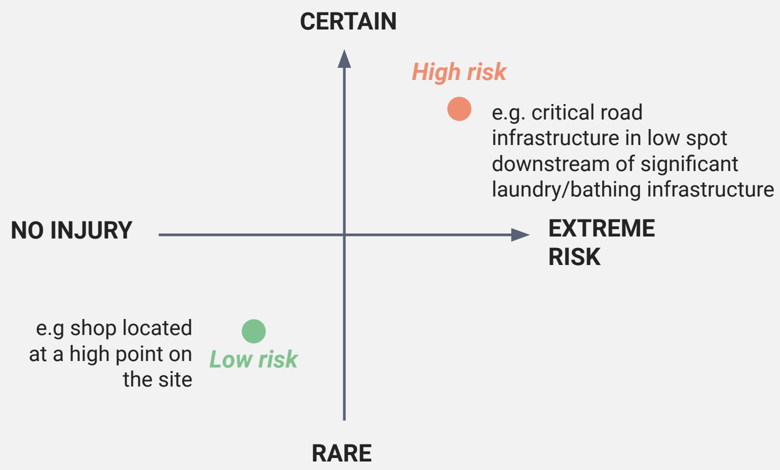
Ideally collaboratively with stakeholders identified (see p.11), identify risks associated with surface water on the site. It is important that a site-wide hazard risk assessment is undertaken. This should be reviewed periodically throughout the site's life-span. There may already be a method to log risks on the site, if this does not exist an example is provided below. This may be used to communicate risks with stakeholders.

RISK		LIKELIHOOD				
		RARE	UNLIKELY	POSSIBLE	LIKELY	CERTAIN
CONSEQUENCE	NO INJURY	Very Low	Very Low	Low	Low	Medium
	MINOR	Very Low	Low	Medium	Medium	Medium
	MODERATE	Low	Medium	Medium	High	High
	MAJOR	Low	Medium	High	High	Extremely High
	EXTREME	Medium	Medium	High	Extremely High	Extremely High

Each potential risk should be considered separately. It is then useful to rank them from high to low.

PRIORITISING RISKS WITH STAKEHOLDERS

With stakeholders, map the magnitude and likelihood of surface water issues in the settlement to help prioritise tasks.



For further advice refer to https://emergency.unhcr.org/entry/253298/risk-analysis-and-monitoring-multihazard-iasc w and https://emergency.unhcr.org/entry/176734/risk-analysis-and-monitoring-refugee-emergencies.

QUICK TEST

WHY?

Quick analysis of the site is important so that an initial understanding can be gained and early decisions regarding the site and its layout made promptly. This is not a comprehensive list and a full site investigation should be undertaken and revisited where necessary when changes occur or a deeper understanding is needed.

This test only looks at ground conditions and topography therefore only water quantity is considered. Water quality should also be considered early.

QUICK SITE TEST		TOPOGRAPHY (GROUND LEVEL) FACTORS Unsure? Go to – Site Walkover p.24 and Topography p.17			
		Very flat	**Gently sloping;**	**Changes in gradient throughout;**	**Very steep**
GROUND CONDITION FACTORS Unsure? Go to p.18-20	Sandy- gravel: high infiltration; good vegetation	Low Risk	Low Risk	Medium (increased landslide risk)	High risk (increased landslide risk)
	Sandy-silt: medium infiltration; some vegetation	High Risk	Medium	Medium	High Risk
	Silty- clay: low infiltration; no vegetation	Extremely High Risk	High Risk	High Risk	Extremely High Risk

REMEMBER

- Sandy soils could lead to increased erosion in the drainage components.
- Ponding of water could occur on very flat sites
- Beware risk of landslides on very steep sites with a lack of vegetation or sandy sites
- The site may still be at risk of flooding from other sources, such as rivers or the sea, seek assistance as appropriate.

WHAT SHOULD BE DONE?

Low Risk Sites

- Ensure that any surface water generation points are well drained – e.g. tap stands, showers
- Implement site wide surface water management to make sure multiple benefits are obtained

Medium Risk Sites

- Move key facilities including shelters to lower risk areas (e.g. high points, areas with better natural drainage)
- Monitor nearby watercourses during heavy or prolonged rainfall events.

Extremely high risk/ High risk sites

- Monitor weather conditions for heavy/ prolonged rainfall events to anticipate flood risk.
- The site may be at risk of severe flooding with potential danger to human lives, discuss this with key stakeholders (identified in Stakeholder Engagement p.11) and investigate this further.
- Advocate for a better site or at least more resources to mitigate against surface water risks.
- Discuss opportunities to develop an emergency evacuation plan with colleagues and beneficiaries and to put critical infrastructure/shelters on higher ground.
- Prioritise relocation of people outside these areas.

INFLUENCING SITE SELECTION AND

WHY?

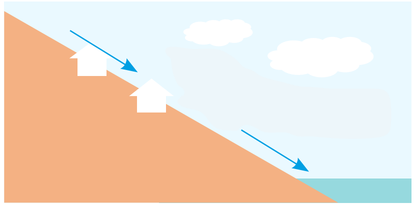
Poor site selection can threaten the security and health of the displaced population and their hosts. There are a number of threats and hazards which should be considered when assessing the site, including it's internal and external security and natural hazards (such as potential for landslides and location on existing floodplains).

WHAT CAN BE DONE AT SITE SELECTION STAGE?

Within the context of the site selection appraisal, hazards posed by surface water and flooding (from all sources, including rivers, the sea, groundwater and surface water drains) should be considered.

Key factors to consider should include:

Steep sites

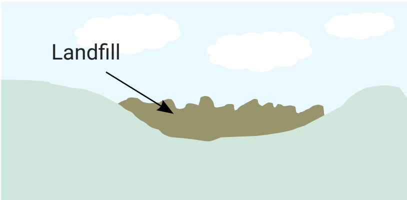


Steep sites can be prone to landslides and rapid runoff and flash flooding

Flat sites

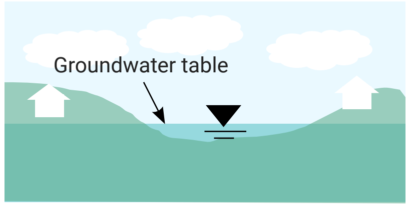
Very flat sites particularly with existing ponding

Pollution



Avoid polluted sites

High water table

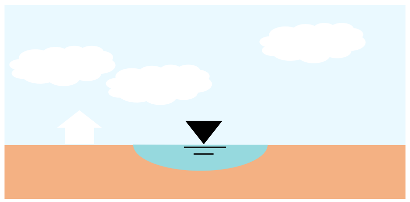


High water tables

Non-porous soils

Impermeable ground

Floodplains



Sites situated in floodplains

Further information and advice is available here: https://emergency.unhcr.org/entry/45582/campplanningstandardsplannedsettlements==

The Quick Site Test on p.27 will help to assess the site quickly. It is recommended that a more detailed assessment is undertaken following the Site Assessment and Planning section.

INFLUENCING DECISION-MAKERS

It is recognised that frequently refugee and IDP camps/settlements are on land of low value or desirability. Humanitarians usually have little control of this process. Therefore, it is key to minimise potential threats to affected populations by appropriate planning, design and forward thinking. This guidance will help minimise the impacts of surface water.

However, if the site is of severe risk to human health and lives, change should be advocated to the host authority. Identification of severe risks and raising awareness may help to convince local authorities to provide a more appropriate site. Discuss this further with the IDP/refugee site manager or regional leader. This relates to 'why is surface water management important' (see page 6).

REMEMBER
If the site is of severe risk to human health and lives, you should advocate for change to the host authority.

INFLUENCING SITE SELECTION AND LAYOUT - ACTIVITY

WHAT CAN BE DONE DURING SITE LAYOUT DEVELOPMENT?

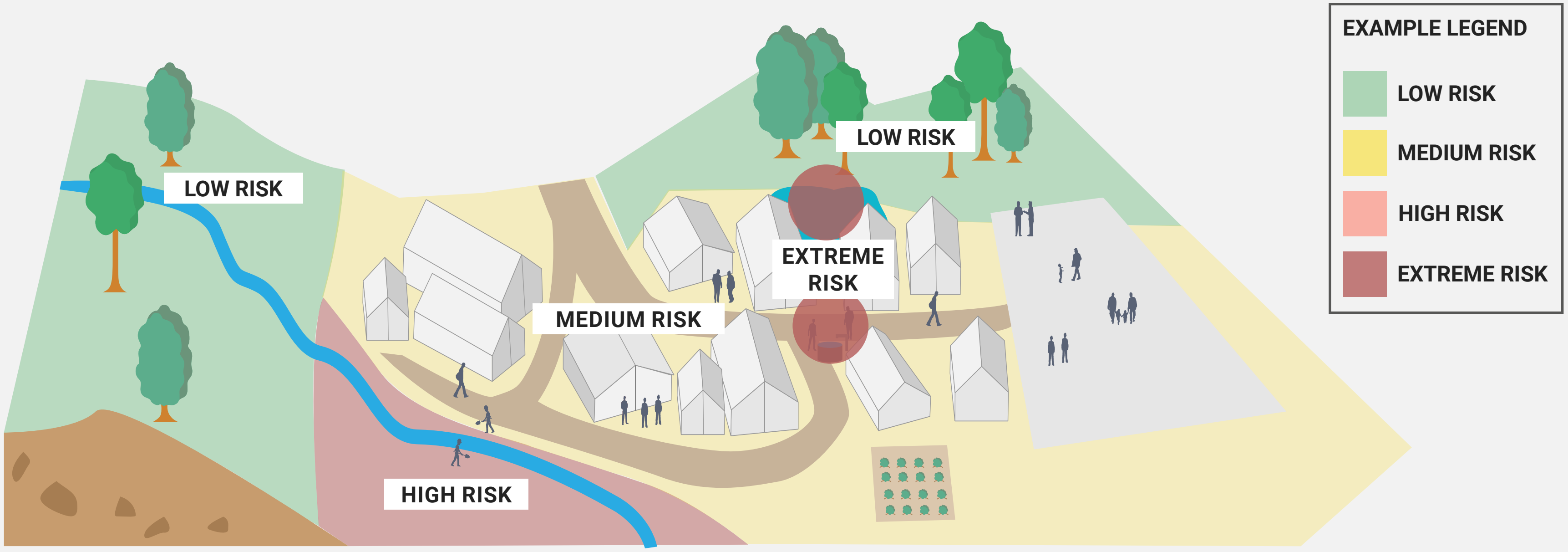
Runoff is only a problem if it interferes with human activities and the environment. Within the context of the site plan, the hazards posed by surface water and flooding should be considered. The Quick Site Test in this chapter will help rate zones in the site based on water quantity.

> **REMEMBER**
> - The risk prioritisation relates to topography and soil type in the figure (left). However, the risk prioritisation could relate to other design criteria (e.g. vector risk, location of stockpiles, food stores, landfill or location of vulnerable groups).
> - Stakeholders affected by the risk should also be identified (e.g. shelters, logistics).
> - Consider making a constraints plan including the location of existing shelters, roads and utilities.

A ACTIVITY: SITE LAYOUT RISK PRIORITISATION

Ideally in a meeting setting (considering which stakeholders should be involved, see page 11-13), identify risks associated with surface water on the site. Use the risk assessment in the 'understanding risk' section to define which areas might be low risk and which areas are high risk. Prioritise land use that would be impacted greatest by surface water management risks to the low risk areas.

Risks can also be mitigated by the design of the infrastructure on the site, by designing for more intense and longer storms, providing or a more conservative estimate for greywater flows or in the way infrastructure is located (e.g. roads should ideally follow contours). Therefore the site should be reviewed to understand where the greatest impacts to flooding occur and whether surface water management components need to be upsized accordingly or threshold levels increased.



SITE ASSESSMENT & PLANNING CHECKLIST

- [ ] Decide whether the site selection is appropriate. Minimise surface water vulnerabilities through the site layout.
- [ ] Obtain existing information from a wide range of sources and reduce key gaps through additional surveys and site walkovers. Understand the possible impact of uncertainty in the data.
- [ ] Map drainage flow paths and pollution pathways.
- [ ] Ensure ground conditions such as infiltration and slope stability and water quality conditions are well understood.
- [ ] Decide whether the site selection is appropriate. Minimise surface water vulnerabilities through the site layout.

A ACTIVITY: CHOOSING SUITABLE TECHNIQUES

Develop a strategic plan for the site considering which techniques (p.3) might be suitable for the site. The table to the left indicates which techniques may be high or low priority given certain site constraints but this should developed in further detail for the context and should include other elements.Consider the design criteria for the site. Are their other elements beyond those listed on p.3 that should be considered?

This table is subjective. When applying it to a site, risk and site context should be considered.

Key	
(green)	Higher priority
(yellow)	Lower priority / Avoid harm
(grey)	More relevant to other site assessment findings

Site assessment findings / Technique prioritisation		Prevent	Treat	Use	Infiltrate	Slow	Store	Convey
TOPOGRAPHY	Flat							*e.g. shallow swales*
	Steep			*Pumping?*	*Check slope*			*High velocities*
INFILTRATION	Poor							
	Good							
SOIL TYPE	Stiff/hard							
	Soft/loose							
RAINFALL		*Change surfaces*						
GREYWATER				*Avoid harm*	*Avoid groundwater pollution*			
WATER POLLUTION (INCLUDING SILT)				*Avoid harm*	*Avoid groundwater pollution*			*Avoid harm downstream*
IMPERMEABLE SURFACES		*Change surfaces*			*Subsidence check risk*			
LIMITED POTABLE WATER RESOURCES								

DESIGN & IMPLEMENTATION

This stage uses the information gathered in the site assessment and planning stage to design and implement surface water management techniques. The techniques highlighted (see p.30 and p.36) return surface water to the natural watercycle, at the earliest opportunity, whilst not damaging the local ecosystem. This is achieved by understanding the catchment and trying to manage water as close to where it lands as possible (source control).

The overall approach to design and implementation is highlighted in:

This feeds in to the component design which follow the seven prevention and mitigation techniques. This components covered in the guidance include:

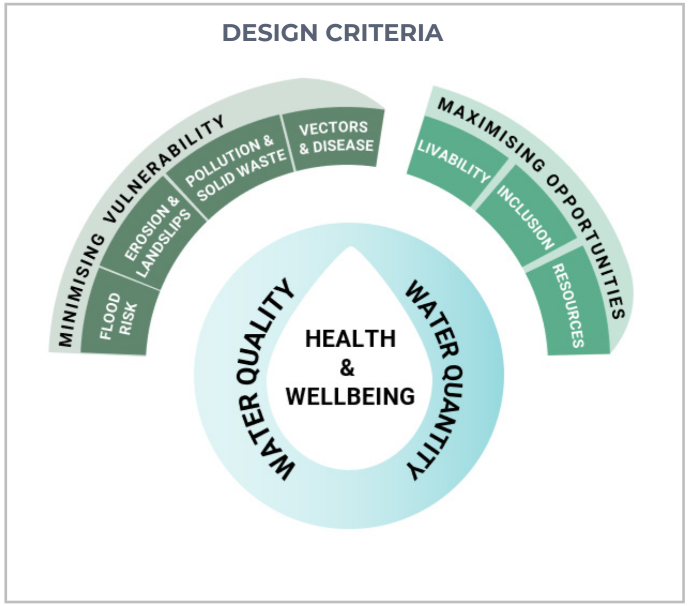
These should be designed to meet the design criteria and each page highlights some key considerations for each criterion.

Generally proprietary products (e.g. pre-cast channels or tanks systems) have been covered in limited detail as their availability may vary in different contexts. The components list is not comprehensive and their may be other local components that are appropriate.

SECTION OVERVIEW

WHY?

The design process should try to minimise vulnerabilities and maximise opportunities by balancing water quantity, water quality to ultimately achieve health and wellbeing (see page 4). Seven design criteria, linking to the benefits of surface water (see p.8), allow these principles and benefits to be delivered and maintained (refer to p.3).



DESIGN CRITERIA

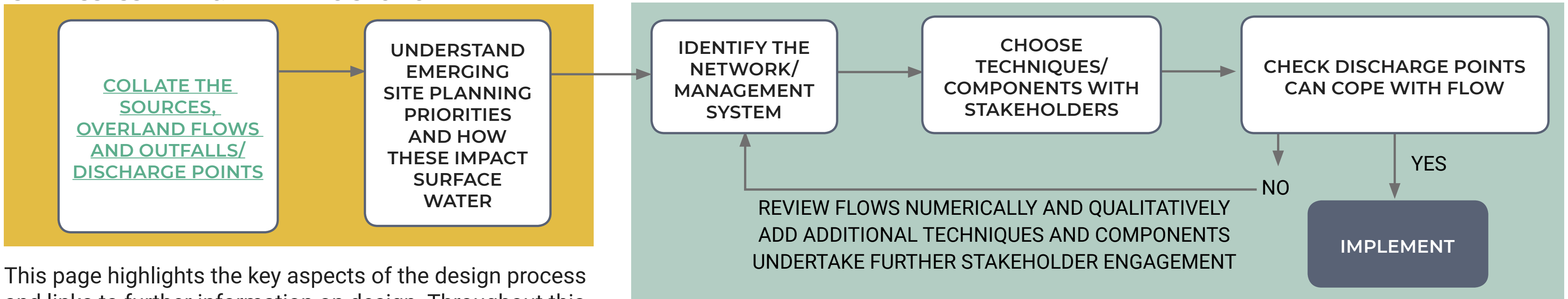
Rules for selecting and making techniques site specific (see digram right).

1. REDUCING FLOOD RISK
2. MANAGING EROSION AND LANDSLIPS
3. MANAGING AND REDUCING POLLUTION
4. REDUCING DISEASE AND VECTORS
5. ENSURING LIVEABILITY
6. ENSURING INCLUSION
7. MANAGING RESOURCES
?. CONSIDER ADDITIONAL CRITERIA SPECIFIC TO THE SITE

THE DESIGN PROCESS INVOLVES THE FOLLOWING ACTIVITIES:

SITE ASSESSMENT & PLANNING SECTION

DURING DESIGN AND IMPLEMENTATION



This page highlights the key aspects of the design process and links to further information on design. Throughout this section we consider how surface water can be managed between the source and the discharge point also known as the 'outfall'. Along the pathway an interconnected system of techniques and components (see p.36) should be chosen to best meet the site conditions.

REMEMBER

The process of designing a surface water management system is likely to be be a non-linear process. As more information on the site is gained, previous sections may need to be revisited and repeated.

DRAINAGE NETWORK

WHY?

Surface water management must be considered from the point at which the runoff starts (the source) to the point at which it is discharged to the 'receiving water' at the 'outfall/discharge point, whilst remembering water flows downhill via the fastest route.

DESIGN TIPS

- **NATURAL DRAINAGE PATTERNS** - Follow and enhance the natural drainage patterns of the site as much as possible to reduce use of resources (e.g. earthworks). Try not to concentrate flows.
- **EROSION REDUCTION** - Refer to topography (p.17) site walkover (p.24), ground conditions (p.18-20) and planting (p.23) to understand where erosion is most likely to occur due to the site conditions. Provide manageable gradients but avoid steep gradients to reduce fast flows and erosion. Where this is not possible consider flow dissipation methods. Steep gradients may be deemed steep depending on their geology and risk to the site (see risk assessment section).
- **MINIMISE FLOW INCREASE** - Overall flow quantity and quality should remain similar to the pre-development situation to reduce impacts downstream.
- **SOURCE CONTROL** - Manage surface water as close to where it falls before it becomes a bigger problem downstream and larger scale actions are needed.
- **DISCHARGE LEVELS** - Carefully consider the levels between the source and the outlet (i.e. level of outfall/discharge point fixes the minimum level of the drainage channels.)
- **RISK REDUCTION** - Consider how the linkage between the source -> pathway -> receptor (see top right) for both water quality and quantity can be removed or reduced.

Further information and advice is available here: CIRIA SUDS MANUAL (2015)

RISK REDUCTION: BREAKING THE WATER QUANTITY AND QUALITY LINKAGE

SOURCE	PATHWAY	RECEPTOR
Removing, reducing and modifying at source (e.g. changing behaviours)	→ Preventing further movement (e.g. increasing vegetation along the pathway)	Protecting the receptor (e.g. raising threshold levels)

SUB-CATCHMENTS/ EXISTING DRAINAGE INFRASTRUCTURE

It is recognised that in some areas there will be limited ability to define the network for an entire or even part site. However, the same principles should apply considering how the sub-catchment flows in to the wider system, or even small individual components. Where it will be retained, existing infrastructure should be incorporated in to the network.

RECOMMENDATIONS FOR VERY FLAT SITES

On flat sites it is recommended that:

- Behaviours and surfaces are changed to minimise runoff and infiltration components used (e.g. soakaways);
- Divide the site in to small sub-catchments;
- Shallow components are used (swales etc.) with combined storage, the hydraulic head should help maintain flow in the system; and
- Avoid ponding, but where this is not possible consider impact on soil strength to local structures.

RECOMMENDATIONS FOR STEEP SITES

- Run drainage along contours to make sure that drainage has manageable gradients.
- Make sure water can cross hillside roads without causing erosion. This will require culverts or crossing-points will sufficient spacing.
- Consider erosion and landslide risks (see p.18-19).

The following pages shows how a drainage network is drawn.

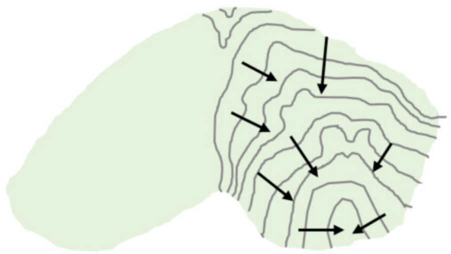
i Accurate records of the network should be maintained so that the impacts of changes to the catchment can be recorded easily as well as any future issues.

! **REMEMBER**

- Make sure that the network aligns with shelter, road configuration, key access routes and primary infrastructure and fire breaks. Ideally the drainage network should influence these to ensure an efficient design.
- If all the water can be removed at source there may be no downstream network - this would be an ideal scenario.

NETWORK ANALYSIS

1



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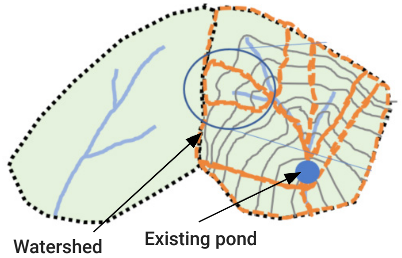

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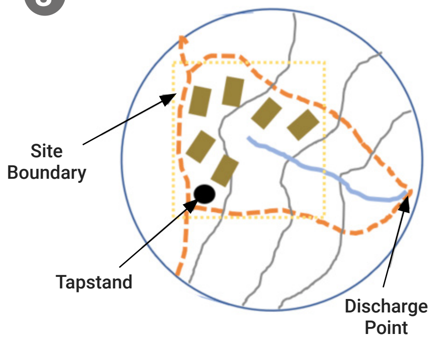

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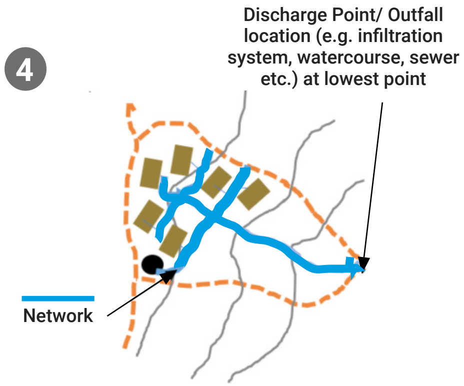


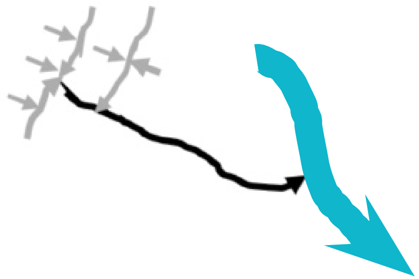
1. Identify the topography and contours and flow paths (refer to p.17). Modelling software can produce this automatically from contour information, but it should be verified by a site walkover. Flow paths (direction of flow downhill) should be directed at 90° degrees from contours.

2. Identify existing natural catchments (black dashed line) and the sub catchments (orange dashed line).

3. Identify proposed and existing drainage components.

4. Identify the drainage network (if all the water cannot be prevented or used at the source).

5



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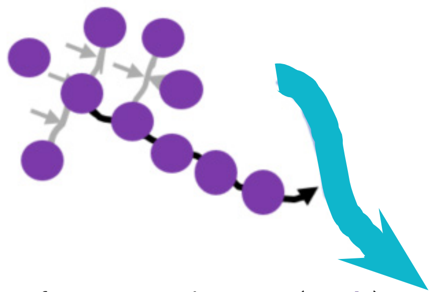


5. Identify hierarchy of the drains:
Tertiary (grey) – neighbourhood level
Secondary (black) – running past the site in to which the tertiary site drains discharge
Primary drain (blue) – a large drainage canal, stream or river in to which a secondary drain discharges.

6. Identify component locations (purple)

i

Clearly record the catchments and use a widely used naming convention for the network (e.g. a number per branch and then a section number i.e. 1.2). This will make it easier for areas of the network and components to be identified.

!

REMEMBER

- **Try to prioritise primary drainage routes before secondary or tertiary.**

See how flows link together through components on page 35.

DESIGN FLOWS

For each catchment or/and source of surface water an estimate of the flow should be calculated. This will be needed for sizing components allowing optimal resources to be used. When sizing components, it is important to remember that the flow **IN** to the system is **EQUAL** to the flow **OUT** of the system. Storage and infiltration in components can be used to manage flows so that flooding does not occur on a site.

Examples of calculation methods for flows in to the network (inflows) for different sources are covered in the table below.

NETWORK LOSSES

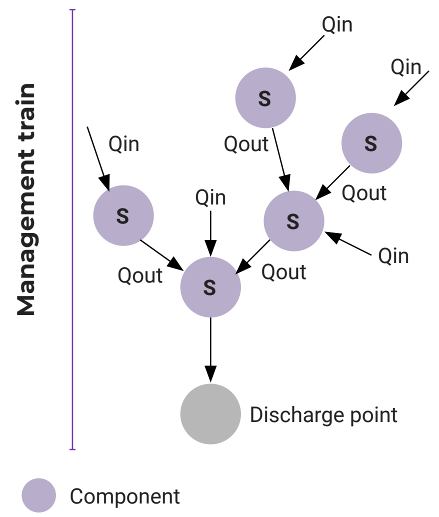
Losses in the network including evaporation, evapotranspiration, transportation and infiltration should be considered, but may be small compared to a heavy storm.

CHECKING THE DISCHARGE POINT AND EXCEEDANCE

Make sure that the discharge point is checked for its capacity and also exceedance (where the water will go if the flows are greater than anticipated). Flows should be discharged off-site slowly to prevent downstream flooding.

If the inflow is too large for the discharge point, and exceedance occurs, surface water will back up potentially causing flooding as the surface water cannot flow away fast enough. Where this happens inflows will either need to be stored or will need to be diverted to another discharge point (refer to the diagram on the right).

Flow in (Qin) =
Flow out (Qout)± Storage/Infiltration (S)



Type	Calculation
Rainfall	Calculating inflows from rainfall is usually completed using the Rational Method if the catchment is smaller than 1km² this states: **Rainfall flow = runoff coefficient x rainfall intensity x area** Refer to the Rainfall on p.21 to find the intensity. Refer to the table on the right for the runoff coefficient. Ideally appropriately experienced hydrology/civil engineering expert should be consulted to help calculate the flows. Refer also to local guidance collated in the site 'assessment and planning' stage. Site larger than 1km² use a different method.
Greywater	Flows can be calculated in several ways: 1. Ideally measure the outflow as it is likely that the volume will have reduced slightly from the tap/ initial source. 2. If (1) cannot be done measure the flow from the tap/ initial source and make an assumption for losses. 3. Make an estimate based on the number of litres used by the population in a given time. Refer to 'Key Indicators' in Sphere Association (2018).
Spilt Water	Consider the volume and whether this would exceed the volume of rainfall. If it is greater consult an appropriately qualified person.

Surface/ Landuse	Rainfall Runoff Coefficient
Asphalt	0.7 - 0.95
Concrete	0.80 - 0.95
Brick	0.7 - 0.85
*** Grassland - flat site (compact/clay/silt soil)**	0.13 - 0.25
*** Grassland - steep site (compact/clay/silt soil)**	0.25 - 0.35
*** Grassland - flat site (silt/sand/gravel soil)**	0.05 - 0.15
*** Grassland - steep site (silt/sand/gravel soil)**	0.15 - 0.2

** - May vary seasonally*
Adapted from Stormwater Drainage Manual: Planning Design and Management. Drainage Services department, Hong Kong Government 2nd Ed 1995.

REMEMBER

- Take care with units particularly when converting .
- Note 1m³ is equal to 1000l and therefore 1m³/s is 1000 l/s.
- Ensure that the worst case scenario is considered when calculating flow within catchments. Make sure that flow enters at the most upstream part of the network as this will be the worst case condition.
- Consider the impacts of multiple flows i) is this likely ii) what are the impacts iii) how can the risk be mitigated?
- Modelling software can help design the network and components as well as indicating sizing but this should be checked.
- It is likely that there will be many solutions to the same problem.

CHOOSING TECHNIQUES AND COMPONENTS

A range of techniques and components can be adapted to the context and used together to manage runoff across each site (see table below). When choosing techniques consider the following aspects (refer to the figure left):

- Consider all the design criteria and use techniques that will meet these benefits (refer to p.3, p.30 and 32)
- Prioritise source control techniques (techniques used to manage the water where it lands rather than allowing it to move downstream). This reduces the size of infrastructure needed downstream. Source control techniques include using prevention, use, treatment, infiltration and storage at the place that the surface water originates;
- Manage the runoff in sub-catchments (parts of catchments). Refer to p.33;
- Infiltrate, slow and store where appropriate (note this may vary across the site) considering the site assessment information;
- Avoid conveying surface water as much as possible;
- As a last resort consider berms/ plinths to redirect the water; and

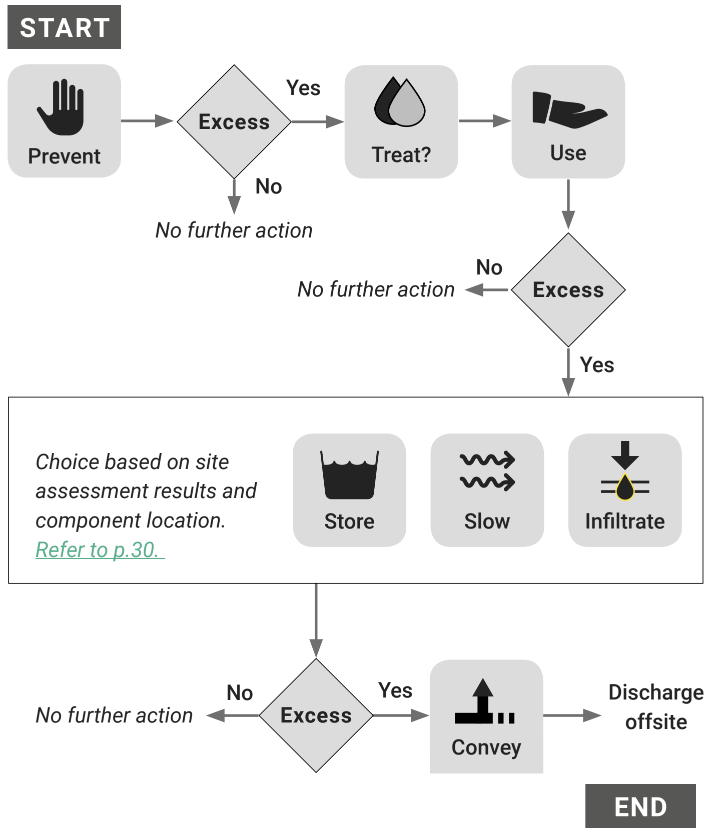
Manage water as close to the surface as possible.
This hierarchy is explained in the diagram on the right. Make sure that through this process the route of the surface water to and between components is considered as well as exceedance routes (see page. 35).

Note: ✓ = Yes ~ = can design component to function in this way

		Prevention and mitigation techniques (see appendix 4)	Prevent	Treat	Use	Infiltrate	Slow	Store	Convey	Cost
COMPONENTS	I	Changing behaviours	✓		✓					$
	II	Changing surfaces	✓	✓	✓	~	✓	~		$
	III	Rainwater harvesting and tanks		~	✓			~		$$
	IV	Soakaways & infiltration devices		~		✓	~			$$
	V	Dry basins (incl. retention basins)		~	~	~	✓	✓		$
	VI	Ponds & wetlands		✓	~	~	✓	✓		$$-$$$
	VII	Channels (swales & lined channels)		~	~	~	~	~	✓	$-$$
	VIII	Berms and plinths	✓						✓	$$-$$$
	IX	Check dams		~		~	✓	~		$-$$
	X	Silt and grease traps		✓						$$
	XI	Culverts and pipes				~		~	✓	$$-$$$

Table showing components and techniques available and which surface water management tools they include or could include if designed in to the component or technique.

DECISION TREE FOR CHOOSING SURFACE WATER MANAGEMENT TOOLS (SEE PAGE 4)



REMEMBER
Make sure that there is a good appreciation of all the different techniques and components before deciding on the most suitable technique or component for the site.

I CHANGING BEHAVIOURS

COST: $ Low

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

This component involves educating the community about surface water management principals and advocate for the benefits of behavioural change This section covers behavioural changes that:

- Remove runoff (completely take out of the system), reduce the chance of runoff or move flows (to another part of the catchment or a different catchment);
- Improve the operation of surface water management systems; and
- To enable appropriate multi-functionality of systems.

WHEN/WHERE?

- These methods should be discussed with stakeholders before implementation, see stakeholder engagement section p.11.
- Consider the impact of changing behaviours and prioritise interventions that will reduce the drainage infrastructure needed and increase livability for all.

DESIGN CRITERIA

Reducing flood risk

- Consider how people might change their behaviour during periods of high flood risk (e.g. avoiding zones allocated to short-term flooding).
- Consider how people can reduce peak (maximum) flows (e.g. by washing in dry periods as much as possible or having a washing rota to spread out the flow, using low flow fittings so that the total runoff from greywater is reduced and increase/maintain vegetated areas.

Managing erosion and reducing landslips

- Reducing/removing runoff influenced by human behaviours. This can reduce total flows and therefore downstream erosion.
- Avoid behaviours that increase erosion - for example removal of vegetation (this may require provision of alternative fuels or sheltermaterials), walking or driving off-roads and off formal paths, causing rutting in roads (which will cause water to stagnate if their is no drainage). Avoid shelter drainage that discharges quickly in a concentrated area causing local erosion particularly in steep areas prone to landslips (refer to p.17-20).

Managing and reducing pollution

- Encouraging people to avoid/reduce pollution of watercourses (e.g. reconsideration the location of washing out potable water containers)
- Good solid waste management that avoids blockage of components of the network or water pollution.
- Latrines should be designed to avoid contamination of surface or ground waters.
- Encouraging people to grow vegetation.

Reducing disease and vectors

- Explore opportunities to reduce the impact of pests and disease by considering risk reduction (p.33) e.g. by persuading people to avoid going to hazardous areas (e.g. swimming in contaminated waters) or behaviours that encourage disease/vectors.

Ensuring livability and inclusion

- Consider how behaviour change towards a common goal can improve morale and feeling of community.
- Before implementation, consider how behaviour changes may impact on particular parts of the community (e.g. women, children and vulnerable groups) positively and negatively. Encourage behaviours that improve the lives of members of these groups and avoid behaviours that could cause issues for these individuals.

Managing resources

- Consider and discuss widely how good surface water management can reduce cost the site infrastructure, improve health and wellbeing and quality of life.

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

- Where appropriate get the local community to support operation and maintenance activities (e.g. working with stakeholders to appoint a drainage committee, considering educational levels and past experience and people's roles in the community).
- Set procedures for monitoring the behaviour change needed.
- Look for opportunities to reskill or upskill community *members.*

PHASING

Consider what might have the greatest impact on the site overall and try to encourage these behaviour changes first. Incrementally encourage additional behaviour changes and communicate the impacts.

C CASE STUDY

Water point in an IDP camp in Juba, South Sudan (Source: Oxfam, 2014), taken from HIF (2016) Surface Water Drainage WASH Problem Exploration Report (2016).

Images shows stagnant water around a water point, potentially due to cleaning out of water cans.

i Record the behaviour changes requested and the predicted impact. During operation and maintenance record the impact of these actions and communicate widely.

A SITE APPRAISAL ACTIVITY

Make sure that stakeholders and their influence is well understood. Work with other individuals and groups to try to strength behaviour change programs.

! REMEMBER

It is important to monitor these behaviours particularly if the assumption that these are being done is critical to the surface water management plan.

CONT.

II CHANGING SURFACES

COST: $ Low

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

This technique covers changing the surface of the runoff surfaces like the ground or roofs to:

i. increase natural infiltration;
ii. increase evapotranspiration rates;
iii. slow runoff and reduce the overall volume;

By increasing vegetated surfaces many other benefits can be gained (see p. 23). 'Changing surfaces' also applies to the design of shelters to minimise fast runoff.

WHEN/WHERE?

The principles can be applied everywhere to reduce runoff and improve the quality of runoff.

DESIGN CRITERIA

Reducing flood risk

- The greater the permeability of the surface the lower the runoff, the lower the flood risk. When calculating flows make sure that the surface type is included, see p.35.
- In steep locations terracing could be used to help slow runoff and reduce flood risk.

Managing erosion and landslips

- Increased vegetation can reduce erosion locally and help reduce landslips. Vegetation must be carefully chosen as it may increase erosion/landslips, see p.23.

Managing and reducing pollution

- Permeable surfaces can help improve water quality locally. However, if the water is highly polluted, the runoff should be treated before it is released to the environment, see p.22.

Reducing disease and vectors

- Try to understand vectors and their preferred and least preferred surfaces and vegetation. Use this information to deter them from the site, refer to p.23.

Ensuring livability

- Involve local stakeholders when choosing materials. Avoid blocking escape routes and support public space creation, see p.10).

Ensuring inclusion

- Make sure vulnerable groups are considered, for example vegetated areas/gravel might be difficult for people with mobility impairments to cross.

Managing resources

- Consider the benefit to the environment, refer to OCHA/UNEP (2014) Environment Marker.
- Use materials/vegetation that are are already insitu (see activity right).

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

- Involve stakeholders when choosing materials.
- Make sure that the surface chosen is suitable for the daily loading expected. Consult an appropriately qualified person to design trafficked roads.

Consider who will maintain the surfaces chosen including:

- Cutting grass and vegetation
- Desilting drainage routes close to loose gravel/stone paths

PHASING

Prioritise the use of highly vegetated surfaces as these will make the greatest difference to flows, pollution reduction and therefore improve health and wellbeing.

SIZING

Refer to p.35 to see the impact quantified in the flow reduction.

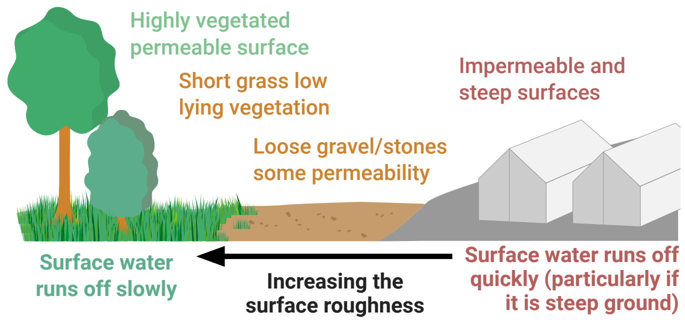


Figure illustrating impact of increased surface roughness

C CASE STUDY

In Cox's Bazar, the impact of high temperatures, direct sunlight, a lack of wind breaks and poor thermal insulation of shelters was reduced by planting trees and using climbing plants around shelters. The community and environment specialists were consulted as well as WASH and Shelter to avoid impacts on underground works. This also reduced runoff.

IOM (2018b) Catalogue of Site Improvements

A SITE APPRAISAL ACTIVITY

Make sure that during a site walkover, refer to p.24, existing surfaces are reviewed:

- Identify local materials available
- Identify where existing surfaces are fit for purpose and where there are issues.
- Identify vegetation that grows well locally.
- Understand what local stakeholders think and prefer.

! REMEMBER

It is recognised that heavily trafficked areas may need more tightly bound materials and therefore permeable gravel or vegetated surfaces may not be suitable, particularly in wet weather. In these areas carefully designed drainage networks will be key to making sure the impact of these surfaces is mitigated.

III RAINWATER HARVESTING

COST: $$ Mid Range

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

This component collects rain water and stores it for use.

WHEN/WHERE?

This component should only be implemented where the water will be used (i.e. there must be a purpose for using the water for example washing clothes etc.).

DESIGN CRITERIA

Reducing flood risk

During extreme events, unless the RWH storage tank is empty there will be limited benefit to reducing flood risk. Consider this when calculating the storage capacity by assuming that the storage tank is full.

Managing erosion and landslips

- Consider how flows can be slowed during use or overflow.
- Consider how this system might overflow and prevent erosion of these areas.

Managing and reducing pollution

- Install a first flush system (see image right). Pollutants are likely to bind to surfaces between rainfall events therefore concentrations of pollutants are usually higher at the beginning of a storm event. A first flush system can help remove these pollutants.
- Install a filter system to improve water quality.

Reducing disease and vectors

- Make sure storage devices are covered to prevent the storage being used as a breeding location.
- Try to use a black plastic tank. This will reduce growth of bacteria as the tank will be dark inside. Use a roofing material that will reduce the need for treatment

Ensuring livability, inclusion and managing resources

- Rainwater harvesting can increase water availability (e.g for irrigation) there may be an opportunity to use this water elsewhere on the site, but it is easier, and may reduce spills and contamination, if storage and use is close to where the surface water lands. Consider how water usage changes through the seasons and how to make sure that there are equitable water resources for all. Refer to p.11-13.
- Involve local stakeholders when choosing the rainwater harvesting system location. Make sure vulnerable groups are considered - for example think about the height of the tap at the storage device.

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

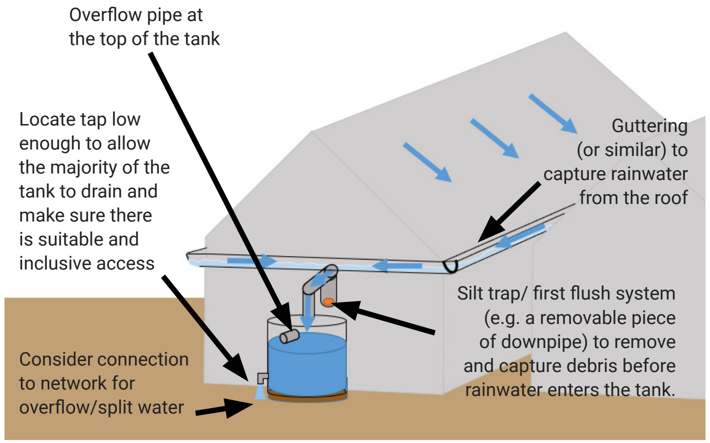
- Involve stakeholders when choosing locations of RWH systems.
- Make sure that water will be used every few days to keep the water circulating in the tank and reduce issues from stagnation.
- Consider who will maintain the rainwater harvesting units. Make sure that the tank can be accessed for cleaning etc.
- Make sure there is another supply for water for dry seasons/extreme cold and consider how the maintenance needed during these extremes.

PHASING

Unless a significant volume of surface water can be captured, prioritise other components before rainwater harvesting unless the additional water would be beneficial immediately.

SIZING

Refer to Engineering in Emergencies (2002) p.285-287 and the CIRIA, SuDS Manual (2015).



Rainwater harvesting unit including downpipe for removal of debris/silt.

A SITE APPRAISAL ACTIVITY

- Refer back to site appraisal to understand feasibility and possible uses of water.
- Follow Sphere Handbook (2018), WASH Chapter, Water supply standard 2.1: Access and water quantity.
- Look for opportunities to reuse water, such as for vegetable gardens, brick-making or irrigation."

! REMEMBER

- Consider how water enters the rainwater harvesting system. Are the gulleys sized correctly for the rainfall predicted (will the water even reach the tank?).
- Make sure that the tank has an overflow pointing away from shelters or structures.
- From a construction, operation and maintenance perspective it may be easier to design these systems for institutional structures.

CONT.

IV SOAKAWAYS & INFILTRATION DEVICES

COST: $$ Mid Range

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

This component helps remove water from the system by increasing the natural ability of the soil to soak water to the ground through infiltration

WHEN/WHERE?

This method can only be used when local ground conditions allow water to naturally infiltrate in to the ground (see p.18-20). Before designing any infiltration systems, make sure an infiltration test has been completed. If the infiltration rate is lower than the incoming predicted flow, increase the size of the infiltration device to create storage and increased surface area for the water to infiltrate through or consider how the excess water will be dealt with. Infiltration may also be encouraged by increasing permeable surfaces and vegetation.

DESIGN CRITERIA

Reducing flood risk

- Consider where the surface water might overflow in an extreme event and how this impacts downstream areas.

Managing erosion and landslips

- Make sure inlets have a shallow gradient to slow flows in to the system. Distribute (i.e. do not concentrate) flows .
- Make sure appropriately graded and compacted gravel/media is used.

Managing and reducing pollution

- Make sure rockfill/media or gravel fill used is not contaminated
- Install a silt trap before the infiltration device to remove silts. Pollutants often bind with silts therefore this may help with pollutant removal.
- Make sure polluted water doesn't infiltrate/contaminate ground water.

Reducing pests/vectors

- Try to make sure that pipes are inaccessible to pests and vectors.
- Ensure that if components overflow, there is a flow route available. If the water ponds this could become a habitat for pests/vectors.

Ensuring livability and inclusion

- These components can free up space in constrained sites to use for recreational/outdoor purposes. Avoid trafficking above infiltration trenches (unless designed for this load). Refer to p.11-13.

Managing resources

- Use materials on-site wherever possible. Optimise the design and the location for the component based on assessment of ground conditions (see. p.17-20)

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

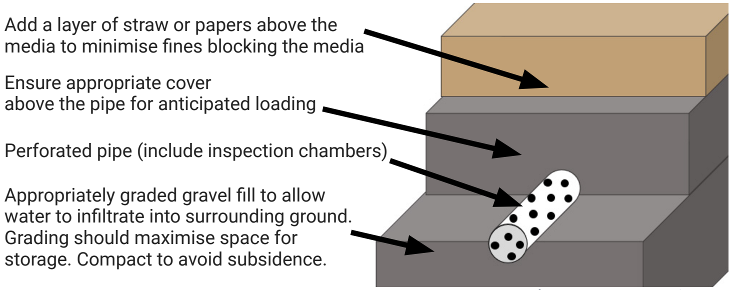
- Involve stakeholders when choosing locations and decide who will maintain the device. Make sure the area above the device is not trafficked, this could lead to compaction, reducing the ability of water to infiltrate in to the ground.
- Perforated pipes can be used to distribute flows. Consider their maintenance in the design including suitable inspection chambers
- Concrete rings may be used instead of a trench filled with media.

PHASING

Prioritise the use of highly vegetated surfaces to improve infiltration as these will make the greatest difference to flows, pollution reduction and therefore improve health and wellbeing.

SIZING

- Calculations should account for volume loss due to gravel/media.
- Refer to Engineering in Emergencies (2002) p.175-178.
- Consider impact of lower than expected infiltration rates.



Soakaway cross-section

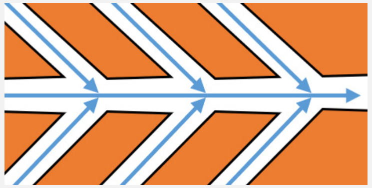
A **SITE APPRAISAL ACTIVITY**

Need to find out the infiltration capacity? Refer to p.20
Obtain a rate in mm/ e.g. if the rate is 300mm/hr this means that a 0.3 m deep trench of plan area 1m², if filled with water, will take 1 hour to drain.

Trench dug for an infiltration device (IOM, 2018c)

! **REMEMBER**

- A high water table will limit infiltration.
- Consider the hazards in the local context (see Appendix 1). Hazards may include ground water, excavations and unstable ground.
- Infiltration and soakaway devices only work when the local soil conditions have sufficient infiltration capacity. If there is insufficient capacity ensure storage or an overflow is provided (checking that downstream areas can cope with these flows).
- Herringbone drainage should not be confused as an infiltration device. It is component to drain land through shallow conveyance through pipes (see image below).



V DRY BASINS OR DETENTION BASINS

COST: $ Low

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

This component involves an excavated area where water can be stored **temporarily** during heavy rainfall, allowing evaporation, before draining slowly back in to the network. Vegetated depressions for detaining water can also be called rain gardens.

WHEN?

Use in areas without shelters/critical infrastructure, where space is available, and the levels are suitable to allow in and outflow.

DESIGN CRITERIA

Reducing flood risk

- Make sure the basin is adequately sized. The basin may be stepped for different storm events.
- The basin may have to cope with events in quick succession during a storm so there should be suitable capacity. Consider exceedance events.
- A flow control will be needed to hold the water back.
- If the ground and water quality is suitable infiltration (p.20) can occur in the basin. Therefore it can be sized for both infiltration and storage.

Managing erosion and landslips

- Make sure that the inlet and outlet are carefully sized to keep flows low enough to reduce erosion.
- Make sure slide slopes are shallow (max 1 in 3) and vegetated.

Managing and reducing pollution

- A silt trap/forebay and pollution control before the device will help catch silt and pollution before it enters the basin. Gratings can be used for large debris if needed. Ensure people don't dump waste in the basin.
- Include vegetation in the basin (grasses are ideal) to increase natural treatment of surface water. Ensure shallow slopes to avoid erosion.
- Geotextiles may be used to avoid infiltration if the water is polluted but these are expensive.

Reducing disease and vectors

- Try to understand local pests and vectors and their behaviours, see 'Remember' on p.23. Designs may access for predators ii) avoid a bathymetry (shape) that creates isolated pools where water may stagnate iii) provide pollution control upstream so food/habitats are not provided in the basin iv) ensure levels will naturally fluctuate which will help disturb breeding cycles.

Ensuring livability and inclusion

- Involve local stakeholders when choosing locations. Basins could be public space areas, stepped meeting space etc. when dry and planted accordingly. These features may also be hard landscaped - although this reduces the basins infiltration and ecological potential.
- Involve stakeholders, including vulnerable groups (see p.13) when choosing a location, considering user needs and communicating how the space will change during storm events. Consider using offline storage if there is a desire to avoid all flows going through the basin.

Managing resources

- Try to use natural depressions on the site to avoid the need for earthworks.

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

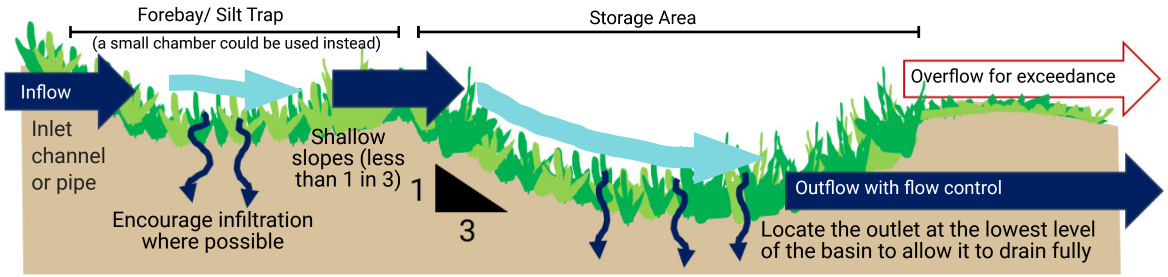
- Provide easy access for O&M including monitoring of pests, vectors and water quality. Ensure maintenance procedures do not result in wheel rut and other localised depressions that create isolated pools when water levels fall.
- Consider who will maintain the component and associated landscaping and how this will be done.
- Consider extreme weather events (e.g. cold) and where extreme flows will go.

PHASING

Prioritise larger storage areas as these will have the greatest impact.

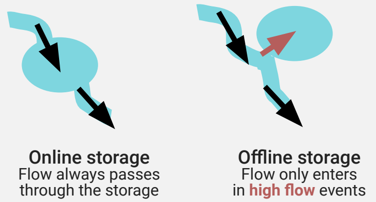
SIZING

- Refer to CIRIA SUDS Manual Chapter 22 or/and the US EPA Stormwater Best Practice Design Guide.



Dry basin cross-section

KEY INFORMATION
Offline and Online Storage



Tanks
Tanks may also be considered as storage devices. However, these often require significant excavations and resources. Tanks can be difficult to maintain underground, require sediment traps and do not provide water treatment. More information can be found in the CIRIA SUDS Manual (2015).

REMEMBER

- Consider hazards (see Appendix 1) for example make sure the depth of the basin is communicated or mitigation measures are put in place, as the depth of water may cause a hazard.
- Make sure that exit routes are clearly indicated and well design also for vulnerable groups.
- Signs should be place indicating that that area is a dry basin and it has a flood risk.

VI PONDS & WETLANDS

COST: $$ Mid Range to $$$ High Cost Note: Ponds and wetlands may be low cost if they are already on the site.

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

This component can help store water and improve water quality.

WHEN?

Ponds/wetlands can be used when permanently flooded areas are appropriate.

DESIGN CRITERIA

Reducing flood risk

- Make sure the pond is adequately sized. The pond may be stepped for different storm events. Consider how flow in and out is controlled and where the water overflows.

Managing erosion and landslips

- Increased vegetation can reduce erosion locally
- Side slopes should be shallow (try a minimum of 1 in 3) to avoid erosion unless sufficient edge protection is designed.
- Consider overland flow paths for an exceedance event - where will excess water go to in a big storm.

Managing and reducing pollution

- Wetlands may be designed to treat pollution.
- Ensure people don't dump waste or clean clothing in the pond (refer to 'changing behaviours' p.37)
- If the water is highly polluted the waters should be treated before the water is released to the environment. If designed appropriately these components can help with treatment of water.
- Make sure there is a silt trap upstream.

Reducing disease and vectors

- Consider preferred surfaces and vegetation, refer to p.23 and p.41 and in addition i) incorporating a steep slope into the water, preferably greater than 30° or 3:1 horizontal to vertical. Note that steep edges may be unacceptable for safety reasons ii) allow wave action from wind to disrupt breeding iii) avoid water weeds that support breeding (e.g. water hyacinth) iv) enable natural/man-made water fluctuations to disturb breeding. Ponds should be avoided if standing water is likely to make disease/vectors difficult to control.

Ensuring livability

- Consider health, wellbeing and safety risks and benefits before implementation. Ponds can create relaxing public spaces and create significant local environmental benefits.

Ensuring inclusion

- Consider the safety and health of vulnerable groups, for example children may be attracted to play near open water.
- Involve stakeholders, including vulnerable groups (refer to p.11-13), when choosing locations.

Managing resources

- As per p.41, try to use natural depressions or existing ponds/ wetlands/lake features on the site to avoid the need for earthworks and lining materials.

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

- Make sure that the pond chosen is suitable for the daily flow of surface water.
- Consult an appropriately qualified person (e.g. WASH expert) if the pond/wetland is to be used for water treatment.
- As per p. 41, **consider who will maintain the component and associated landscaping chosen including:** cutting grass/ vegetation and desilting drainage routes and ongoing managagement of solid waste. Design in adequate access for maintenance and vehicles.
- Systems can continue working during cold temperatures. The impact of extreme weather on O&M should be considered.

PHASING

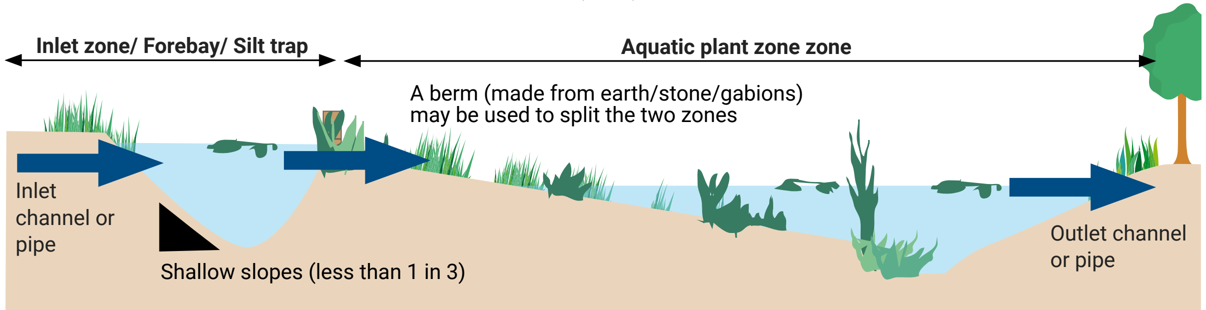
Prioritise the largest ponds as they are likely to have the greatest benefit.

SIZING

- Ponds and wetlands should be carefully designed to meet the needs of the site and minimise health/water quality risks. Carefully design the shape of the pond to distribute flow and avoid stagnant zones.
- Refer to CIRIA SUDS Manual (2015) Chapter 23 or/and the Compendium of Sanitation Technologies in Emergencies (2018) p.112.

! REMEMBER

- **Make sure the depth of the basin is communicated or mitigation measures are put in place, as the depth of water may cause a hazard to people. This may be helped by careful design of the margins and suitable planting.**
- **A risk assessment should be conducted and risks mitigated, see p.25, 26, 62.** Seek support from appropriately qualified staff.
- **Consider hazards at the inlet - e.g. high velocity/sudden discharge or concentration of contaminants/ pollution.**



CONT.

VII CHANNELS (SWALES, FILTER DRAINS & LINED CHANNELS)

COST: $-$$ Low to Mid Range (depending on specification)

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

This component moves/conveys water from one location to another, and. if carefully designed, can provide slowing, storage and infiltration.

WHEN?

A channel should be used to connect components, or promote runoff in a particular direction to a discharge location.

DESIGN CRITERIA

Reducing flood risk

- Consider the use of flow controls and check dams to slow flows and store water in the channel.
- Consider where water will go if the system over-tops and that this would not cause harm to anyone.
- Encourage infiltration at the base of the channel but also consider the location of the channel /if it could increase landslide risk (p.18-20, 23).

Managing erosion and landslips

- Make sure that the gradient is <5% to avoid fast flows. Make sure side slopes are shallow and include check dams as necessary.
- Vegetation in the channel can reduce erosion (refer to p.23) temporary linings may be used until vegetation established to prevent erosion.
- There should be careful consideration of lining options, it may be better to construct a earth channel and to review/adjust as necessary.

Managing and reducing pollution

- Permeable surfaces can help improve water quality locally refer to p.38. However, if the surface water is highly polluted the water should be treated before the surface water is released to the environment.
- Use planting and rockfill/gravel in the channel or swale to capture pollutants and allow filtration, refer to p.23.

Reducing disease and vectors

- Try to understand local pests and vectors and their preferred and least preferred surfaces and vegetation (refer to site assessment section particularly p.23). Use this information in the design to deter them from the site. The channel should not have flat areas or depressions where water can pond.

Ensuring livability and inclusion

- Involve stakeholders when choosing locations. Involve local stakeholders when choosing materials. Avoid blocking escape routes and support the creation of public spaces.
- If greywaters are not carefully managed these channels may turn in to open sewers (refer to 'changing behaviours' p.37).
- Make sure vulnerable groups are considered. Ensure adequate crossing points for all refer to p. 47 Consider the levels around the channel. Will the ground level change at a different rate to the invert level? What impact does this have on the channel depth and how it fits in the landscape? Could the depth create a hazard?

Managing resources

- Wherever possible, use shallow vegetated channels these can be crossed easily and safely and are likely to provide the greatest environmental and health benefit. It is likely to be lower cost and risk to have many shallow vegetated channels than few deep lined channels or closed drains, refer to Ouano, E. A. and Cairncross S., 1991.
- Turnout drains on roads/paths may help networks reduce concentrated flows and erosion.

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

- Weepholes in lined channels and masonry drains avoid water building up behind the drain which could cause collapse.
- In soft ground consider aprons around drainage to reduce erosion next to the drain particularly if there is insufficient vegetation locally.
- Consider maintenance at steps/check dams to remove silt/debris.
- Increasing the steepness of the side can be achieved with stronger ground material or reinforcing the channel sides with concrete, rubble or sandbags but a vegetated channel likely to be safer, easier to maintain and will optimise infiltration.
- Consider who will maintain the channel and cut vegetation, this component will require regular de-silting and removal of solid waste
- Size appropriate/safe crossings (both vehicles and pedestrians) p.47.

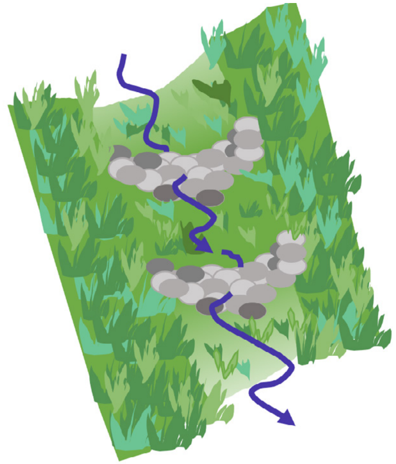
PHASING

Prioritise primary channels first.

SIZING

- Refer to Surface water drainage in low-income communities (Ouano, E. A. and Cairncross S., 1991 p.78-82) & CIRIA SUDS Manual (2015).

Covered channel in Cox's Bazar (IOM, 2018c).



Swale with check dams

! REMEMBER
Lining channels may reduce erosion however they are likely to be high capital, require greater skill in design and construction and are harder to maintain. They also do not help reduce pollution. They can also give an impression of permanent infrastructure in a temporary camp and create a hazard.

VIII BERMS AND PLINTHS

WHAT?

This component involves raising areas and redirecting runoff using earth mounds/embankments. These are not drainage elements but provide resilience to a settlement through flood prevention.

WHEN?

Plinths can be localised at shelter or tapstand scale.
Berms are applied usually over large site areas to protect land downstream. It may impact areas up and downstream from the site as flood storage is lost. The system can be costly particularly if pumping is needed to dewater areas inside of a berm.

DESIGN CRITERIA

Reducing flood risk

- Estimate the peak flood levels based on the site appraisal or site specific flood modelling, berms or plinths should be above this level.
- Consider how surface water runoff drains from berm or plinth structures and affect infrastructure and people downstream.
- Consider exceedance flow routes and sacrificial flooding routes. Berms are very likely to cause flood in other areas and this need to be studied before the implementation.

Managing erosion and landslips

- Berms and plinths should be designed by an appropriately experience person who will understand how the material available should be used on the site. For example plinths and berms should be carefully compacted and should have appropriate slope angles so that erosion of the berm, plinth or surrounding area does not occur.
- Use vegetation to support slope stability. Consider use of cement stabilisation in plinths.

Managing and reducing pollution

- Include vegetation in the designs where feasible to reduce local pollution.

Reducing disease and vectors

- Try to understand local pests and vectors and their preferred and least preferred surfaces and vegetation. Use this information in the design to deter them from the site. The earthworks should not have flat areas or depressions where water can pond.

Ensuring livability and inclusion

- Consider how berms can be combined with other critical infrastructure, for example roads, power supplies and pathways. Berms and plinths can have a very big impact on mobility and need to be designed considering any current and future roads.
- Mitigate impact on stakeholders/vulnerable groups referring to engagement with these groups (see p.11-13).

COST: $$ Mid Range to $$$ High Cost

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

Managing resources

- The system can be costly particularly if pumping is needed to dewater areas inside of a berm. Try to build berms and plinths by optimising resources already on the site (refer to p.18-19).

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

- Involve stakeholders when choosing locations and discussing implementation and maintenance. Consider how maintenance can be delivered to optimise functionality - e.g. could road maintenance be scheduled at the same time as drainage.

PHASING

- Prioritise construction before the rainy season and areas of highest risk or areas with critical infrastructure.

SIZING

Seek advice from appropriately qualified staff, these are potentially costly and hazardous infrastructure if not designed properly. Refer also to Ouano, E. A. and Cairncross S., 1991 Surface water drainage for low-income communities.

IOM/Muse Mohammed, 2016 - Protection of Civilians site in Bentiu, South Sudan, 2016.

Plinths in Cox's Bazar. IOM (2018b) Catalogue of site improvement

i Additional reading on design in flat areas can be found on p.19-22 in Ouano, E. A. and Cairncross S. (1991)

! **REMEMBER**
Seek support from appropriately qualified staff when designing plinths and berms. These must be carefully designed for local conditions, loadings and use of local materials.

IX CHECK DAMS

COST: $ Low to $$ Mid range

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

This component involves building a small barrier across a swale or channel to slow of flows. They may be called baffles.

WHEN?

Use check dams to reduce velocities, prevent erosion and reduce downstream lood risk.

DESIGN CRITERIA

Reducing flood risk

- If carefully designed check dams can reduce flood risk by slowing and storing surface water (refer to p.41).
- When designing check dams consider how the check dam overflows and where this excess water will go. Consider also the consequence of check dam failure and try to mitigate the impact.
- Ensure regular maintenance of check dams by removing silt/debris build-up, so the designed capacity is maintained.

Managing erosion and landslips

- Check dams are very good at slowing flow but if not carefully designed erosion could undermine the check dam particularly where the water collects behind the dam and where it splashes over the dam. If required strengthen these areas for example by using loose stones or pitching but this can be done incrementally during operation.
- Make sure that the checks are embedded in to the sides of the channel to stop flow around the check dam rather than over the dam. Consider incorporating a notch/lower section in the centre of the dam to encourage flow to pass at centre rather than eroding the side slopes.

Managing and reducing pollution

- Include vegetation in the design and use the check dam to capture debris and silts.

Reducing disease and vectors

- To avoid standing water behind the dam incorporate a small outlet (e.g. gap or pipe near the base of the dam to promote flow through the dam) or use gabion baskets (refer to p. 23 and 41).
- Remove silts/solid waste during O&M these could provide habitats.

Ensuring livability and inclusion

- Involve local stakeholders when choosing locations.

Managing resources

- Check dams can help increase the longevity of surrounding drainage infrastructure. Use local resources to reduce costs and complexity of maintenance. Avoid steep channels wherever possible as these are likely to cost more per metre and require greater maintenance.

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED OPERATION & MAINTENANCE

- The height of the dam should be lower than the surrounding channel.
- Check dams should be spaced so that the top of the check dam is no higher than the foot of the check dam upstream.
- Involve stakeholders in the maintenance - removing silt, debris and solid waste from behind the dams and making sure that the dams are working correctly. Ensure solid waste is not left behind the check dam.
- When choosing the material for the dam consider the longer-term maintenance, wood may be cheap and natural but would need replacing more often than stone. Make sure that the dam is fixed in place to avoid flow beneath the dam compromising the structure and stability and causing it to collapse.

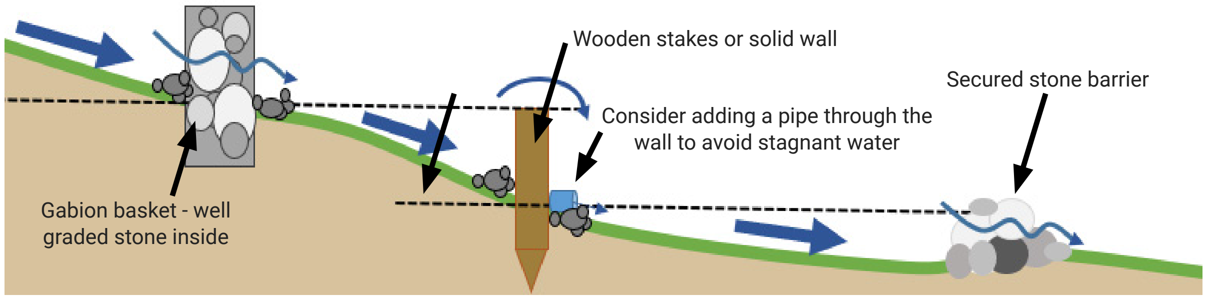
PHASING

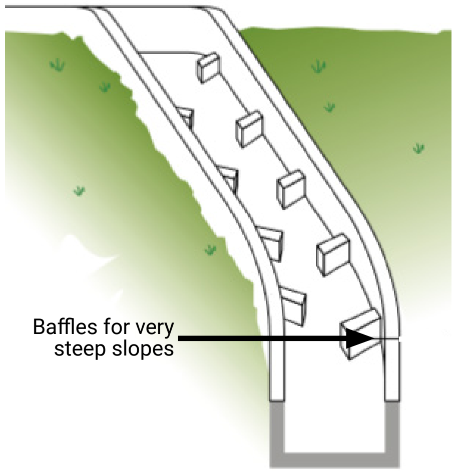
- Construct before the rainy season and in the steepest channels first.

SIZING

- Refer to: Building Roads by Hand (1990) Chapter 22 and Engineering in Emergencies (2002) p.516-17.
- As a guide, make sure that the top of the check dam is no higher than the base of the upstream check dam. Spacing will need to increase with gradient and in softer (less cohesive) soils, refer to p.18-19.

Check dam options





For very steep channels baffles, steps and checkwalls could be used to slow flows. However, the gradient of the channel should be reduced wherever possible first (image from the Compendium of Sanitation Technologies in Emergencies, 2018*)*

REMEMBER
Make sure that there is a maintenance plan for checking the operation of check dams and clearing debris/silt and solid waste away from the area behind the check dam safely.

X SILT AND GREASE TRAPS

COST: $$ Mid Range

WHAT?

This component involves trapping silts and grease. The primary aim of these systems is to slow the velocity down, minimise turbulence and allow silts to fall on to the base/bed of the system and grease to float to the top. Nature can be used to trap pollutants as well as concrete traps, for example filter strips may also be used to remove pollutants and forebays (see ponds and dry basins), refer to the CIRIA SUDS Manual (2015) p.291.

WHEN?

These should be used as close to the source as possible to remove silts or grease, for example around cooking, parking bays or washing areas. Silt traps should be used prior to surface water being transported underground/to inaccessible locations as silt will be very difficult to remove from these locations. Small quantities may be removed by vegetation without the need for formal silt or grease traps.

DESIGN CRITERIA

Managing flooding

- Try to design out the possibility of blockage of the device.

Managing erosion

- Make sure inflow is controlled to stop erosion of the device.

Managing and reducing pollution

- Dispose of silts carefully to avoid them re-entering the system.

Reducing disease and vectors

- Try to understand local pests and vectors and their preferred and least preferred surfaces and vegetation. Use this information to design. Silt or grease traps may require covers and gratings.

Ensuring livability and inclusion

- Involve local stakeholders when choosing locations. Avoid putting them in very busy areas but make sure that they are accessible and can be easily cleared. Make sure that the behaviours of vulnerable groups does not make the silt trap a hazard (e.g. inquisitive children)

Managing resources

- The inclusion of silt and grease traps is likely to reduce the need for costly pollutant removal downstream and will reduce blockages. Therefore reducing negative impacts of water quality and quantity.

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED MAINTENANCE

- Involve stakeholders when choosing locations and designing maintenance plans.
- Make sure that it can be easily and safely maintained.
- For ease of implementation proprietary products could be used.

PHASING

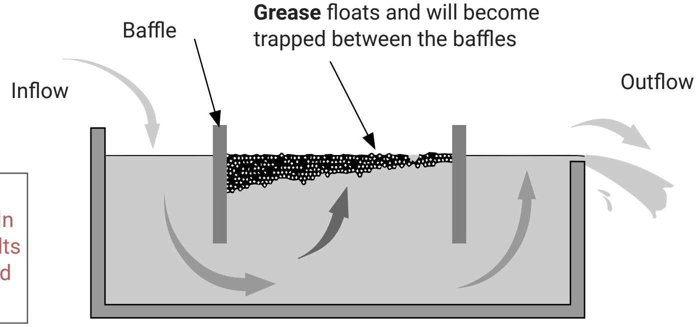
- Prioritise these in areas of highest risk or importance. Prioritise grease traps as close to where grease is likely to arise.

REMEMBER

- **Traps must be regularly maintained otherwise the silt or grease trap could block and cause localised flooding.**
- **Further information can be found** in the Compendium of Sanitation Technologies in Emergencies (2018) p.100.

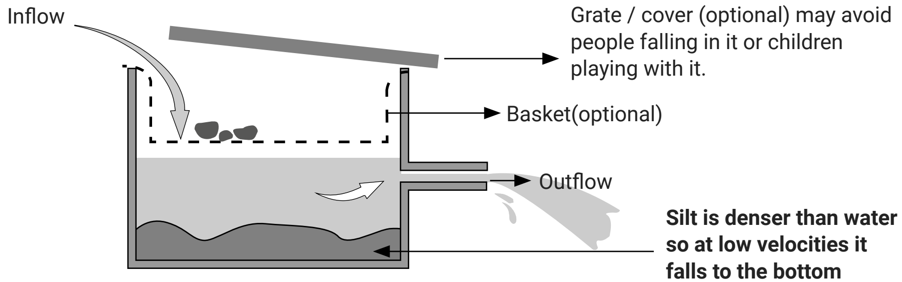
Typical grease trap

also called an oil separator



These may be combined if both functions are needed. In both systems grease and silts need to be regularly removed through O&M.

Typical silt and debris trap



XI PIPES AND CULVERTS

COST: $$ Mid Range to $$$ High Cost

Prevent | Treat | Use | Infiltrate | Slow | Store | Convey

WHAT?

These components are often used to connect components or allow other functions to occur above the surface water network. Despite their simplicity they are difficult to design well.

WHEN?

It is very difficult to completely avoid culverts and pipes, but their use should be minimised as they can be difficult to maintain and require significant skill in designing and construction to avoid unwanted consequences relative to other components.

DESIGN CRITERIA

Reducing flood risk

- Make sure pipes and culverts are not blocked and well maintained.
- Pipes should be steep enough for self-cleansing to reduce blockage.

Managing erosion

- Make sure gradients are shallow but still allow self-cleansing velocities (refer to Ouano, E. A. and Cairncross S., 1991).
- Consider how water enters and leaves pipes or culverts. If there is a steep drop or fast flowing water consider adding protection (e.g. stones/rocks/pitching) and ensure adequate downstream capacity.
- Significant erosion could lead to instability of surrounding ground and pipes or culverts may collapse with surrounding infrastructure.
- Avoid sharp bends, particularly if more than 45 degrees.

Managing and reducing pollution

- Make sure that access points are provided to enable any blockages/ siltation to be easily cleared. Make sure that solid waste does not get thrown in the pipes or culverts. Consider having a silt trap or grating upstream to avoid debris travelling in to the pipe.

Reducing disease and vectors

- Try to understand local pests and vectors behaviours. Pipes may become great habitats for pests and vectors particularly if debris/solid waste provide food and shelter.

Managing resources

- Optimise the shape of the pipe for the anticipated flows/ return periods and velocities e.g. circular, arch, box, stepped.

Ensuring livability and inclusion

- Consult stakeholders on the location of pipes and culverts
- Make sure vulnerable groups are considered. Pipes may help people with reduced mobility by creating safe crossing points etc. Consider the size and location of pipes and culverts for vulnerable groups e.g. sufficient space/railings and careful design of the shape and size to prevent children from playing or injuring themselves.

DESIGNING FOR EFFICIENT IMPLEMENTATION AND IMPROVED MAINTENANCE

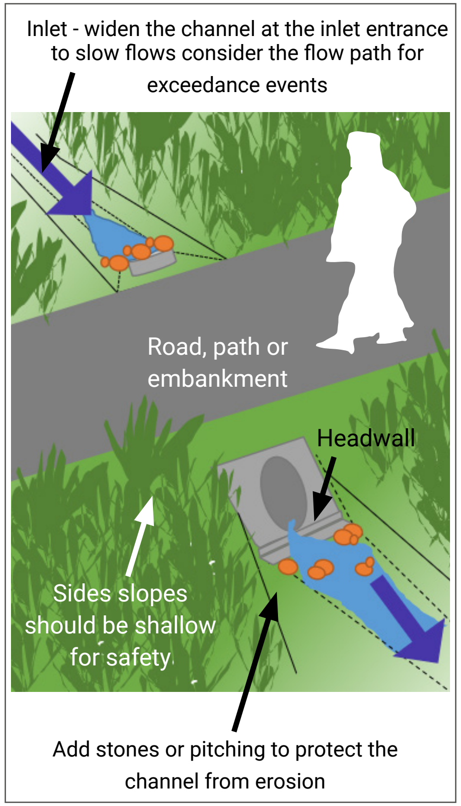
- Remember that culverts are not the only option for drainage crossing roads. Fords, drifts and baffles (humps in the road) may also be used to move surface water across a road/path.
- Consult an appropriately qualified person to check the design, particularly if there is infrastructure (e.g. a road) above the pipe with vehicles or other high loads. Avoid building above pipes. Make sure there is sufficient cover and bedding for the loads expected.
- Make sure that the gradients of the pipe/culvert chosen can be easily constructed. Too low and this may lead to localised ponding as these gradients can be difficult to achieve.
- Consider who will maintain the feature(s) particularly before/after extreme events (e.g. cold or rain). Design and construct access chambers at turns and to split up long lengths for maintenance.
- Consider local material availability, the maintenance needed and its design life. Pipes and culverts come in many materials (usually plastic, steel and concrete), shapes and sizes and these will need to be safely moved to site or cast in situ.
- Consider the size of the culvert or pipe and the impact on maintenance. Culverts typically come in 450mm to 900mm diameter. Smaller culverts may be difficult to maintain and larger culverts difficult to work with on site. Make sure pipes are accessible for maintenance this may vary from between approximately 5m to 40m, depending on the availability of maintenance equipment.
- Consider pipe bedding depths and materials in the design.

PHASING

Prioritise areas of highest risk or importance. Pipes and culverts are often used at crossing-points with major infrastructure, consider whether these areas should be prioritised.

SIZING

Refer to Engineering in Emergencies (2002) p.527-528, CIRIA SUDS Manual (2015) and Ouano, E. A. and Cairncross S., 1991.



REMEMBER

- Consider hazards during construction and operation (see Appendix 1). Make sure that exceedance flows are considered, downstream velocities are managed, erosion is reduced and the system is easy to maintain.
- Ensure pipes can be safely installed to the levels designed.
- Software can help model pipe networks but should be used by trained users .

PLANNING FOR IMPLEMENTATION

The following list should be used to help plan the implementation of surface water management systems:

- ☐ Itemising all the components needed to implement the design.
- ☐ For each component of the surface water management system(s),
  - List out the activities/method needed for implementation;
  - Identify dependencies/inter-relationships between components (i.e. what needs to be built first and last);
  - Estimate time and budget needed for each step; and
  - Produce a comprehensive set of drawings/models for each component and how they join/connect, levels through the systems, tolerances, and the regrading (cut and fill) anticipated.
  - Provide a plan of known constraints (e.g. electrical cables or hazardous areas)
  - Define where further site assessment/investigation might be needed.
- ☐ For each activity, what are the labour requirements?
  - Are the affected or local communities able to implement the techniques or construct components ?
  - Are responsibilities clear? Are supervisors needed? Consider the timing of key milestones and whether site inspections should be scheduled.
  - Are contractors needed for any specialist work?
  - Consider adequate welfare provisions (see see Appendix 1) e.g. handwashing facilities.
- ☐ Carry out a risk assessment refer to Appendix 1.
- ☐ For each activity, what are the material requirements? Are these available? Are there alternatives?
- ☐ For each activity, what are the tool requirements? Do these meet the needs of the users?
- ☐ Minimise the impact on the environment during implementation (e.g. provide silt traps or bunds to contain polluted runoff). Carefully site the location of waste and stockpiles to minimise impact on water quantity and quality.
- ☐ Coordinate with other works. Can they benefit from the temporary works needed for the surface water management?
- ☐ Have risks been identified?
  - Carry out a risk assessment refer to Appendix 1.

i It is common for designs to change during implementation. Any changes should be clearly recorded for future reference.

DESIGN & IMPLEMENTATION CHECKLIST

- [ ] Understand the flows and the associated surface water management network needed.
- [ ] Understand how the design criteria can be considered in every technique and component to minimise vulnerability and maximise opportunities.
- [ ] For the techniques and components chosen understand the implementation and longer-term maintenance required and who will take on these responsibilities.
- [ ] Maintain a risk register for surface water management, this may be split in to components, sub-catchments, catchments or an entire site. Mitigate these risks/vulnerabilities (see Appendix 1).
- [ ] Ensure a shared understanding of the implementation plan and risks with relevant stakeholders, allowing expectations to be managed.
- [ ] Make sure that the design considers how surface water management can protect, repair and enhance the local ecosystem.
- [ ] Consider the resilience of the surface water management system design (refer to p.25)

OPERATE AND MAINTAIN

It is recognised that operation and maintenance activities for surface water management will vary considerably from site to site. However, in all sites it needs to be considered during 'design and implementation' stage and carefully planned.

Because operation and maintenance is very specific to the site and the components (p.36) used this section covers only the basic principles: the overall approach to operation and maintenance (p.51) and an example of a maintenance schedule (p.52). It is important that responsibility of operation and maintenance (O&M) is clear and allocated from the start (see p.51). This may be a good opportunity to handover responsibility from one party to another.

The monitoring of risks (p.25) may be done at this stage so that necessary mitigation can be made through maintenance activities (e.g. clearing of debris in pipes that may cause blockage or checking of materials for durability). It is likely that these will need to be more regular during the commissioning stage.

If the O&M procedures are not working it is recommended that the design and implementation stage is repeated (p.36) to better suit the context. An operation and maintenance section is included in the design of each component to help appropriate O&M to be designed from the beginning. O&M may change during the operation of the site, for example due to the change in season or population. At the end of a rainy season or heavy storm, minor repairs may also be needed at the to make sure components have not been damaged and are working as designed.

Further guidance is given in the following references:

- Sphere Association (2018)
- CIRIA SUDS Manual (2015) for O&M given for each component.

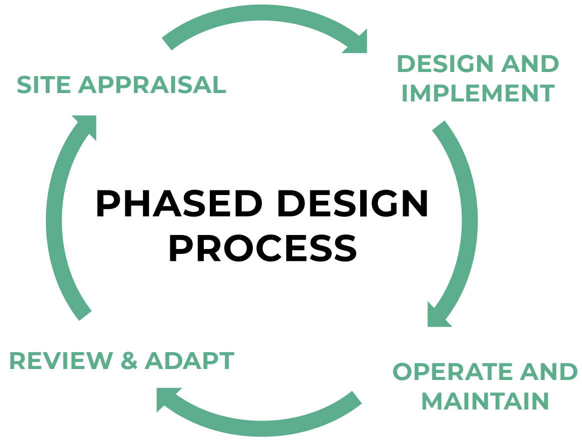
CHAPTER CHECKLIST

APPROACH TO OPERATION AND MAINTENANCE

APPROACH TO OPERATION AND MAINTENANCE

Once the system is working, it may degrade throughout its lifespan or be subject to other challenges (e.g. waste) and changes across the site (e.g. site expansion or change in land use). Planning involves understanding how and who will undertake regular maintenance and monitoring as well as who will help identify potential problems and keep the system working.

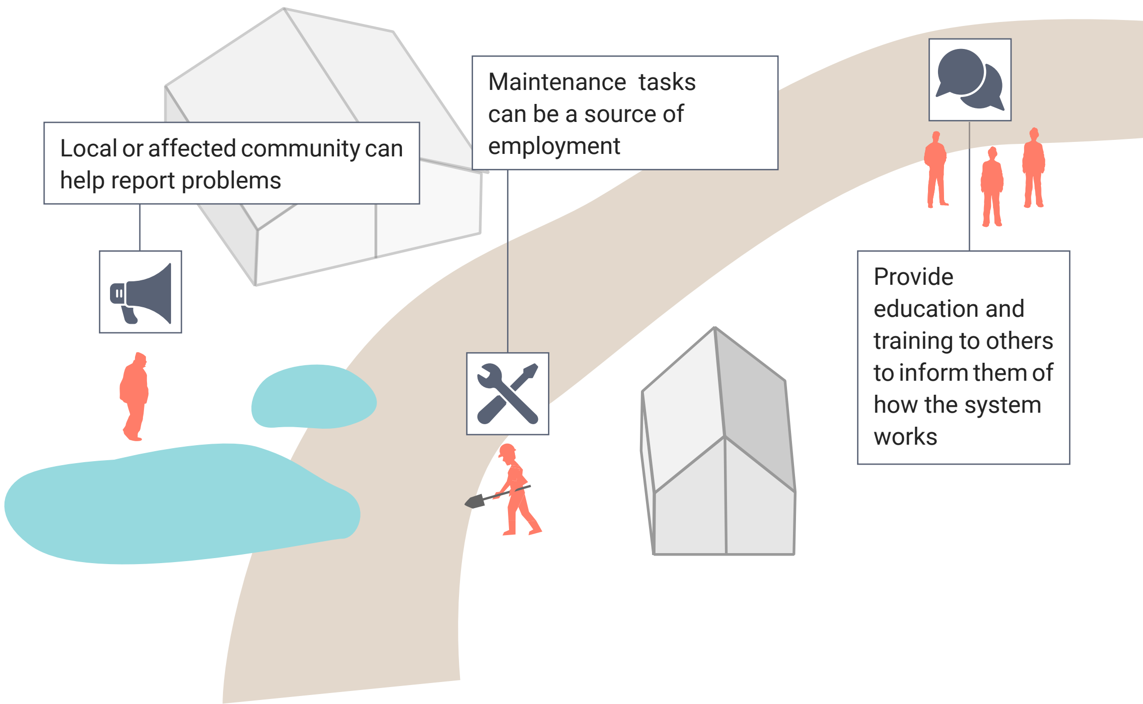
If issues are identified, consider the 'Review and Adjust chapter' and then return to the 'Site Assessment and Planning' and 'Design and Implementation' sections to make modifications to the design. The whole process is iterative and multiple attempts may be needed to get a working system.



WHO IS RESPONSIBLE?

Everyone is responsible for looking after the surface water management system. Surface water management is a cross-cutting issue and different humanitarian disciplines may operate and maintain different components However, someone needs to plan and lead it (refer to p.7).

Ideally, the team responsible for the design (i.e. system designer) and/or construction should plan out the operation and maintenance activities and identify who can undertake them. Everyone in the site has a responsibility to support the operation and maintenance plan. Try to involve the local and affected populations in the operation and maintenance. There are regular examples of these works being carried out as part of a cash-for-work basis or community based scheme for long term maintenance. Further benefits and engagement with communities is discussed on p.7, 11-13 and a case study is shown on p.10.



MAINTENANCE SCHEDULING

Maintenance activities are required to keep the surface water management system working as intended and reduce the risk of the system failing. Create an operation and maintenance plan to outline activities and resourcing requirements. Refer to the specific component page in the 'design and implementation' section for more information and develop a maintenance schedule for the network, collaborating with stakeholders and vulnerable groups (p.11-13).

Activity	Resources and tools required	Frequency	Lead Responsibility Refer to page 7.
Regular maintenance			
Regular monitoring of the system to understand its performance	People	Initially after two weeks. Then once per month alongside the inspection activities and following rainfall events.	Site specific
Solid waste and debris removal – include unblocking inlet and outlet pipes	People Collection bags, shovels, gloves, waterproof boots and overalls	Once per month; before rainy season and after heavy rainfall events.	Site specific
Occasional maintenance			
Vegetation management (e.g. plant removal, cutting grass)	2+ people depending on system size Shovels, long handled hoes, suitable grass cutting tools, gloves, waterproof boots and overalls	Every two-four months	Local/affected population
Sediment removal – e.g. sediment or debris that has accumulated within the system (>10% of capacity of system)	2+ people depending on system size Wheelbarrows, shovels, long-handled hoe, gloves, waterproof boots and overalls	Every two-four months and at the beginning and end of the rainy seasons	Local/affected population
Remedial Maintenance - Reduce the frequency of these activities by improving the design.			
Inlet and outlet repairs	For more details visit 'review and adapt' section	Identified from regular site inspections, particularly at the end of the rainy seasons or heavy rainfall periods should be undertaken. Regular checks of materials should be made for durability, for example untreated bamboo may last 6-12 months before replacement is needed.	System designer
Erosion repairs			System designer
Component repairs / checks of material durability			System designer

Example of a maintenance schedule - This is just an example with basic activities and it is recommended that each specific camp should create its own plan. The plan should also be reviewed and updated if new activities are identified.

REMEMBER

- The function of the surface water management system should be understood by those responsible for the maintenance. If involving local or affected populations, provide appropriate education and training including health and safety.
- People will require appropriate tools and protective equipment (such as gloves) to be able to clean and remove deposited material, particularly if the work is dirty.

Record operation and maintenance activities and when/who they were carried out.

OPERATE & MAINTAIN CHECKLIST

- [ ] Consider when 'operate and maintain' should transition to 'review and adjust'
- [ ] Consider engaging local communities in operation and maintenance activities.
- [ ] Implemented an operation and maintenance plan and continually review associated risks.

REVIEW & ADJUST

The surface water management system may not work as planned – this is quite typical. It is difficult to predict changes in conditions, the site and its use. By monitoring the system from the beginning and on a continual basis, problems can be identified and systems improved – saving time, money and reducing risks to health and well-being. The following topics are covered in this section:

*These topics relate to some of the design criteria (**see p.32**). including:*

1. Reducing flood risk
2. Managing erosion and landslips
3. Managing and reducing pollution
5. Ensuring liveability

In addition it is recommended that wider reviews of inclusivity (6.), disease/ vectors (4.) and resource use (7.) are undertaken to improve the system in relation to these design criteria (p.32) in order to meet the overall desired outcome for surface water management. However, these three criteria are likely to be context specific and therefore specific information is not given in this section.

FLOODING

WHY IS THIS HAPPENING?

Flooding may have many different characteristics, it may be:

- Localised (in a small area) or site-wide;
- Last for a long or short time;
- Be caused by one source or many sources including river flooding; extreme rainfall (refer to p.21), groundwater or a tidal surge. It may also be due to depressions/topography or blockages (p.57).

What is known, is that flooding is caused by insufficient capacity in the drainage network for the actual flows, either because the predicted flows were miscalculated or were lower than the actual flows.

First check the network (see p.33) for the area flooded to see if it was implemented and maintained as intended. Check where and how it was flooded. Record peak water levels and check local rainfall gauges. Identify how to fix this issue. If no immediate issues are found look at the network upstream (before) and downstream (after) the flooded area and repeat this check. Consider whether all/some of the flood water can be redirected. Check the outflow and whether this was as designed.

If the flooding is causing contamination refer to the contamination section.

If the rainfall intensity was greater than anticipated re-evaluate incoming runoff sources and decide how best the site should be designed to be resilient to this intensity. Consider the resilience of the system.

Prevent

1. Can the source (or part of the source) be removed? Could the site be regraded to avoid standing water?
2. Consider trying to change behaviours and surfaces to reduce runoff. Refer to blockages section.

Treat

1. Consider increased risk of contamination due to flooding. Where possible, try to divert polluted flows to areas where it can be managed safely.

Use

1. Increase capacity of collection structures

Infiltrate

1. Check if the infiltration structures are working. Is there silting? Are more components needed?
2. Check the infiltration rates (p.20) and re-size the structure accordingly. It may be easier to build a new structure than adapt an existing structure.

Store

1. Check the structures are working as designed.
2. Increase the size of storage as needed. Refer to p.40.

Slow

1. Check that structures to slow flows/runoff are working, make sure that there are no blockages in the system or silts/debris reducing flows.
2. Modify the height or/and frequency of the check dams. Refer to p.45.

Convey

1. Check the levels. Are there low-points that water cannot drain from? Is flow bypassing components and going elsewhere?
2. Increase the capacity of conveyance structures (i.e. depth or width) or additional structures.
3. Check the outfall. Is it working correctly?

!
REMEMBER

- Good design records including division in to sub-catchments will make it easier to monitor and rectify in future. Refer to p.33-34.
- With the resources available it may be very difficult to resolve site-wide flooding issues particularly if the site is very flat. If flooding persists more drastic measures including berms and raised areas (p.44) or moving the site should be considered (p.29). Diversion without slowing/storing elsewhere is likely to make the problem occur somewhere else and could cause risk to life.
- Incrementally increase the size of the component or system to avoid increasing flows significantly.
- Extreme rainfall events may occur and designing for these events may considerably increase costs and use of resources so this must be considered carefully.
- Consider hazards (see Appendix 1) when assessing flood waters.

i
Record flooding events including the:

- time, date and duration;
- depth and area impacted;
- cause or likely causes (if known);
- methods used to reduce/remove flooding (if applicable); and
- the resources (financial or otherwise) used to reduce impacts of flooding (this may help with future discussions on whether to move/rebuild part of the site).

POLLUTION

WHY IS THIS HAPPENING?

Similar to flooding, contamination of surface water may have many different characteristics, it may be:

- Localised (in a small area) or site-wide;
- Last for a long or short time;
- Be caused by one source or many sources including latrines; naturally occurring minerals, roads.

First understand identify the source(s) of contamination, where in the network contamination is present (the pathway) and the areas upstream (before) and downstream (after) the area. Identify if and how it is causing harm (receptor). Refer to the diagram illustrating the pollution linkage model between the source(s), pathway(s) and receptor(s) on p.33. Use this information to understand the impacts of the contamination. Refer also to p.9 and p.22.

Prevent

1. Can the pollution be removed, reduced at source or isolated? This might include using natural/man-made treatment devices including vegetation refer to p.23, 37, 38 and 46 or reseeding/trying new vegetation if it is not working Engage stakeholders to help change behaviour if the pollution is caused by the stakeholders. If solid waste is reaching drainage paths, improve solid waste management.

Use

Treat

1. Divert contaminated surface water away from areas where it is being used (e.g. in vegetable plots) to avoid contaminated surface water entering food or water sources.

Infiltrate

1. If safe to do so, divert surface waters from entering infiltration areas as it may contaminate ground water. Refer to p.40.

Store

1. If safe to do so, contain contamination in a safe storage system. This may reduce the spread of the contamination around the site in the short-term. Treat the contamination quickly to avoid the system overflowing and creating additional hazards.
2. Algae may occur if water is stagnant and poorly aerated. If safe to do so, drain the storage component and clear the algae before refilling. Seek specialist support if it continues.

Convey

1. Prevent flow in channels in problem areas temporarily.

i Record contamination including the:

- Time, date and duration;
- volume (if applicable) and the area impacted;
- Cause or likely causes (if known);
- Methods used to reduce/remove contamination (if applicable); and
- The resources (financial or otherwise) used to reduce impacts of pollution (this may help with future discussions on whether additional interventions particularly if the contamination is being caused by another stakeholder.

! REMEMBER

- **Good design records including division in to sub-catchments will make it easier to monitor and rectify in future.** Refer to p.33-34.
- **Blackwater must be kept separate from surface water. It requires separate treatment.**
- **Consider hazards (see Appendix 1) when assessing contamination.**

BLOCKAGE

WHY IS THIS HAPPENING?

Managing networks in sub-catchments will make maintenance easier. Blockages in surface water networks may have many different characteristics, it may be:

- Localised (in a small area) or site-wide;
- Last for a long or short time;
- Happen once or recur;
- Be caused by one source or many sources including: solid waste, construction sites, siltation (see siltation section p.58), debris reaching the system (particularly after high winds, overgrown vegetation or leaves falling).

Blockages may lead to contamination and flooding, so it is important that they are reviewed regularly. Check the system before and after a large storm event and clear blockages.

When reviewing blockages use the network plan to record blockages and consider upstream and downstream impacts. It may be the case that during flooding the blockages may be covered. Is important to understand the different outflows beforehand and check those inthe first instance.

Trapped water when drainage outlet was blocked near Cox's Bazar (IOM, 2018c)

Prevent / **Treat**

1. Can behaviours (p.37) or surfaces (p.38) be changed to prevent debris entering the system. This includes more frequent maintenance and improved solid waste management and interception of fats/oils (see p.46). Check treatment methods are sufficent.

Use

1. Check that blockages are not impacting on the use of water. This could have significant impacts if water is not reaching areas as expected (e.g. food irrigation).

Infiltrate

1. Review the system to see if blockages have occurred. Silts may prevent water flow through granular material. Add a silt trap upstream if this is an issue and consider regrading aggregates used. Refer to p.40.

Store

1. Add gratings/screens/silt traps (refer to p. 46) upstream of storage devices. Include basins (called forebays) deliberately designed to catch silt/debris/litter (especially during construction).

Slow

1. Decrease the flow by using components (see page 36) to reduce velocities. This may reduce the distance debris is moved so that it does not collect in one place. These devices will still need to be maintained regularly. Refer to the 'Operate and Maintain' section.

Convey

1. Review the levels of conveyance structures. Blockages may be caused by flows not being sufficient to remove debris, consider a low flow channel.
2. Consider adding gratings or screens to structures passing underground. This will help catch large objects and reduce the risk of internal blockages which are hard to access.

! REMEMBER

- Consider hazards (see Appendix 1) when assessing blockages. If a significant volume of water has backed-up behind the component this could lead to a sudden flow of water after the blockage is removed. There is an increased risk of hazardous material at the location of blockages (e.g. sharps and vermin).
- Make sure debris causing the blockage is moved to a place where it does not cause blockages. This includes areas where the wind or flow of water can move it back in to the drainage system.

i KEY INFORMATION

Ensure there are access points at every structure or along conveyance channels to allow blockages to be safely and easily unblocked.

i Record blockages including the:

- Time, date and duration;
- Area impacted;
- Cause or likely causes (if known);
- Methods used to reduce/ remove blockage (if applicable);
- Discuss causes and impacts of blockages widely with appropriate stakeholders; and
- Continuously improve the maintenance plan with new information.

SILTATION

WHY IS THIS HAPPENING?

Siltation and sedimentation can be caused by:

- Loose ground material being transported by surface water on the site. Material may be transported particularly if the ground is granular and made up of small particles (review ground conditions). Refer to p.18-19 on soil types.
- Fast flows causing erosion and then increasing the transportation of silts. Refer to p.18-19 on soil types.
- A lack of vegetation on the site which would help reduce transportation of silts. Refer to p.23.
- Wind picking up loose material and moving it to drainage systems (refer to p.38). This often happens due to dust/ particles from construction work or from marram/gravel paths or roads.
- A lack of silt traps (refer to p.46).

When reviewing siltation use the network plan to record areas where there are issues.

Clearing silt-clogged drainage canals to stop flooding and contamination of clean water sources in Cox's Bazar (IOM, 2018c)

Prevent / Treat

1. Check silt is not being increased due to behaviours (e.g. people sweeping in to the drainage network) or lack of maintenance of silt traps. Consider changing surfaces to reduce silt getting in to the drainage system. Refer to p. 37.

Use

1. Look for ways silt can be used on the site. This might include building materials (non-structural) and media to grow crops.

Infiltrate

1. Check if blockages have occurred. Silts may prevent water flow through granular material. Incorporate, improve or increase maintenance of silt traps (see p.46). Reseed/replant vegetation.

Store

1. Check storage devices have silt traps and that these are being maintained. Refer back to the 'Operate and Maintain' section.

Slow

1. Consider measures to slow runoff and reduce silt transportation. This might include increasing the height/depth or frequency of structures and increasing vegetation (p.38 and p. 45).
2. Incorporate or increase the number of check dams (silt is easily seen/collected behind check dams and can be removed easily). Refer to p.45.

Convey

1. Check the levels and sizing of conveyance components (refer to p.43).
2. Consider adding a low flow channel.
3. If the channel is steep consider adding vegetation and components to slow flows or moving the structure to reduce the gradient. Refer to p.23 and p.45.
4. Check cross-sectional areas, oversized sections may reduce flows and cause siltation.

REMEMBER

- Consider hazards (see Appendix 1) when assessing siltation. If a significant volume of water has backed-up behind the component this could lead to a sudden flow of water after the blockage is removed. In addition contaminants can stick to silt causing a hazard.
- Siltation is likely to occur during construction and implementation. Make sure sufficient mitigation is in place to reduce siltation occurring (refer to Appendix 1)
- Make sure silt is moved to a place where it does not cause future blockages. This includes areas where the wind or flow of water can move it back in to the drainage system.

KEY INFORMATION

Ensure there are access chambers/ points at every structure or along conveyance channels to allow blockages to be safely unblocked.

Record siltation including the:

- Time, date and duration;
- Area impacted;
- Cause or likely causes (if known);
- Methods to reduce/remove siltation (if applicable); and
- Discuss causes and impacts of siltation widely with appropriate stakeholders and continually improve the maintenance plan on this data.

EROSION & SCOUR

WHY IS THIS HAPPENING?

Erosion and scour can be caused by:

- Loose ground material, particularly if the ground is granular and made up of small particles (review ground conditions). The ground conditions may have been inadequately assessed. Refer to p.18-19 on soil types.
- Fast flows increasing erosion rates, this may be caused by steep slopes or a lack of components to slow runoff/flows. An extreme weather event (e.g. storm) may have increased flows and therefore scour. Refer to 'Design and Implement section.'
- Action of the wind, movement of people or vehicles.
- A lack of vegetation on the site helping 'anchor' ground. Refer to p.23.

When reviewing erosion use the network plan to record areas where there are issues.

Prevent

1. Check erosion is not being increased due to behaviours (e.g. people walking up earth slopes rather than staying on paths). See p.37.
2. Consider changing surfaces (p.38) to reduce erosion. Particularly the at the location affected.
3. Consider diverting runoff to reduce erosion.

Infiltrate

1. Scour and erosion can damage infiltration devices consider flow controls to slow the runoff and divert flows. Construct aprons at inlets to prevent local erosion. Review planting and replant/reseed where necessary.

Store

1. Scour and erosion can damage storage components consider flow controls to slow incoming flow and diversion of flows. Refer to p.41/42.

Slow

1. Try to add components to help slow flows and reduce erosion. Be careful when increasing the height of the structure, as water spilling over the structure might cause a 'splash pool' and increase erosion locally.

Convey

1. Check the levels and sizing of conveyance components (refer to p.43).
2. Use gravel, rocks or vegetation (see p.23) to increase roughness and reduce erosion. Consider using localised scour protection (such as large stones).
3. Reduce side slopes.
4. If flows are still causing erosion consider adding components to slow flows or/and moving the structure to reduce the gradient.

REMEMBER
Consider hazards (see Appendix 1) when assessing erosion. Erosion may cause slope instability and associated hazards. This should be carefully assessed by an appropriately experienced person.

KEY INFORMATION
Ensure there are access points at every structure or along conveyance channels to allow erosion and scour issues to be addressed, refer to the design and implementation section.

Record erosion including the:

- Time, date and duration of issue;
- Area impacted;
- Cause or likely causes (if known);
- Methods used to reduce/ remove erosion (if applicable); and
- Discuss causes and impacts of scour and erosion widely with appropriate stakeholders.

Embankment erosion (IOM, 2018c)

INFRASTRUCTURE FAILURE

WHY IS THIS HAPPENING?

Poor management of surface water can result in the deterioration, operational failure or even collapse of infrastructure and shelters

Failure/deterioration of drainage infrastructure

- Components (p.36) may have been over or under-sized.
- The soil strength and type may have been poorly understood (refer to p.18-20)
- The site may be on hazardous ground e.g. black cotton soils.
- The drainage infrastructure may have been overloaded (e.g. by vehicles passing over or too close to the drainage).
- Roots may damage structures.

Road/transportation infrastructure

- Insufficient drainage
- Water is building up on the pavement surface or beneath the surface of the pavement (i.e. in the subbase or subgrade). For further information refer to 'Building Roads by Hand' (ILO,1990) and Engineering in Emergencies (2002).

Shelters

- Insufficient drainage (including guttering or downpipes) or drainage outlets too close to the shelter, which can cause softening of ground below and around foundations, resulting in damage to a shelter's structure.
- Foundations may have not been designed properly for the site conditions, consult an appropriately qualified person to reduce the risk.

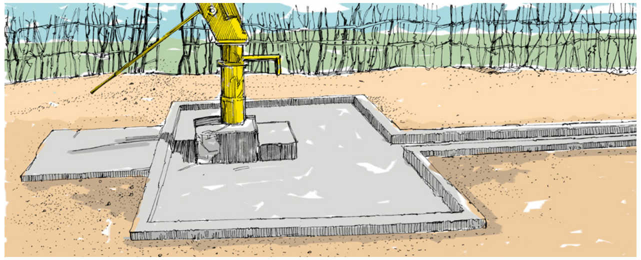
Road damaged by water runoff at high level areas near Cox's Bazar (IOM, 2018c)

Prevent

1. If safe divert or reduce runoff to lower the impact on the infrastructure.
2. Consult a geotechnical expert particularly if the site has problem soils (see p.18).
3. Ensure there is sufficient depth of clearance between the infrastructure and surface.

Infiltrate

1. Decrease the depth of the infiltration pit excavation. Refer to p.40.
2. Strengthen the sides with a frame.
3. Construct aprons at inlets to prevent infiltration, local erosion/ the structure being undermined. Make sure edges of the apron are protected.



Handpump with apron (© Rod Shaw, WEDC Loughborough University)

Store

1. Make side slopes shallower and decrease depth of storage so that damage is less likely to be caused. Refer to p.41-42.

Slow

1. Slow flows to reduce erosion using appropriate components, refer to p.36.

Convey

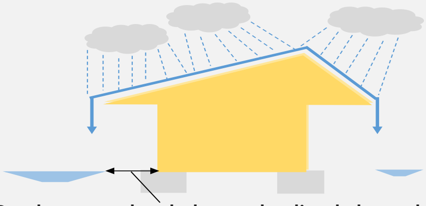
1. Check the levels and sizing of drainage structures. Reduce gradients of channel sizes and longitudinal gradient or protect side slopes using rocks/vegetation. Refer to p.33 and 47
2. If flows are still causing collapse consider slowing flows (e.g. by check dams p.45) or/ and moving the structure to reduce the gradient.

! REMEMBER

Consider hazards (see Appendix 1) when assessing failures.
Reviews should be carefully undertaken by an appropriately experienced person.

C CASE STUDY

This case study shows examples of poor surface water management and its impact on buildings, potentially undermining structures.



Gap between the shelter and unlined channel

i Record infrastructure collapse including the:

- Time, date and duration of issue;
- Area impacted;
- Cause or likely causes (if known);
- Methods used to mitigate impacts; and
- Discuss causes and impacts widely with appropriate stakeholders.

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APPENDIX 1 – GENERAL HEALTH AND SAFETY PREVENTION GUIDANCE

It is appreciated that the application of this guidance will take place in many different contexts. Where possible, likely hazards have been mentioned. However, these lists are not comprehensive and an appropriately qualified person/people should assess the hazards and mitigate accordingly in the local context.

The following **general principles to prevent incidents** are stated as follows (taken from Construction Design and Management Regulations 2015):

a. avoid risks;
b. evaluate the risks which cannot be avoided;
c. combat the risks at source;
d. adapt the work to the individual, especially regarding the design of workplaces, the choice of work equipment and the choice of working and production methods;
e. adapt to technical progress;
f. replace the dangerous by the non-dangerous or the less dangerous;
g. develop a coherent overall prevention policy (at every level of responsibility) which covers technology, organisation of work, working conditions, social relationships and the influence of factors relating to the working environment;
h. give collective protective measures priority over individual protective measures; and
i. give appropriate instructions to employees.

ROLES AND RESPONSIBILITIES

The organisation for whom a project is carried out should ensure is it clear how responsibilities are split between duty holders, following international/national law. Adequate welfare provisions should be provided e.g. handwashing facilities for handling soils. The immediate safety and ongoing health of workers is a responsibility of all clients, planners, commissioning bodies and overseeing agents.

APPENDIX 2 – INFILTRATION TEST

This sheet should be used to undertake the 'improved' infiltration test method. **Note that this is a simplified and less accurate method than the 'robust' method on p.20.**

Name of tester:............................

Date:........./......../.........

Weather: Sun/Cloud/Rain/Snow/Windy/Humid (delete as appropriate)

Approx temp: ....degrees Celsius/Fahrenheit (delete as appropriate)

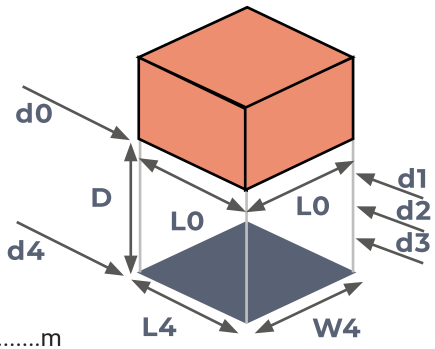
Weather and temperature may affect the results and may explain why the design works better or worse when implemented. This is worth reviewing at the 'review and adjust' stage if necessary.

Step 1 - Trial pit location

Choose location based on information on p.18

Step 2 - Test pit size

Dig the test pit to the minimum depth of the planned soakaway and at least 0.3m width and 0.3m length. The depth may not be from ground level if friable/desiccated soil or made ground is found (as per orange area in the figure below), the test pit depth (d4) should be below the level of this material (refer to p.18) to define the appropriate depth. It is preferable to dig pits with straight and equal sides. Once dug measure and calculate the following (to two decimal places):



Depth (D)= ....m

Width top (W0)= ....m

Width bottom (W4)= ....m

Length top (L0)= ....m

Length bottom (L4) = ...m

Average width and depth:

W=(width top+width bottom)/2 = ...m

L=(length top+ length bottom)/2 = ...m

Step 3 - Infiltration test - Obtain a measuring stick or mark a length of timber equal to/greater than the depth of the test pit. Fill the pit quickly to d0 (see figure) and measure the water depth at the following intervals, to an accuracy of 0.01m:

MINUTES	*DEPTH (m)*	*MINUTES*	*DEPTH (m)*
0.25/ 15s		*9*	
0.5 / 30s		*10*	
0.75/ 45s		*15*	
1		*20*	
1.5		*25*	
2		*30*	
2.5		*40*	
3		*50*	
3.5		*60*	
4		*80*	
4.5		*100*	
5		*125*	
6		*150*	
7		*175*	
8		*200*	

Abandon test if it takes longer than 200min for all water to infiltrate.

Step 4 - Calculation (refer to figure left)

Total time for infiltration of all the water=........min (200min if test abandoned)

t1= Total time/4 =...........min

d1= water depth at t1=...........m (can be interpolated from the table above)

V1= Volume at d1=d1xLxW=...........m³

t3= Total time - Total time/4 =...........min

d3= depth at t3=...........m (can be interpolated from the table above)

V3= Volume at d3=d3xLxW=...........m³

d2= mid depth = d2+((d1-d3)/2)=...........m

a=surface area for half the depth = 2(d2xL)+2(d2xW)+(LxW)=...........m²

(60,000 x (V1-V3)) / (a x (t3-t1))=...........mm/hr

Where possible repeat test and take the lowest rate.

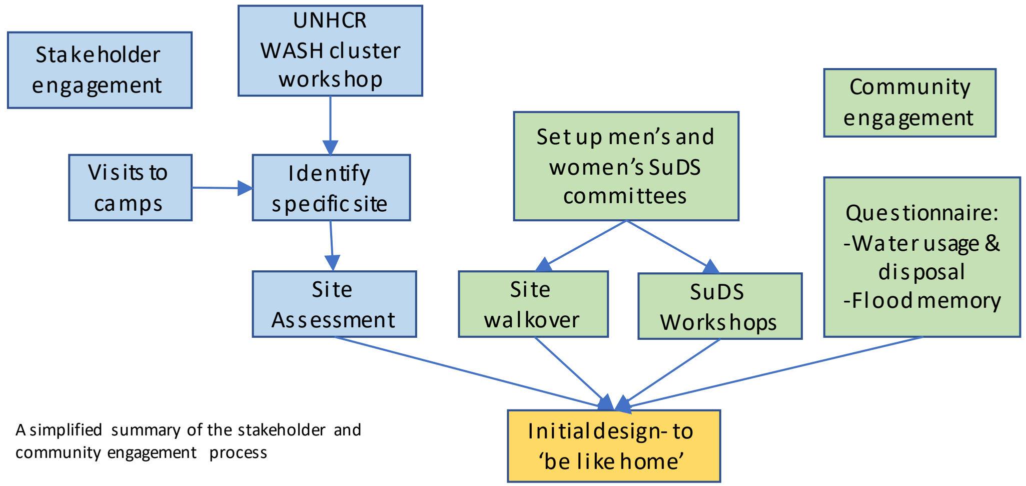
APPENDIX 3 - CASE STUDY - GAWILAN, IRAQ STAKEHOLDER ENGAGEMENT

Stakeholder engagement, with both the community and other institutional stakeholders, was an important aspect of the project. A simplified summary of the engagement process and the outcome is given in the diagram to the right. The community were involved in the construction process and will be responsible for the maintenance.

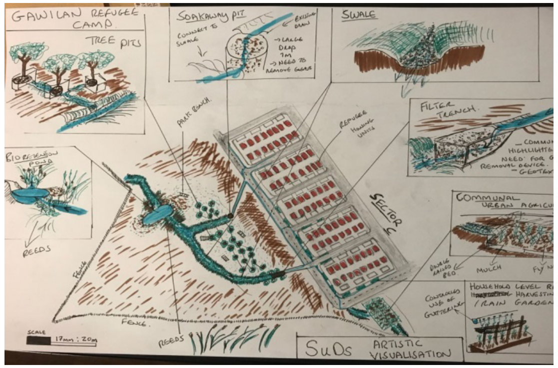
There was engagement with three levels of stakeholders, UNHCR and camp manager from Board of Relied and Humanities Affairs (BRHS), WASH cluster partners and camp residents.

The "SuDS" (Sustainable Drainage System) management committee was composed of 4 men and 6 women. A common theme was "making it like home", taking memories from Syria. Participants were asked to draw their version of drainage after learning about SuDS and surface water management.

Sustainable drainage systems constructed via a cash for work (CfW) program. Over 60 households involved in home gardens program to reduce runoff and use water at source.



A simplified summary of the stakeholder and community engagement process



The final design, as envisaged by the refugee community after the workshop. This was sent to the landscape architect to be drawn up.

A site walkover with UNHCR WASH Associate, camp management and women from the SuDS community committee was conducted.

A participatory design and planning workshop was held with the SuDS management committee, from the sector nearest to the proposed demonstration area.

APPENDIX 3 - CASE STUDY - GAWILAN, IRAQ SITE ASSESSMENT

Site assessment carried out by the design team on the ground in Gawilan. This information, along with the outputs of the community and stakeholder engagement sessions were used by the landscape architect to do the design.

HOUSEHOLD WASH PRACTICES

The majority of respondents (60.0%) stated drains smelled once a month. Household's would engage in a project that improved health (9, 90.0%), was better for the environment (9, 90.0%)

SITE LEVELS AND TOPOGRAPHY

Drone survey used to create digital elevation maps for spatial analysis (see right).

SITE WALK-OVER (WITH VIDEO CAMERA)

- Flow paths- highlighted in blue lines;
- Infrastructure- identify road and housing; and
- Water sources and receptors.

SOURCES AND RECEPTORS

Natural drainage features- two low points with ponds, natural reed vegetation channel. Water sources- two sources of grey water + road surface runoff. Identify where water currently leaves the site.

PLANTING

Mapped native plants to understand what flourishes in the area.

GROUND CONDITIONS

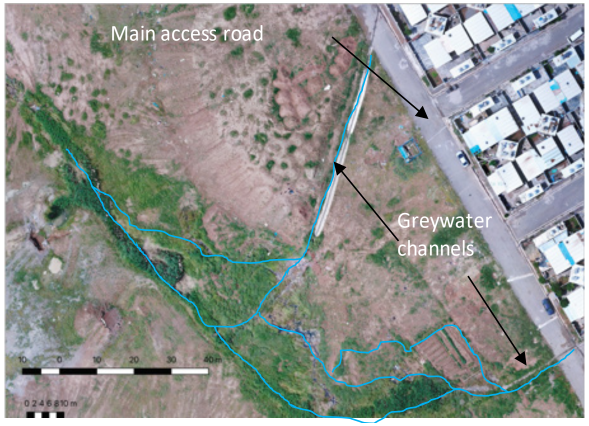
- Infiltration – slow infiltration, ponding occurring, high run off rates.
- Classify soil type – Clay loam/sandy clay loam.

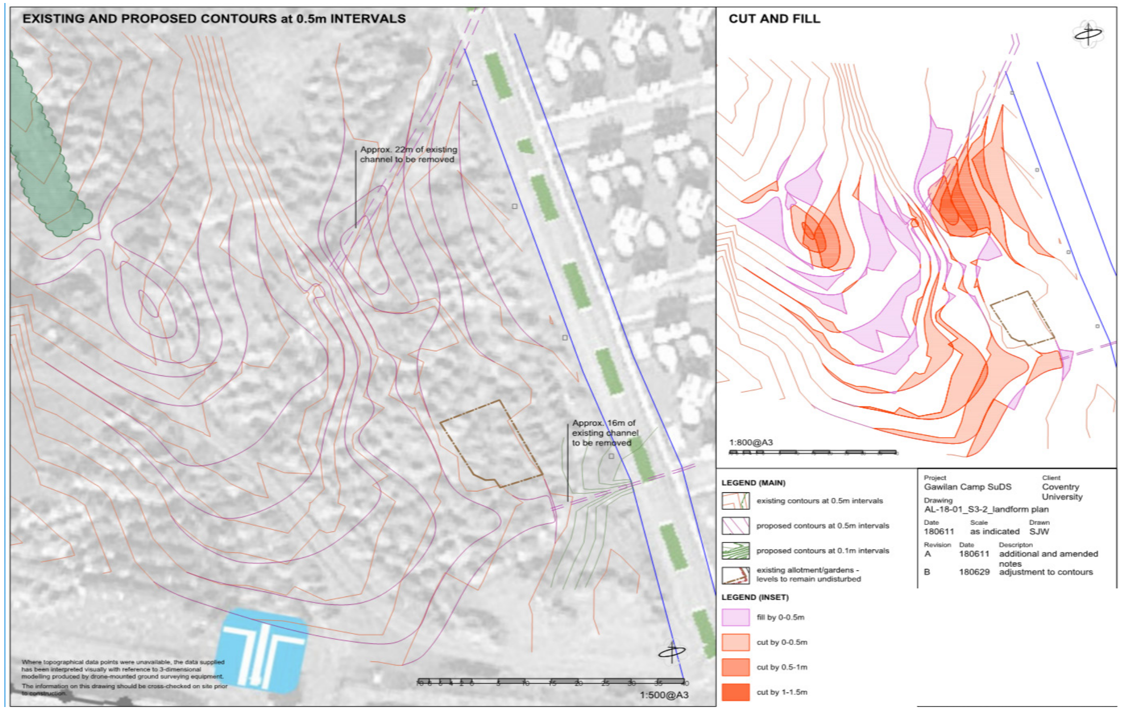
WATER QUALITY

Results:

- Colour- fairly black and smelly;
- Heavy metals - minimal traces;
- Suspended solids - high;
- COD and BOD - high; and
- Bacterial count - high.

Compared against guidelines: World Bank (1998), General Environmental Guidelines, Pollution Prevention and Abatement Handbook.





Case study information courtesy of the Centre for Agroecology, Water and Resilience Coventry University; Board of Relief and Humanitarian Affairs, Dohuk Governorate; UNHCR, Iraq; French Red Cross, Iraq; Lemon Tree Trust, Middle East Branch. The project was funded by the HIF.

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OPERATE & MAINTAIN

REVIEW & ADJUST

GLOSSARY & REFERENCES

APPENDIX 3 - CASE STUDY - GAWILAN, IRAQ DESIGN

DESIGN PRINCIPLES

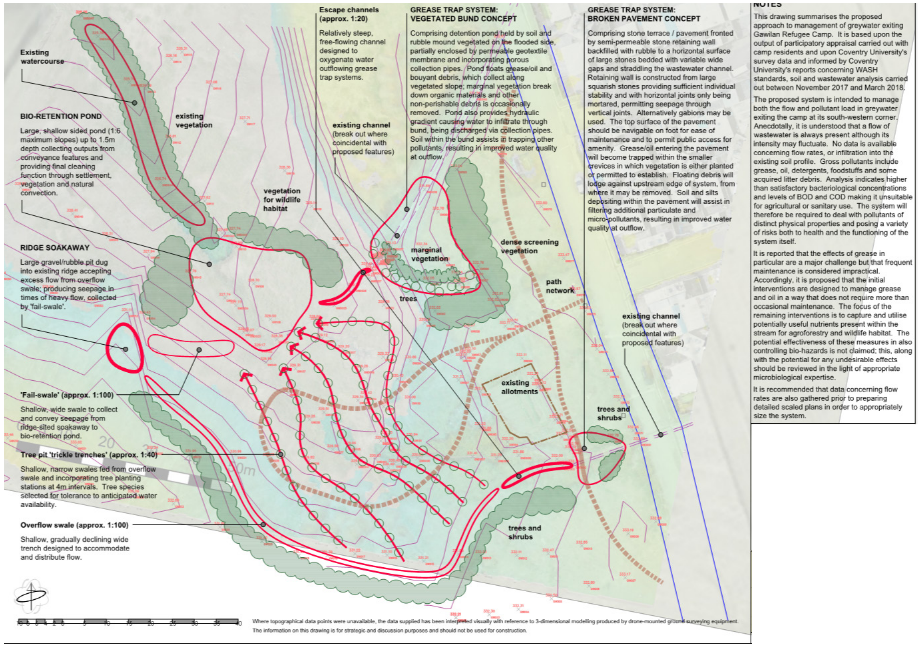
- Multi-functionality goes beyond the main SuDs principles of improving water quality, reducing water quantity, increasing biodiversity and amenity. For example tackling local climate change, addressing disease vectors etc, as shown on page 3;
- Ensure that the system is better than existing system and that risks are minimised and mitigated in order to make them acceptable; and
- Ensure system appears temporary by NGOs and local management.

PROJECT KEY INDICATORS

- Reduce flooding based on flood "memory";
- Reduce potential breeding sites for nuisance insects; and
- Provide a facility for residents to take ownership.

DESIGN PROCESS

- The residents generated the design through the engagement;
- Carried out by landscape architect with input from Coventry University team;
- A flexible design, which once constructed, will have room to be adapted to mitigate risks should environmental conditions change, e.g. an increase in population leading to increased greywater flows (see "potential Risks and Mitigation" on the next slide); and
- Flow calculations were not appropriate since the site was designed to cope with long term greywater (GW) flows and short term, seasonal stormwater flows. GW flow data wasn't consistent.



Water Quality - Pollution Control & Silt management

- Important aspect because grey water entering site was polluted with fats and grease from households;
- A public health issue due to it potentially running off into agricultural fields and camps further downstream;
- Use gravel and stones to capture large debris and particulate pollution initially;
- Use a pressure head to drive the greywater through gravel/ grit in order to separate the water; and
- Use vegetation, including reed beds to treat the fats and oils and to filter the water.

LIVELIHOOD CREATION

- Creating vegetable gardens and allotment spaces;

EROSION CONTROL

- Create terraces; and
- Use vegetation, including trees.

PLACEMAKING

- Create community spaces – with multiple uses.

Information courtesy of the Centre for Agroecology, Water and Resilience Coventry University; Board of Relief and Humanitarian Affairs, Dohuk Governorate; UNHCR, Iraq; French Red Cross, Iraq; Lemon Tree Trust, Middle East Branch. The project was funded by the HIF.

CASE STUDY - GAWILAN, IRAQ IMPLEMENTATION, OPERATION & MAINTENANCE

POTENTIAL RISKS & MITIGATION

- Site may flood- design aims to reduce flow at source; create infiltration opportunities; and provide storage.
- Greywater not treated enough- there will be an increase in water quality; the run-off will not be used as potable water; the water quality will be monitored and the treatment improved iteratively where possible.
- Nuisance insect breeding sites- the landscape will discourage ponding; flow through the pond means it won't be stagnant.
- Hazard of slips, trips and falls especially to children playing- water in ponds is not very deep; there is dense vegetation around ponds to restrict access; landscape in the public areas are designed to be accessible to all; stepping stones provided in the channel.
- Hygiene risks- monitoring of water quality will feed into iterative improvements where needed.
- Risk of community not maintaining the site- community engagement was a very important aspect of the project from the start to encourage ownership by community by ensuring that the intervention is something everyone wants.
- Increase in population - should greywater flows increase, design is flexible and adaptable.

APPROVAL PROCESS

Approval of the design provided by Board of Refugee and Humanitarian Relief for Dohuk and UNHCR senior technical team (engineers).

MONITORING

- This is managed through a results-based framework & measured through a household survey. Base line data was collected initially with plans for a midterm survey in Jan/Feb and an impact assessment in Apr/Jun upon completion.
- Water quality - Plan to monitor water quality after construction
- Water quantity- rely on resident's memory versus what is happening- to show quantity reduction
- Amenity - creating gardens/ community space/ footpaths and reducing solid waste - check usage of this space.
- Biodiversity - not a focus of the project

Monitoring pH prior to construction using a handheld instrument in the field.

LESSONS LEARNT

- The initial engagement with stakeholders and the community was essential to the design process and for ensuring ownership.
- During the consultation process, the community wanted the space to 'feel like home'. Therefore it's important to bear in mind that 'context' isn't always limited to the site but also to the community, their origins and demographics. This has an impact on their attitudes to surface water, interventions etc.
- Due to the transitional nature of stakeholders in the sector, it was difficult to build up long term relationships. During the project, new stakeholders needed to be engaged to get buy-in.
- Stakeholders and local management were very open to the concept of SuDs. Particularly because of the emphasis on encouraging vegetation and non-permanent infrastructure. This would enable the camp management to leave the site in a better state when decommissioning.
- The security of staff in refugee camps is paramount and therefore if the nature of the 'emergency' or the situation in the country or surrounding area alters, then staff can be pulled out at short notice.
- Funding was an issue due to the limited amount; the difficulties getting it into the country and due to the ties to how it was to be spent.

Case study information courtesy of the Centre for Agroecology, Water and Resilience Coventry University; Board of Relief and Humanitarian Affairs, Dohuk Governorate; UNHCR, Iraq; French Red Cross, Iraq; Lemon Tree Trust, Middle East Branch. The project was funded by the HIF.

APPENDIX 4 - PREVENTION AND MITIGATION TECHNIQUES

Prevent – *To avoid or reduce a source of surface water for example through changing behaviours or increasing vegetation in a catchment.*

Use – *To remove water from the system for another purpose (e.g. cleaning or irrigation dependant on water quality).*

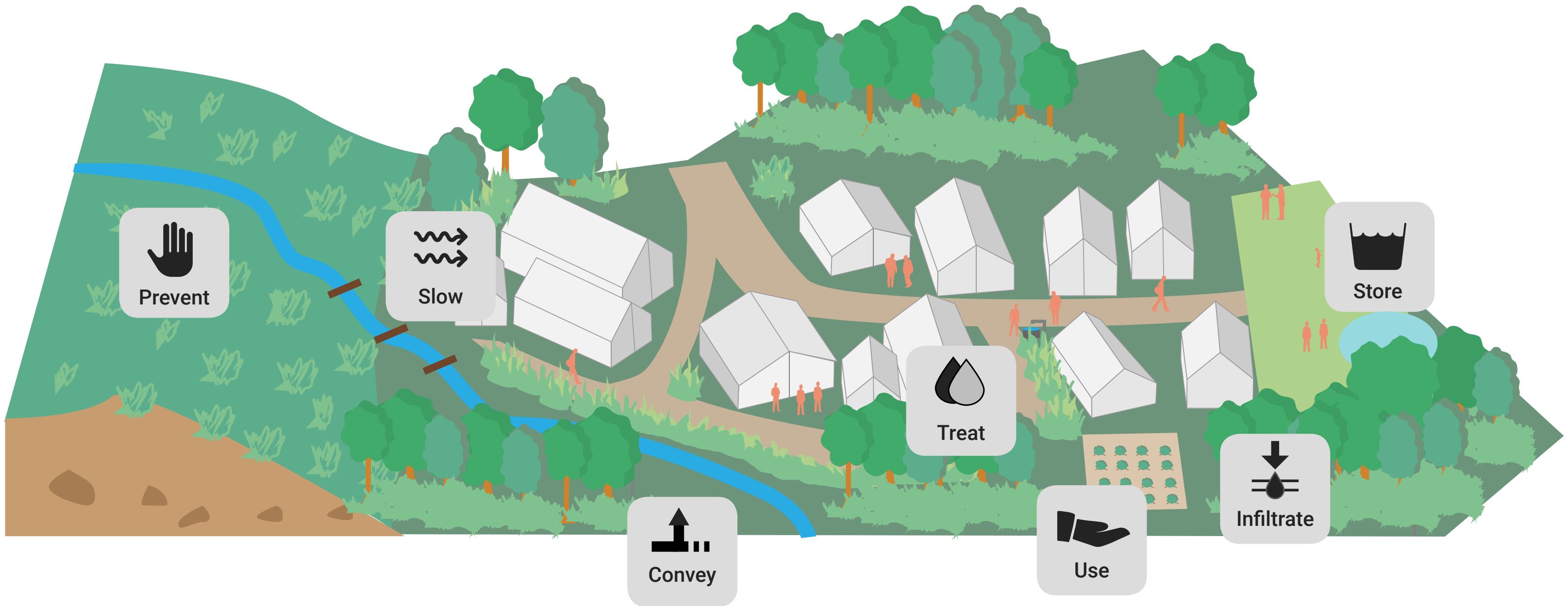
Store – *A place where is safely held/stopped for a period of time (e.g. a pond).*

Convey – *To transport water from one place to another, usually in a channel or pipe.*

Treat – *To improve water quality for example by trapping silts or using vegetation to improve water quality.*

Infiltrate – *A process where water on the ground surface enters the soil (e.g. through a soakaway).*

Slow – *To reduce the velocity of surface water as it moves, for example by using check dams.*



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GLOSSARY

Access/Inspection Chambers - A chamber on a sewer e.g. at the junction of a drain with a sewer.
Apron – a small area covered in a robust/impermeable material around an outflow to protect it from erosion (p.60).
Attenuation - A term frequently used to describe storage where water is actively held back for a period of time.
Blackwater - Water that is polluted with a high proportion of faecal matter and solid waste.
Brownfield - Development upon a site previously developed
Catchment Area - The area draining naturally by gravity to a watercourse or given point.
Combined System - A single pipe system of sewerage in which foul water and surface water in the same pipe.
Convey or conveyances – to transport water from one place to another, usually in the form of a channel or pipe.
Critical Duration - The specific duration that gives the largest result during an analysis of multiple durations.
CSO/Combined Sewer Overflow - Structure that diverts excessive storm flow out of the combined sewer, normally to a watercourse.
Culvert - Large pipe or conduit used to pass water under a road, railway or embankment.
Design Life - Time (years) that the structure or system is expected to last before suffering deterioration.
Depression - a dip, temporary decrease in levels or hollow on a surface.
Detention Storage - A storage system that detains water (i.e. dry pond)
Digital Elevation Model (DEM) - A digital representation of the topography or terrain of an area
Digital Surface Model (DSM) - This is a DEM which has had selected features (for example buildings) reinserted.
Digital Terrain Model (DTM) - Commonly known as a bare earth model, this is a DEM from which features such as trees have been removed.
Discharge point – see OUTFALL
Drainage - drainage refers to the structures/processes used to link surface water from its source (e.g.rainfall) to a discharge point (for example groundwater etc.).
Drainage Area- The area draining to a given point, this may not coincide with the catchment area as artificial drainage can be achieved.
Duration (rainfall) - The length of rainfall, expressed in minutes, hours or days see p.21.
Evapotranspiration - Vegetation has an important role in intercepting rainfall and transpiring moisture to the air. A significant proportion of ‘greenfield’ stormwater is removed from the site via evaporation or transpiration.
Exceedance – when planned drainage system is overwhelmed/ overflows usually due to a flow greater (i.e. longer or more intense) than planner.
Flow path – direction of water flow. Naturally at a 90 degree angle to contours.
Fluvial Flooding - Flooding from a river or other main watercourse.
Forebay – a small depression, usually at the inlet of a component, to allow solids to settle and be removed easily before entering the main structure of the component.
French drain - A ditch filled with gravel or rock that redirects surface and ground water. Can have a pipe or pipes along the bottom to increase capacity.
Frequency – see p.21. Also called recurrence/repeat interval or annual exceedance probability.
Greenfield - Development upon a site not previously developed
Greywater/Sullage - Water that has been used for washing, bathing etc. and is contaminated but, unlike sewage (or black water), contains little faecal matter/solid waste; and very low % or no faecal matter.
Ground Water - Water contained in the soil or rocks below the standing water level i.e. water table.
Hazard - is something that can potentially cause harm or danger to anyone or anything.
Hydrograph - A graph which shows the variation with time of the level or discharge in a sewer or watercourse.
Hydrology - The study of the movement, distribution, and quality of water throughout Earth, addresses both the hydrologic cycle and water resources.
Hyetograph - A graphic representation of the average distribution of rain.
Inflitration – a process where water on the ground surface enters the soil.
Intensity (rainfall) - The rate of rainfall, expressed in mm/hour. See p.21.
Invert - The lowest point on the internal surface of a sewer, drain etc. (Opposite to SOFFIT).
LiDAR - Is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target, commonly used to measure topography
Made ground - the organic/top soil layer or fractured/desiccated ground.
Management/treatment train – Surface water management techniques used in series to change the flow and quality characteristics of the runoff in stages see p. 35 and https://www.susdrain.org/delivering-suds/using-suds/suds-principles/management-train.html
O&M - Operation and Maintenance
Outfall - The point of discharge.
Overland flow - the flow of water over the Earth’s surface.
Precipitation - any product of the condensation of atmospheric water vapour that falls under gravity this includes rain and snow.
Pre-treatment - Normally refers to treatment processes before primary treatment to remove materials that can be easily collected i.e trash screen or grit trap
Prevent – to avoid or reduce a source of surface water.
Risk - is the hazard x the likelihood of it happening
Resilience - the ability of systems, in this case those related to a site, to withstand shocks and stresses. See p.25.
Retention Storage - A storage system that retains water.
Return Period - A return period (also known as a recurrence interval) is an estimate of the interval of time between events like a flood or river discharge flow of a certain intensity or size. See p.21
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Self cleansing - The minimum flow within a sewer that will not deposit sediments or solids
Sewage – see blackwater.
Sewer - A pipe conveying wastewater discharged into it from two or more shelter drains.
Silt trap – place where fine particles can settle and be removed.
Slow – to reduce the velocity of the surface water.
Source Control - managing surface water as close as possible to the point where it enters the system (source control).
Splash pool – area immediately after a drop in levels in a flow path where energy is lost and erosion often occurs.
Spilt water - Clean/treated; water that might be spilt on the site Water that is accidentally spilt this could be at a tapstand, by a water truck.
Store – see ATTENUATION
Subgrade - The native material underneath a constructed road, pavement or railway track. It is also called formation level.
SUDS - Originally sustainable urban drainage systems, which gave rise to the acronym “SUDS”. This specialist drainage technique is now commonly referred to as sustainable drainage systems and SUDS. The ‘u’ may be lower case.
Sullage – see greywater
Surcharge - The condition obtaining when the flow in a sewer increases after it is already flowing full.
Surface Water – water moving across the ground.
Surface Water Management - is the act of controlling water that moves across the ground.
Treat - to improve water quality.
Use – to take water out of the system for another purpose (e.g. cleaning or irrigation dependant on water quality).
Water table - Level at which the groundwater pressure is equal to atmospheric pressure.