Community Site Planning Manual:
A comprehensive process for community infrastructure and housing upgrading

August 2014
**Community Empowerment and Development Team (CEDT)**

Villa no. 5, Street 260,
Phnom Penh
Cambodia

**Engineers without Borders (Australia)**

PO BOX 708
North Melbourne, VIC 3051
Australia

**Manual Author:** Johanna Brugman

**Authors of technical guidelines:** Rod Tower, Gareth Clemens, Katie Baker, Katrie Lowe, Linh Nguyen, Mary Li, Michael Baker, Michael Ridger, Miriam Buchhorn, Pawan Dallakoti, Peter Hobbs, Raymond Tsao, Robert De Cataldo, Samantha Guo, Sofia Lardies, Tim Walton, Nicola Bailey, Andrew Mcmillan, Chanditha Karunanayake, David Williamson, Mark Evans, Anna Thompson, Oscar Aitchison, Kathryn Silvester, Patrick Lewis, Devinda Perera, Rahul Chowdhury, Julius Susanto.

**Contributions:** Rod Tower, Sath Kanyara, Depika Serchan, Sinit Lonh

This community site planning manual may be reproduced and/or adapted in part or in full with acknowledgement of the author(s).
1. Introduction
   - What is Community Site Planning?
   - Purpose and Audience of the Manual

2. Implementing a Community Site Planning Process
   - Stages of the Community Site Planning Process
     - Stage 1: Understanding and prioritizing
       o Mapping resources and problems
       o Mapping existing infrastructure conditions
       o Mapping existing housing and household conditions
       o Surveying community skills
     - Stage 2: Dreaming of a better future
       o Developing a new community layout
       o Dreamed community
       o Dreamed house
     - Stage 3: Developing community housing and infrastructure financial action plans
       o Cost-estimation for infrastructure and housing
       o Financial planning for housing and infrastructure
     - Stage 4: Construction and monitoring
     - Stage 5: Sharing experiences with networks

3. Complementary Forms

4. APPENDIXES
   - APPENDIX 1: MAPPING AND PLANNING FOR INFRASTRUCTURE
   - APPENDIX 2: TECHNICAL GUIDELINES FOR THE DESIGN OF INFRASTRUCTURE
   - APPENDIX 3: GUIDELINES FOR MATERIAL AND LABOUR COST-ESTIMATION
   - APPENDIX 4: TECHNICAL GUIDELINES FOR CONSTRUCTION OF INFRASTRUCTURE
Introduction

Working with urban poor communities in the field of land, housing and infrastructure upgrading requires a holistic view and understanding of the communities’ problems, opportunities and priorities, their place in their cities and towns, and the relationships and partnerships they can create with different actors at different scales ranging from the city, to the national and even international levels. For this there is a need for a comprehensive process that supports people to express their infrastructure and housing needs, priorities and ideas freely, apply their knowledge and skill, form or strengthen partnerships and networks, and like this be recognized by government authorities, NGO’s and donors as key development partners. This manual is complemented by 5 appendixes which describe technical details of infrastructure planning, design and construction development.

What is Community Site Planning?

Community site planning (CSP) is a comprehensive and participatory process that allows the holistic understanding of urban poor communities’ problems, opportunities, infrastructure and housing characteristics, and priorities, as well as the visualization of potential upgrading solutions and (based on these) the development of community actions plans (CAP). This process aims to integrate social, cultural, physical, spatial, environmental and economic dimensions in the planning for housing and infrastructure so that upgrading solutions can be more holistic and responsive to the variety of needs of different groups of people as well as the community context.

The process is divided in five phases and includes different methodologies to engage with and mobilize poor communities for housing and infrastructure upgrading. A Community Site Planning process should be implemented with time and commitment, rather than dictated by external deadlines and “professionals” should have the capacity to step back, listen and offer people space and support to discuss, visualize, organize, and plan together how they can develop their housing and infrastructure initiatives in a way that is owned by them, and responsive to their needs and priorities.

Purpose and Audience

The Community Site Planning Manual is an invitation to explore different methodologies that can be used to engage with urban poor communities, to support their organization and development of housing and infrastructure upgrading plans in partnership with different actors such as NGOs, academia, donors, the private sector and/or government authorities. This manual introduces the different stages involved in a community site planning process and relevant participatory tools and methodologies that can be used in each of these stages to engage with and mobilize communities during housing and infrastructure upgrading.

This manual can be used by urban poor communities, development practitioners, students or people interested in working and experimenting new ways to engage with communities in topics of land security, housing and infrastructure upgrading.
Stages of a community site planning process

- Mapping problems and opportunities
- Mapping existing infrastructure conditions
- Mapping existing housing conditions
- Surveying community skills

Dreaming of a better future

- Developing a new community layout
- Dream community
- Dream house

Developing Infrastructure and Housing Financial Action Plans

- Cost Estimation
- Financial Planning

Construction and Monitoring

- Construction Management

Sharing experiences with networks

Understanding and prioritizing

Exhibitions
- Community Exchanges
Stage 1: Understanding and Prioritizing

Stage 1 proposes the use of mapping and surveying as tools to support urban poor communities to visualize the current characteristics, strengths and weaknesses of their communities and start thinking about potential solutions for their housing and infrastructure problems. Mapping and surveying are an opportunity for community members to get active and gain an understanding of their communities’ context by collecting information, visualizing the existing problems and resources that exist, as well as an opportunity for people to come together to discuss, find common problems and priorities and develop together potential solutions.

Activity 1: Mapping community resources and problems

The purpose of this exercise is to mobilize and incentive the interest of community members in housing and infrastructure upgrading activities. The idea for this is to start from the very basic and make a “drawn survey” of the strengths and weaknesses of the community, and encourage members to identify and analyse main issues, resources and upgrading priorities in the area.

The exercise should start with a transect walk where community members and facilitators go for a walk together around the community and listen to the people’s stories and understanding of issues, problems, resources and potential solutions in the area. During this walk facilitators can take photographs and record videos, and take notes. The main purpose of the walk is to have a more grounded understanding of the issues in the communities, and give opportunity to community members to express and share their knowledge and understanding of their own problems and potential solutions.

Image 1: Community leader discusses the problem with drainage infrastructure during a transect walk in Hung Hoa Commune – Vietnam.
After the walk, the mapping exercise should start with an introduction of the activity and its purpose to the participants. Since it is a mapping exercise, a short introduction on how to “map” using symbols and creating a legend can be beneficial. Community members can then be divided into groups of approximately 10 members. It is a good idea to encourage community members to divide into specific groups such as women, men, elderly, and youth, so everyone has the chance to identify their priorities according to their needs, but also mixed groups are important.

If the community already has a map of the settlement, groups can use it as a base map, or they can choose to draw their community from scratch and according to their understanding.

On the base map community members can then identify the existing physical, spatial, environmental, economic, social, and cultural resources in their community and any important places (for example gardens where people grow food, common sport areas, trees for shade, etc) as well as problems that they experience (such as flooding, pollution, dark areas where people don’t feel safe, lack of access roads, etc).

In the beginning people might feel shy or confused so the facilitators can give them some encouragement by asking questions such as: Which spaces are important for you in the community? Where do you play? Where do you meet with other members? Where does it flood? Are there some areas where you feel unsafe? Then people can draw (or chose their own symbol) and map these areas/issues.

Once all the maps and corresponding legends are developed all groups can present and explain their map to each other. This exercise will allow a first identification and analysis of resources and problems that are important for people in the community and their life together, and identification of the most pressing issues that might need prioritizing for upgrading (these can be related to infrastructure, environment, housing).

*Image 2: Community representative presents to community members a map of the organisation of saving groups (resources) in their community*
Materials

Transect walk: sheets of paper, pens to take notes, cameras

Mapping: Large sheets of paper, copies of existing community maps if available, colour pens, colour paper, transparent paper, sticky tape, stickers, glue, and scissors.

Time

Transect walk: 1 hour

Mapping: Approximately 3 hours

Responsibilities

Transect walk: Facilitators and community representatives to coordinate the exercise, community members to take notes and explain the importance and/or associated problems of some areas.

Mapping: Facilitators and community representatives to coordinate the exercise

Activity 2: Mapping existing community infrastructure

The purpose of this mapping exercise is to make an “inventory” or “data base” available infrastructure in the community and generate information to be taken into consideration when thinking and developing a new community layout (by re-blocking, land-sharing, etc).

The exercise should start with an introduction of the activity and its purpose to the participants. Since it is a mapping exercise, a short introduction on how to “map” and creating a legend can be beneficial.

For this exercise community members can map the community infrastructure together in 1 group using a large map. Community members can use their existing community map as a base (making sure that all houses are included) or draw the map from scratch.

Then community members should focus on mapping information such as (but not limited to):

- Existing electricity connections (formal and informal)
- Existing drainage channels (opened and closed)
- Existing water connections (formal and informal) and/or water sources (e.g. rain water collection tank, wells, etc).
- Existing access roads and their present use
- Existing sanitary infrastructure (private and common toilets)

Information can be mapped by drawing or using symbols. Once the map and corresponding legend are developed the group should have a discussion about the existing infrastructure situation of the community and based on these think about priorities and solutions. It is important that the facilitator guides the discussion and raises to community members the consequences of upgrading infrastructure in the community (for example some people might
have to start paying formal electricity and water rates every month) and the need to get organised and develop together an infrastructure upgrading plan for the future.

*Image 3: Community representatives present the mapping of drainage infrastructure in their settlements mapped by a group of community members where they identified the existing channels in their community and upgrading needs to prevent flooding.*

This exercise can be done mapping all infrastructures in the community, or/and can be done by mapping and selecting a particular infrastructure such as drainage, water supply, sanitation, electricity, roads, etc. See Attachment 1 on specific mapping and planning processes for these infrastructures.

**Box 1: Identifying priorities**

Mapping and surveying exercises are a way in which communities can visualize the current conditions and characteristics of their settlements, analyse and understand which are their problems and start to think about potential solutions. Even when these exercises are holistic and designed to ‘pull out’ a range of problems and conditions that the communities are facing, it is important to also use them as a way for communities to be able to think and prioritize what their immediate needs are, and what would they like to invest in as a priority in their lives and their settlements. Prioritizing is important in order for communities to be able to manage in a ‘step by step’ approach the upgrading of their settlement, and learn and plan together for this purpose.
Once the map is finished technical staff can digitize this map using programmes such as AutoCAD and organize the information to be used at a later stage (e.g. for developing a new layout for the community by re-blocking or land-sharing).

**Materials:** Copies of existing community maps if available, large sheets of paper, colour pens, colour paper, transparent paper, sticky tape, stickers, glue, scissors, tables, chairs

**Time:** Approximately 2 hours

**Responsibilities:** Facilitators and community representatives to coordinate the exercise, community members to map and technical staff to digitize map in AutoCAD or other design programme.

**Activity 3: Mapping housing and household characteristics**

The purpose of this mapping exercise is to make an “inventory” or “data base” of the characteristics of all houses/households in the community and generate information to be taken into consideration when thinking and developing a new community layout (by re-blocking, land-sharing, etc).

The exercise should start with an introduction of the activity and its purpose to the participants. Since it is a mapping exercise, a short introduction on how to “map” and creating a legend can be beneficial.

For this exercise community members can map the whole houses of the community together in 1 group, or divide into groups of approximately 10 neighbours for this purpose.

Community members can use their existing community map as a base (making sure that all houses are included) or draw the map from scratch. Then community members should focus on mapping information such as (but not limited to):

- Type of ownership (fully-owned, rental, paying for ownership)
- Number of people in each household
- Number of families in each household
- Type of material (concrete, wood, steel sheets)
- Type of structure (removable, fixed)

Information can be mapped in different ways. Qualitative information (such as type of occupation, type of material, and type of structure) can be mapped with different colour paper or symbols. Quantitative information (such as number of people and families in each household) can be drawn directly in each of the houses.
Once all the maps and corresponding legends are developed all groups can present to each other, and have a discussion about the issues that arise. For example, if there are renters in the communities can they be part of the housing solution plans? Or the families that have a fixed house made out of concrete are happy to demolish part of the house to make room for all communities’ equal plot sizes? This exercise is an opportunity for community members to discuss about the compromises they might have to take in the process of upgrading.

Once the map is finished technical staff can digitize this map using programmes such as AutoCAD and organize the information to be used at a later stage (e.g. for developing a new layout for the community by re-blocking or land-sharing).

**Materials:** Large sheets of paper, copies of existing community maps if available, colour pens, colour paper, transparent paper, sticky tape, stickers, glue, scissors, tables, chairs

**Time:** Approximately 2 hours

**Responsibilities:** Facilitators and community representatives to coordinate the exercise, community members to map and technical staff to digitize map in AutoCAD or other design programme.
Activity 4: Surveying internal community skills

The purpose of this exercise is to survey and identify the existing skills of the members living in the community that can contribute to housing and infrastructure upgrading with labour and advice. Form 1 is a survey form that can be used (or used as a reference) to collect this information with the aim of identifying skills in the communities such as building, crafting, designing, etc.

Ideally, the information should be collected by community members themselves. Once the key people and skills in the community are identified a network of community builders can be formed. This network can play an important role in providing advice and leading the stages of infrastructure and housing design, cost estimation, and construction.

Materials: Form 1

Time: Flexible (depending on community)

Responsibilities: Facilitators provide form to the community, and community representatives/members collect information themselves and form community builder network.
Stage 2: Dreaming of a better future

This phase invites people in the communities to dream about the communities they want to live in the future and make these dreams tangible through participatory design. The focus of this stage is about thinking holistically and together with the people about the physical elements (land, housing, and infrastructure) that are needed or need to be improved in their communities to secure a good standard of living and sustainable livelihood according to their culture, job, personal preferences, needs and affordability. Some key questions to keep in mind in this phase include:

- How big should one household’s plot be?
- What should be the size of lanes and open spaces?
- What are the components for houses that support community lifestyle?
- What basic infrastructure is needed?
- How to build these in an economically viable way?

Activity 1: Developing a new community layout

The purpose of this step is to support community members to explore what type of upgrading strategy would be appropriate in their community, and based on this support them to develop a new layout and vision for the upgrading of the site. For the new layout, relevant spaces of the community need to be identified including the size and quantity of housing land plots, open/community space, and the space for infrastructure such as roads, drainage lines, and water and electricity lines. Once the desired spaces and land plot sizes are identified, these are drawn in a map.

The first step in this exercise is for communities to decide which upgrading strategy they are going to use (see box number 2). For this technical staff and/or community representatives can present and explain the different options available for upgrading to community members and decide together which one is more appropriate for their community.

After deciding which strategy to follow, the dimensions of the land plots for housing, infrastructure and other spaces (e.g. community centre, playground) in the community need to be identified. A good way for this is to visualize the dimensions on the real site by measuring with a measuring tape, and decide which dimensions of a house are appropriate to accommodate all households and families, as well as which dimensions are appropriate/available for open spaces, lanes, roads, etc. Information collected in previous mapping and survey exercises (for example the number of families in each household) can help community members to decide the appropriate the dimensions of land plots.

After the components/spaces of the community and dimensions of the land plots are decided, community members (with assistance of the technical staff) can develop a map showing the future layout of the community. For this a poster size (at least A0 size) map showing the boundary of the community is used (a good scale is 1:500). On the map, community members will use different colour papers representing the different features of
the community (houses, roads, lanes, open space, etc) to construct the future community layout. The colour papers should be scaled according to the base map. The final product should be a map presenting the organisation of the future spaces of the community. After the map is completed technical staff can digitize the map in AutoCAD/GIS and present and give back to the community.

**Box 2: Housing resolution strategies**

There are 5 different options that urban poor communities are currently using to obtain security of tenure and improving housing and living conditions in their settlements. Considering these different options is important for communities to choose which one is more appropriate for them rather than following a single development model. The five solutions are described below:

- **On-site upgrading**: the process where houses, lanes, roads, and open spaces are improved without changing the layout or plot sizes that exist in the community. This can be applied when the community does not have the need to move their existing houses to make room for infrastructure, and where communities agree to have different land plot sizes for housing.

- **On-site reblocking**: the process where infrastructure, housing and living conditions are improved by making adjustments to the layout of the houses to install sewers, drains, walkways and roads. In re-blocking some houses usually have to be moved and partially or entirely reconstructed to improve access. Some lanes may also have to be re-aligned to enable drainage lines, water supply systems or sewers to be constructed.

- **On-site reconstruction**: The process where existing communities are totally demolished and re-built on the same or adjacent plot of land. This strategy is usually applied in government-funded housing where existing houses are demolished for constructing new blocks of housing, and it is usually expensive.

- **Land sharing**: The process which allows both a private land owner and slum dwellers to live in the same land. After negotiation and planning, an agreement is made to “share” the land, where the settlement is divided into two portions. The community is given, sold, or leased one portion (usually the less commercially attractive part of the site) and the rest is developed by the private owner. This strategy is usually applied when there is opportunity to negotiate with land owners (such as private company, pagoda, or government) depending on their good-will and availability. In some cases communities have purchased their piece of land after negotiating an affordable price for them.

- **Nearby relocation (usually within 5km of the original settlement)**: The process in which communities are moved to an entirely new site and have to reconstruct their houses, infrastructure and communities from scratch.

Source: CODI, 2005
**Materials:** Measuring tape, base map with community boundaries (poster size), colour paper, mapping scale rulers, sticky tape, glue, scissors, tables, chairs

**Timing:** Approximately 4 hours

**Responsibilities:** NGO/technical staff and community representatives to coordinate the exercise, community members to measure land plots, cut paper and map, NGO/technical staff to digitize map in AutoCAD/GIS.

**Activity 2: Dream Community**

The purpose of this exercise is to allow all people to dream and visualize their “ideal or dreamed” community, identify which are the infrastructure priorities that need to be addressed, and together with the people construct appropriate designs for particular infrastructure. In the first place this exercise should be holistic allowing people to dream about the community as a whole including houses, open spaces, access roads, drainage, lighting, water accessibility, sanitation etc. However the ultimate focus should be directed towards particular infrastructure.

The exercise can start with an introduction of the activity, its purpose and significance to the people. Community members can be divided in different groups (people themselves can chose their own groups) or chose to do the exercise together in one group. It is a good idea to involve children in this exercise, and they can be in one separate group.

The exercise can be done in two ways, depending on the availability of the community and the number of people present. One way is “dreaming by drawing” in which community members are given large sheets of paper and colour pens to draw their dreamed community. The other way (which can also be an extension of the drawing process) is “dreaming by modelling” in which community members (with support from technical staff) can make a simple model of the community using cardboard and colour paper. The main purpose of the exercise is to visualize together the ideal community.

When the drawings/models are finished (and if people are divided in groups) they are encouraged to present their drawings to each other. Most important, with the support from the facilitating and technical team the group should enter into a deeper discussion about the particular infrastructure that is needed to build the “ideal community” and prioritize 1-2 infrastructures to work on. As well as how the design of the particular infrastructure should be, and use big sheets of paper to draw these ideas so that all participants can visualise it.

Here it is essential to have the input from the community builders, technical staff and government officials (if present) on potential materials, cost-reduction strategies, and other consideration regarding the design of the infrastructure. From this discussion, draft drawings identifying dimensions, areas, and possible materials for each particular infrastructure should be generated. Once the draft drawings are made, the technical staff can translate these ideas into technical drawings and present to the community members at a later stage. These drawings should be the base to work towards the next step of cost-estimation.
Important: Following this exercise the technical team together with community builders and community representatives should do a site visit to the area where the infrastructure needs to be built, and collect necessary information including background information on the problem, dimensions needed, etc (see Attachment 2 for technical guidelines for the design of infrastructure including drainage, water supply, sanitation, electrical systems, roads, earthworks and civil works) and make a good assessment of the site. It is important also to have the advice from a technical person (e.g. engineer) with the appropriate skills and knowledge about the infrastructure that will be developed. Because of these in some cases more that one individual site visits would be required as well as consultation with local authorities, communities and/or private construction companies.

Materials: Large sheets of paper, colour markers, pencils, sticky tape, tables, chairs, rulers, tape measure, camera

Time: 1 day

Responsibilities: Technical staff and community representatives to coordinate the exercise. Community members draw, provide ideas, participate in discussions, and guide the site visits. Community builders, NGO/technical staff, government representatives provide ideas and advice and help make initial drawings, NGO/technical technical staff to digitize drawings in AutoCAD or other drawing tool.
Activity 3: Dream house

The purpose of this exercise is to allow people in the community to dream and visualize their “ideal or dreamed” house. For this it is essential to have the technical support of architects and community builders, able to translate the ideas of community members into different designs and housing models that are appropriate to their culture and preferences, needs, environment and affordability.

The exercise should start with an introduction of the activity and its purpose to the participants. Then a group discussion should be facilitated to collect and summarize the information that community members have and that is relevant to housing development, as well as discuss financial aspects and strategies. This discussion is important to learn from community members about their ideas and affordability. Information collected in the “mapping” process should be shared here to enhance this discussion.

The discussion should identify the size of the land plots available for housing (these should be based on the community layout) and aspects that are important for their living space, such as the number of families now and in the future, culture, livelihood, climate, and other environmental factors as well as the affordability of the different households (the technical team can facilitate this discussion and write down the main points on a sheet of paper that is visible to all the participants).

Members can then be divided in different groups (people themselves can chose their own groups) of about 10 people each or the exercise can be facilitated within 1 group depending on the number of people. The involvement of women is particularly important, as well as the elderly and youth. The technical team (including community builders) can be distributed among the groups.

Sheets of paper (A4) are then given to each of the participants to encourage them to draw their dream house. People should be encouraged to draw the housing typology that they prefer (such as wooden house, cement house, etc) as well as identify the spaces that
important for them (such as garden, or an empty space below the house to develop a future business, etc). In addition, architects/technical staff can support community members to develop the architectural plans of the house identifying the different spaces (toilet, kitchen, living and sleeping place, garden, etc) and decide together with the participants on the appropriate dimensions for these. Participants and technical staff are then encouraged to provide ideas on the preferred materials and any cost-reduction strategies that can be applied (see Box number 3).

Once these aspects are identified, it is important to decide with the participants on an average housing price which is affordable for all in the community, as well as a housing development strategy: this means whether people are willing to develop their house collectively and share costs or develop their house individually. Sharing experiences from other communities in Cambodia and Asia can be beneficial for communities to learn how different ways in which people have organized together and develop housing and infrastructure.

Based on the community drawings the architect/technical staff can produce housing models, which are scaled and represented in a physical form using cardboard and/or other materials, and/or technical drawings and presented to the community. These models/drawings should be the base to work on the next steps of cost-estimation and financial planning.

**Materials:** large sheets of paper, cardboard, scissors, colour pens, glue

**Time:** 2-3 hours

**Responsibilities:** Technical staff and community representatives to coordinate the exercise. Community members to provide ideas, participate in discussions. Community builders, technical staff, and government representatives to provide advice on cost-reduction strategies and materials.
Stage 3: Developing community housing and infrastructure financial action plans

This stage aims to go a step further in making the dreams of communities more tangible by grounding their infrastructure and housing ideas with cost-estimations and financial strategies. This is important in order for communities to realize whether their dreams are really affordable to them or think ways in which they can reduce costs. Also, this phase is an opportunity for community members to come together and discuss which type of financial strategy they want to use to finance their settlement’s upgrading, and with these discussions open the possibility to incentivize collaboration between each other with the aim of working together for infrastructure and housing upgrading.

Activity 1: Cost-estimation for infrastructure and housing

The cost-estimation for infrastructure and housing aims to provide communities with information about the cost for a desired infrastructure and/or house so they can have grounded idea of the resources that they need to develop it, and start organizing themselves financially for this purpose.

Cost-estimation for infrastructure

This step will use as a starting point the infrastructure designs/drawings that were developed together with community members in the previous stages. It is encouraged that

Box 3: Cost Reduction Strategies for housing and infrastructure

- Share housing foundations and walls
- Design common car/moto parking
- Encourage community labour and skill to reduce labour costs
- Incorporate recycled and/or low-cost materials into housing design to bring down materials costs (these include community-made earth and cement blocks, materials from existing structures that can be recycled such as wood, glass, iron sheet, etc, local materials such as wood, bamboo and rattan)
- Encourage the use of only 1 contractor to reduce administrative fees
- Buy materials collectively to get bulk discounts on cement, steel, roofing sheets, sand, etc
- Build housing collectively to make use of “economies of scale” to bring down per-unit costs
- Find opportunities to partner with the private sector, local government (to find support or find subsidies for water/electricity and other services)
this step is done together with community builders and representatives and encourage them to use their local knowledge and experience. Nevertheless it is important to recognize that the appropriate technical expertise is needed to support this process.

Based on the infrastructure drawings (which should identify all the different sections of the infrastructure, materials, and dimensions) the quantity of each material needs to be identified (see Attachment 3 for a guideline on how to calculate material’s quantities and relevant costs). When the quantity of materials is calculated, community members can make a market survey in order to make a comparison of the costs of materials available in the city/town, and choose the best price that is available. Form 2 can be used for this purpose. Once the best materials prices are identified, the technical staff together with community builders and representatives can develop a bill of quantities (BOQ) using Form 3 describing all materials, quantities and rate used. In addition, the community needs to decide what type of labour they are going to use (self-built, community contractor, external contractor, and/or private company) and identify labour costs (see Attachment 3 for a guideline on how to calculate labour cost).

When the costs for materials and labour are calculated, Form 4 can be used as a reference to calculate the total cost of the infrastructure upgrading project, including materials, labour and other additional costs such as administration fees, transport, storage of materials, etc.

It is important to maintain flexibility and be able to change the design the infrastructure, and adapt to new ideas that can reduce the costs of the project. This can happen when communities realise that their initial ideas might be too expensive.

Materials: Large sheets of paper, markers, sticky tape, forms 2,3,4

Time: Calculating the quantity of materials (2 days), Material Survey (1 week), Cost estimation (1 day)

Responsibilities: Community representatives and technical staff to coordinate exercise, technical staff to support community builders and representatives to identify relevant materials and quantities, community builders to do material survey using form 1, technical staff to assist communities to identify total costs referring to forms 2 & 3.

Cost-estimation for housing

As for infrastructure, materials and labour are the main elements to take into consideration in order to calculate costs for housing. (see Attachment 3 for a guideline on how to calculate material’s quantities and relevant costs). Additional costs for housing can include interest rate from loans, as well as transport, storage of materials, temporary accommodation, etc.

The cost-estimation should be made following the design models/drawings made in the dreamed house exercise. After developing the housing design and respective quantities, the materials need to be identified. The community also needs to decide what type of labour
they are going to use (self-built, community contractor, external contractor, and/or private company) and identify labour costs.

**Form 5** can be used for facilitating the calculation of housing costs. This form divides the house in different sections such as foundations, walls, roof, toilet, etc, for which materials, quantity and price can be identified. This form can be completed after the materials and quantities are identified (with the support from an architect, technical staff and community builders) and a market-survey is completed identifying the best rate available for materials in the city/town.

When the costs for materials and labour are calculated, **Form 6** can be used as a reference to calculate the total cost of the housing project, including materials, labour and any additional costs such as administration fees, transport, storage of materials, interest from loans etc.

**Materials:** Forms 2, 5, 6

**Time:** Material Survey (1 week), Cost estimation process (1 week)

**Responsibilities:** Community representatives and technical team to coordinate exercise, technical team and community builders to identify relevant materials and quantities, community members to do market-survey, technical team and community representatives/builders to assist communities to identify total costs referring to forms 4 & 5

**Activity 2: Financial planning for housing and infrastructure**

By having a clear financial strategy, communities move a step forward in making tangible their infrastructure and housing needs. The aim of this activity is to think about the different ways in which communities can finance infrastructure and/or housing by themselves and/or leverage external resources.

For this it is important for communities to consider their internal resources as well as identifying who they can partner with in the city for this purpose. By being organised financially, and knowing how much money they have and can invest in their upgrading and how much money they need, communities are more likely to find a partner that supports them with finance (either by obtaining money directly or obtaining a loan).

**Infrastructure**

For infrastructure, it is a good idea to start with a pilot common and small infrastructure project that benefits the whole community, and can offer experience and learning to communities in working together and financially organize for this purpose. Once community members have gone through the process of working together and financing infrastructure then it is easier for them to organize themselves and generate a financial strategy for housing.

The first step after the prioritization, design and cost-estimation of infrastructure, is for communities to have a clear understanding of the financial products or mechanisms that are
accessible for them in Cambodia to leverage funds for infrastructure. With this understanding, communities can choose by themselves what the best option for them is, as well as have an understanding of how much money can they obtain from an external source and how much money they will need to contribute by themselves.

If a community has a saving group in place and a progressive saving system, they can calculate and decide by themselves the amount of savings that can be used for the infrastructure project, and the amount that needs to be leveraged from other external sources.

If a community does not have a saving group in place or has a weak system, a good strategy to strengthen or develop the saving capacity of the community is for them to find each household affordability conditions. This is done by each household considering their monthly income and the amount that is left over after monthly expenditures, and start thinking about their willingness/capacity to invest these resources for other use such as infrastructure. Considering the amount that is left over after monthly expenditures, is important as it is the most likely amount to be used to contribute to infrastructure. To undertake this process all families in the community should make a calculation of their household monthly income (this includes the income generated by all the families/members in the household), as well as their monthly expenses (such as food, education, transport, etc). Once they calculate these figures each household can see how much is left at the end of the month and how much they could or want to be use for other purposes such as infrastructure development.

Once the household affordability condition is calculated communities can think about organizing this money into a communal fund for the particular infrastructure project or making it part of their existing saving group to finance infrastructure development. If communities are organised financially and know how much money they have and how much money they need to develop an infrastructure project, it is more likely that they will be able to find a partner that support them with funds for this purpose.
This process should be an internal process within community members. Facilitators can support them in giving them an overview of the financial mechanisms that are accessible to them, support them to organize/strengthen their saving groups, as well as initiate dialogue with potential partners such as government, private sector, and/or NGO partners.

**Diagram 1: Financial Sources for Infrastructure Development in Cambodia**

**Housing**

Housing comes in different shapes and sizes, such as blocks of low, medium or high-rise flats, rental rooms, row-houses and free-standing houses. To accommodate a wide range of housing needs and a growing population over time, cities and towns need to provide a steady supply of new housing and expand the existing housing supply. Housing which grows too old or too deteriorated also needs to be maintained or replaced. A housing unit can be built by a household itself, or by a carpenter or small contractor that a household hires. Housing can be built by developers for profit or by government agencies. And housing can either be sold or rented, under a variety of rates, arrangements and payment terms (UNESCAP, 2008).

The shortfall of housing in most cities is primarily for low-income housing, where the population is the least able to pay for rising land and housing construction costs, and where the market has not been able to provide affordable housing in locations where poor people can access employment and others services. Housing is not affordable to the poor, and this is why housing finance is so important. Formal housing finance systems touch only a fraction of
the total houses produced in most Asian countries. These formal financial markets have been unable to reach down the income levels and reach those households in most urgent need of land and housing (UNESCAP, 2008).

When thinking about developing a financial strategy for housing, urban poor communities should be informed about the available options/mechanisms/organisations/institutions in Cambodia that support low-income groups to access affordable housing either by funding the construction of housing themselves (based on their own conditions and design), or by supporting communities in accessing finance (usually in the way of loans) to develop housing according to their preferences and needs. In addition, and based on the mechanism that they will choose to access housing, communities need to decide whether they prefer to pay and develop their housing individually or are willing to pay and develop it collectively together as a community.

These decisions should be an internal process within community members. However facilitators can support in giving community members an overview of the financial mechanisms that are accessible to them, provide successful examples on how poor communities have managed to access affordable housing, support them to organize/strengthen their saving groups (in the same way as described in the infrastructure section), as well as support them to initiate dialogue with potential partners such as available institutions that could give the urban poor access to loans, and/or government, private sector or NGO partners.

**Diagram 2: Financial Sources for Housing Development in Cambodia**

![Diagram showing financial sources for housing development in Cambodia](image)
**Understanding loans:** Loans are considered one of the main mechanisms allowing urban poor communities to access finance for housing. A loan is an amount of money that a person or group can borrow from an institution which is expected to be returned and paid back with interest. If a poor community or family is interested in accessing a loan, it is important for them to understand the conditions of the loan and make sure that the loan is in fact a benefit for them, rather than a way of building unaffordable debt in their lives. A loan’s *conditions* include all those restrictions which determine who is eligible to take that loan and who isn’t — things like a person’s monthly income, history of past savings, available assets and household members willing to guarantee the loan, as well as the repayment period (the amount of time in which a loan needs to be paid back) and the interest rate (the extra money that needs to be payed for accessing the loan). For a loan to be affordable for urban poor communities and families the interest rate should be low (between 1-5%) and the repayment period should be as long as possible (at least 24 months).

**Box 4: Individual vs. collective housing**

Urban poor communities can choose to develop their housing individually (this means each household pays for their individual house) or collectively (this means that all households get organised and pay for their housing together either by accessing a loan and/or forming an internal common fund for housing). There are advantages and disadvantages of both systems. Developing housing individually gives more flexibility to households in the way they spend their money, design and develop their house, and might work better for families that have a steady income and savings that they can spend for housing. Collective housing, requires organisation, collaboration, and compromises between members, which might be hard at the beginning, but at the end can bring great benefit for all members of the community, and the sense of community and place itself.

Some recognized examples (like above in Vietnam) in South East Asia show that collective housing is a successful strategy used to develop housing, as it allows organised communities accessing low interest loans, and/ or finding partners that can contribute funds for this purpose, reduce costs by developing a collective design in which walls and foundations are shared, and increase collaboration between members making sure that all households in the community are able to have a house to live regarding of their income.
Stage 4: Construction and monitoring

Once communities have the money available to finance their infrastructure they should make an action plan for construction management with at least the following components:

- **Budget management and system:** This step refers to how community are going to get organised to manage the budget and do the purchase of materials to start construction.

- **Working schedule:** Here is important for community to do a time-table of the construction process, as well as develop a strategy on how they can communicate with each other during the process.

- **Clear roles and responsibilities:** Here is important that community assigns clear responsibilities between community members. For example who will be uncharged of following up the construction time-line and monitor the process, who will store the materials, etc. This step also includes finding the appropriate support (this means technical support or someone that manages the budget) that communities need, coordinate with them and assign clear roles and responsibilities.

The construction and monitoring stage is an opportunity for community members to support each other, for example, women could cook food while men work in the construction. It is also a good opportunity to involve other members of different communities so they can learn from the example of upgrading, including materials used, labour and community organisation.

It is important that during this time communication between members and representatives is constant by having meetings and reporting on the budget, construction activities and any challenges that might arise.

See [Attachment 4](#) for technical construction guidelines for drainage, water supply, sanitation, electricity supply, roads and earthworks.
Stage 5: Sharing experiences with networks

After communities experience the whole process of upgrading and site planning, it is always good to encourage them to share their experiences and lessons with other community representatives, community members, NGO partners, donors and government officials, to incentive learning and replication of successful examples, as well as learning from difficulties that communities might encountered during this process.

The sharing of experiences should not only focus on the physical products or results of the infrastructure and/or housing, but also on the intangible aspects that communities gain from these processes including community mobilisation and identification of infrastructure/housing priorities and needs, developing a better understanding of their settlement and circumstances through surveying and mapping, visualizing solutions and participating in site planning, infrastructure and housing design processes, organising financially, and been able to make decisions collectively for their settlement’s upgrading.

Some good ways to share experiences with networks include making an exhibition of the results of the “mapping” and “dreaming” exercises, as well as their upgrading process. These exhibitions can help communities gain more support from different partners in the city and also start negotiations with government authorities. In addition, communities that have gone through the upgrading process can invite other community members to see the results of the upgrading and share their own stories and learning. These activities are important as are likely to inspire communities to work together for upgrading their settlement, and believe that change in their lives and communities is possible.
References and Sources


<table>
<thead>
<tr>
<th>House No.</th>
<th>Name of HH head</th>
<th>N. of family members</th>
<th>Main Occupations</th>
<th>Extra Skills</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# FORM 2: MARKET MATERIALS SURVEY

## PART A: SHOP DETAILS

<table>
<thead>
<tr>
<th>Shop 1</th>
<th>Shop 2</th>
<th>Shop 3</th>
<th>Shop 4</th>
<th>Shop 5</th>
<th>Shop 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact person</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## PART B: COSTS OF MATERIALS

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit</th>
<th>Quantity</th>
<th>Price per unit</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>shop 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shop 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shop 3</td>
<td></td>
</tr>
<tr>
<td>Material/Labour</td>
<td>Unit</td>
<td>Quantity</td>
<td>Cost per unit</td>
<td>Total Cost</td>
</tr>
<tr>
<td>----------------</td>
<td>------</td>
<td>----------</td>
<td>---------------</td>
<td>------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## FORM 5: COST ESTIMATION FOR HOUSING

<table>
<thead>
<tr>
<th>Date</th>
<th>Community</th>
<th>Model number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### FOUNDATIONS

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit</th>
<th>Quantity</th>
<th>Price per unit</th>
<th>cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g. cement)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal**

### WALLS

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Unit</th>
<th>Price per unit</th>
<th>cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g. wood)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal**

### ROOF

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Unit</th>
<th>Price per unit</th>
<th>cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g. iron sheets)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal**

### TOILET

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Unit</th>
<th>Price per unit</th>
<th>cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g. WC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal**

**TOTAL COST**
## FORM 6: TOTAL COST ESTIMATION FOR HOUSING

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td></td>
</tr>
<tr>
<td>Labour</td>
<td></td>
</tr>
<tr>
<td>Administration fees</td>
<td></td>
</tr>
<tr>
<td>Transport costs</td>
<td></td>
</tr>
<tr>
<td>Interest rate (for loan)</td>
<td></td>
</tr>
<tr>
<td>Storage costs</td>
<td></td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
</tr>
</tbody>
</table>
ATTACHMENT 1: PLANNING AND MAPPING INFRASTRUCTURES

i. Drainage and Flooding

Drainage is the infrastructure that is used to manage the water that is generated and runs over the ground when rain falls. Rainfall that falls onto the ground and drains over the surface is called surface water runoff. As surface water flows downhill, it starts to collect in low areas and form visible paths of water known as flow paths.

Sometimes drainage systems carry both surface water and wastewater/sewage (waste from homes such as from toilets). This is not considered good practice as it overloads the sewer system and it is now more usual to have separate systems for disposing of surface water runoff and of waste water. In this section drainage refers only to the infrastructure used to manage surface water and not that used to manage wastewater.

Drainage systems aim to collect surface water runoff from urban areas and convey it safely to a receiving water body such as a creek, river or lake.

Flooding in general can occur when there is no drainage to collect surface water runoff or when the drainage is inadequate due to factors such as poor design or lack of maintenance.

A flood refers to a widespread event that happens during or following a big rain storm.

A large-scale/regional or severe flood is not frequent but can disrupt whole communities across the city. The worst regional flooding is usually caused when whole rivers burst their banks. During very large floods, people can be placed in danger by deep and fast-flowing flood water.

Open Channel: An open channel refers to an uncovered drainage channel that carries surface water flows.

Ditch: A ditch is a small open drainage channel, typically not lined (unless with grass) and often running alongside a road.

Flow Pathway: A flow pathway is a path in which surface water travels during or following heavy rainfall. It is different to an open channel in that it may not have an obvious channel shape but it will form along low areas in the ground.

Catchment: An area of land where all water that falls flows to a common point at lower elevation.

Erosion: Erosion is the breaking down of soil, often when water acts on it. Erosion of channels can happen when channels are too steep and water flows too fast. In this case, the channels can wear away, fall into disrepair and no longer work properly.

Levees: An earth wall that is built between a river or other water body and a community or area that needs protection from flooding.
**Overtopping:** Spilling of water over a structure, usually in a way that is not intended.

**Ponding:** Water slowly filling up low areas of ground without flowing away.

**Planning for drainage and flooding**

When planning to address stormwater drainage and flooding issues, the first question to answer is:

**How will the new drainage system or drainage system improvements be delivered?**

It could be:

- Formally, with approval of relevant authorities or
- Community led

This information is relevant to those communities who intend to undertake drainage works themselves with some assistance from trained people and local builders. If the work is to be done through the local authority, some of the planning stage steps will still be useful in gathering information and helping the community to provide their input to the local authority.

<table>
<thead>
<tr>
<th>STEP 1: Map the existing community</th>
<th>Focus Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Understanding your catchment</strong></td>
<td>- Identifying flow directions, - Identify inflow locations: does water from elsewhere outside the community flow into and through the community? - Identify outflow locations: where does the water leave the community and where does it go to? - Identify the locations of lakes and rivers</td>
</tr>
</tbody>
</table>

On the existing community map, draw a bigger picture that includes land outside your site. Draw in water features (lakes, channels) upstream and at the lowest point/downstream of your site. Using arrows, draw where large amounts of water drain into the community and where large amounts of water cannot leave the community during floods. By drawing flow arrows, you will build an understanding of where the water goes and be able to identify where there the problem areas might be. You will also use the flow arrows later on during design of the drainage system. Mark locations of known flooding problems and where water ponds or flows during wet weather. Mark any sources of polluted surface water that the
community is concerned about.  
**Resources:** If you can, find and take a government map of the site and its neighbourhood to compare. Talk to the local authority and find out if they have any drainage or flooding information that can help you, including topographic maps with elevation of the ground (contours).

<table>
<thead>
<tr>
<th><strong>STEP 2: Analyse vulnerabilities and capacities</strong></th>
</tr>
</thead>
</table>

**b. Draw the existing communities’ drainage system**

Draw the site’s existing drainage on the map. The drains may be open channels, ditches or pipes. If there are no existing man-made drains, draw the pathways where water collects and flows during wet weather (use the flow arrows from step 1 to help you) taking into account that water will collect and flow in valleys and low areas.

Use the same colour on your maps for drains so that you don’t confuse them with other features.

Look at your flow arrows and drainage lines. Divide the area into smaller subareas by drawing a boundary around the area that flows towards each existing drain. These boundaries are called catchments and they are discussed below.

Mark where the drains don’t properly connect.

Mark locations of bridges over water and culverts (pipes under roads).

**Resources:** Draw drains on the same map as roads and homes. If waste or rubbish collection is carried out by the authorities, it is also helpful to mark collection points on your map.

- Identify where are the existing drains or paths of water
- Understand if there is enough area for drains and floodwater within existing public land.
- Understand how the site drainage and road systems work during daily rainstorms.
c. **Identify vulnerabilities and risks on your map**

This step aims to gather ‘local knowledge’ about drainage performance. The exercise can work better if women, the elderly, children and people with disabilities are included.

On the community map, mark places where:
- the drains *regularly* overtop and cause problems to roadways/walkways, homes or infrastructure.
- locations of blocked ditches or drains
- areas which get flooded regularly
- water flows too fast or deep and is unsafe
- water is damaging or is causing erosion of infrastructure
- where dirty wash water is a nuisance during the dry season.
- single sources that make a lot of water pollution.

Identify:
1. What is the main source of flooding
   Some ideas include:
   - Is it from a river?
   - Is it from drains blocked with rubbish?
   - Is it from ponding on the ground where water can’t get away?
   - Is it overflowing from the drainage systems, even when the drains are clear of rubbish and debris

2. Are the drains maintained?
   - does anyone clear them out?
   - If so, how often?
   - If so, who?

---

**d. Identify capacities and opportunities for flood risk reduction**

For drainage:
- Identify areas available for drainage such as open channels
- Identify improvements to site grading that could

---

- Understand what is the real cause of the existing drainage or flooding problems
- Identify whether improvements to the drainage system will help to solve the flooding problems
- Identify the priority areas for drainage and flooding works
- Understand the important the community gives to drainage/flooding compared with other infrastructure
remove low points where ponding occurs
- Identify downstream stormwater networks or waterways that drainage could be connected to
- Identify areas where the drainage system works well (why is this so?)
- Where vegetation is helping to reduce erosion risk along drains and roads, and brings other benefits.

For large scale floods:
- Identify higher locations in the community that are less likely to be flooded during a large regional flood event.
In a different colour mark:
- walkways, roadways that can be used during large floods.
- any taps/clean water that are easiest to access during floods
- existing flood levees on or near the site.
- Materials the community could use to build drains, or levees.
- ‘emergency shelters’ (eg. schools) that could be used by vulnerable (temporary refuge, motor parking etc.) during floods.
- Areas important to livelihoods – to help recover from flooding (eg. market places).
- Mark local houses that demonstrate good ideas that are easy to implement and can help people cope and recover from floods.

See reference: IFRC “Safe Shelter Handbook”.

Decision point:
If the main flooding issues in the community are drainage-related, the rest of this manual will provide a process that you can follow.

If regional flooding is the main problem, you will know this as, when the community floods, surrounding communities and whole regions will also experience flooding. If this is the case, see the ideas below on how to proceed. You will need to consult with a flooding expert for further assistance.

Ideas to cope with regional flooding:
Use your maps to start a discussion on what the community can do to tackle the large scale flooding, examples include:

- Any higher ground could be used as ‘flood refuge’ during wet and during the dry season (eg playground).
- Roads/walkways that could be upgraded for access during floods.
- Evacuation routes for fast-onset floods (if relevant).
- You can also talk about ‘non structural’ measures to include in any plans: such as pre-monsoon cleanup days of drainage, steps people can take to reduce illness like diarrhoea, malaria and
dengue.
- During large floods it’s not realistic to drain water away. Another option is to increase people’s capacity to make their homes safer during floods.

**STEP 3: Exploring alternatives for flood management**

Thinking together with the people about the drainage improvements that need to be made to secure a good standard of living and a sustainable livelihood. Identify local, positive examples of good drainage, flood resilient housing /infrastructure that the community already has, that matches this vision.

**STEP 4: Community Walk and Technical Site Survey**

This could be done by a technical engineer/team, with participants from the above mapping exercise. Its objective is to gather data for the design phase. It will include collecting more detailed information than in Step 1, such as
- Site elevations
- Condition assessment of existing drains and roads/ built drainage infrastructure
- Soil, surface cover and terrain
- Catchment mapping (refer to the drainage design section)

**STEP 5: Community Planning Discussion: Drain and garbage maintenance**

Hold a discussion with the community regarding drain maintenance and garbage collection. Often, poor maintenance of existing drains or blockage of drains with rubbish due to inadequate waste disposal can be one of the biggest causes of flooding:

Possible questions to ask the community:

(on the map) If the government doesn’t collect garbage what can we do with it, so it doesn’t clog up the drains?
How can we make cleaning up easier to do / something people want to do here?
Who should clean out drains? (Examples from other urban communities: families are responsible for cleaning drains outside their house; and elected community members visit and inspect all the drains once a week to make sure they are clean).
Do we want to give benefits to people who take responsibility to regularly clean out drains?
What might these benefits be? Examples used by other communities include giving people tools to do this work, other benefits such as market stalls in any market areas. How can we make sure these people keep cleaning out the drains (if they stop doing it someone else can)?

**Decision Point:** If you identified in the steps above that rubbish and blockage of existing drains was the main problem causing flooding, implementing maintenance and monitoring plans for the existing drains may be the best approach to start with.

---

**ii. Water supply**

**Key elements of a water supply system**

A clean, reliable source of water is essential to human health and survival. A water supply source is not only required for drinking, but with good hygiene practices can prevent diseases in the community.

A number of steps require consideration to ensure water is safely supplied from its source to its use. This is generally composed of the three steps, and will be the focus throughout the planning, design and construction stages.

**Step 1:** selection of **water source** (groundwater, spring, surface, etc.) and **transfer** of source water into the water distribution system (raw water gravity main, pumped from a well, hand transport)

**Step 2:** **water treatment** (community level treatment or household treatment)

**Step 3:** **distribution** (community level - tap stands, to individual households) and **storage** (community level, bulk household level (rainwater harvesting), household level - jars)

**Planning for water supply**

The planning process involves working with the community to gather information on suitable water resources from a quantity and quality perspective, identify the water needs of the community, and use this knowledge to assist in defining a water supply system suitable for the local community. The following flow diagram summarises this process:
Step 1: Mapping potential water sources

<table>
<thead>
<tr>
<th>Focus Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Understand water features in the environment (location of potential water sources and sources of contamination)</td>
</tr>
<tr>
<td>ii. Assess the quantity of water the identified water source(s) can supply</td>
</tr>
<tr>
<td>iii. Assess water quality of the identified water source(s)</td>
</tr>
</tbody>
</table>

**a. Mapping Activity:**
The point of the exercise is to map water source and sources of contamination

1. On the community map, draw a bigger picture that includes land outside your site. Shapes and lines can be used to represent existing buildings, roads and utilities. Include contour lines to indicate elevation.

2. Indicate any major water features (potential water sources), including:
   a. Existing established water supply sources within the community (e.g. wells, pipeline networks, water reservoirs, rainwater tanks)
   b. Lakes and rivers - mapping the direction of flow, and any smaller waterways that feed into these.
   c. Known locations of groundwater. The direction of groundwater flow should be drawn too if it is known. If unknown, it can generally be assumed to flow in the direction of the slope of the ground. Soil type (sand, clay, gravel, rock etc.) in the area of groundwater should also be noted.

3. Indicate any potential sources for contamination from environment (e.g. latrines, landfill, polluted water sources, contaminated government piped water supply) and from human activities (where people live, where they cook/wash dishes/ where they wash themselves, where animals are kept.)

**Resources:** Talk to the local authority and find out if they have any information that can assist, including topographic contours, groundwater resource maps; surface water maps; maps showing
existing water supply systems; maps or information on local landfills, farmland, major industrial areas.

**b. Assessing the quantity of water a source can supply**
Once potential water sources have been identified, the first priority in selecting a suitable source is that it produces a sufficient water quantity. Assessing the water quantity a source can supply might require determining the flow rate of a river or the volume of water that can be taken from a lake without it running out. The supply quantity will then be compared to the water supply requirement found in Step 2.

Undertaking a proper assessment of the water quantity of a water source normally requires the assistance of a water resource specialist to undertake a detailed study.

**c. Assessing water quality**
Assessing the quality of water is necessary to determine if treatment is necessary to make it potable. Water quality is normally determined via testing of water samples for particular chemical or microbial contamination, and aesthetic parameters by an accredited water sampling laboratory.

It is recommended that CEDT:
- Confirm that the laboratory undertaking water quality testing has appropriate accreditation (e.g. NATA accreditation) and obtain advice from them on sampling procedures and means of delivery of samples with required time frames.
- Identify the relevant local drinking water quality guidelines in Cambodia by which to assess water sample test results against. Compliance with these guidelines suggests suitability of water quality for drinking water purposes.
- Talk to locals about any known sources of contamination (e.g. chemical or other
- pollution spills) and collect anecdotal knowledge of quality of identified water sources
- Determine if any formal water quality information for a particular source is already known (e.g. maps of arsenic contamination in groundwater). This will prevent unnecessary testing. It is important that this information is up to date. Arsenic contamination maps or other data might be available from scientific organisations (UNICEF, MRD, Ministry of Health)
- Contact appropriated accredited laboratories (e.g. NATA accreditation) for information on water quality testing.
- Locate local Cambodia Water Quality Standard guidelines (locate this from government drinking water quality organisation if this exists)
- Locate / purchase equipment (e.g. field test kits, sterile flasks) for performing water quality tests.

<table>
<thead>
<tr>
<th>STEP 2: Analyse Community Water Needs</th>
<th>Focus Areas</th>
</tr>
</thead>
</table>

Together with the community enter a discussion about the water needs of the people, some information to collect in the discussions include:

- Discuss with community what their water usage habits are (e.g. when they use water, what they use water for, how much do they use.)
- Determine water quality requirements associated with each water use.
- Determine priority of water needs within the community, and create ‘priority need categories’. This may be necessary in prioritising the order in which parts of the water supply system are built.
- Determine what each of the ‘priority need categories’ equates to in terms of quantity.
- Speak to other similar communities about whether they know their water demands and see how this could apply to your situation.

After these discussions CEDT team can make some technical calculations needed to estimate the appropriate water level for the use of the community.

An estimate for total daily water needs for a given area can be calculated by the following formula: **Maximum daily water demand = (Rate of water consumption per person per day) x Population**

The table on the side can be used as a guide to estimate the minimum water demand. However this should be verified based on local knowledge.

Other things to consider are:

*Population growth* - a factor for population growth should be factored into the water
demand when planning a water supply system in order to prevent water scarcity in the future. This factor should be decided by the planner and community.

*Peak usage times* - since water is more often in demand at some times of the day compared to others, it is necessary to identify these “peak times” and plan the system to be able to meet these demands.

**b. Determining water quality requirements of community**

Speak to members of the community about any concerns they have towards the water they currently use for tasks using both potable and non-potable water (e.g. does it taste bad, does it make them sick, do they not like the colour.

In this activity the water quality specifications that is required by the community for potable (i.e. for human consumption) and non-potable water is determined.

*Water for potable uses*

The water quality requirements for drinking water should be based off the following minimum standards. The Cambodian Drinking Water Quality Standards should also be consulted.

*Water for non-potable uses*

The water demand chapter primarily focuses on delivering potable water, however in this activity we briefly consider any water the community uses for non-potable applications. This might include water for washing or cleaning belongings.

Water for non-potable uses does not require the degree of treatment that potable water does. For example dissolved arsenic is a problem in potable water as it causes sickness, however it has no effect if the water is used for washing.
Water quality requirements for non-potable uses should be found by community consultation and after any water quality tests have been performed. There can still be risk of contracting infections from non-potable water.

<table>
<thead>
<tr>
<th>STEP 3: Selection of water source</th>
<th>Focus Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Identifying if water source(s) meet community requirements</strong>&lt;br&gt;By comparing the findings of Step 2 (i.e. knowledge of quantity and quality of water the community requires) with the learning from Step 1 (i.e. knowledge of what water supplies are available to the community), any areas of improving the water source can be identified. Any difference in the water source quality from Step 1 and the water quality requirements of the community from Step 2 will mean that water treatment is necessary before it can be used.</td>
<td>i) Identify if water source(s) meet community requirements.&lt;br&gt;ii) Use list of priorities to select best water source</td>
</tr>
<tr>
<td><strong>b. Using a list of priorities to select best water source</strong>&lt;br&gt;The first priority in selecting a suitable source is that it produces a sufficient water quantity. If a water source was found to not be sufficient in providing the community water demand then it should not be considered as a suitable water source. If no water sources meet the water demand than it might be necessary to use more than one water source. If several sources offer adequate quantity, then a choice should be made based on the following priorities</td>
<td>First Priority: No treatment or pumping required&lt;br&gt;Second Priority: No treatment but pumping required&lt;br&gt;Third Priority: Some treatment but no pumping required</td>
</tr>
</tbody>
</table>
Fourth Priority: Both treatment and pumping required
By using the above priorities the community should be able to select which water source(s) to plan the water supply system around. If more than one water sources are found to be of the same, highest priority, it might be best to perform the design step for these water sources, and base your choice of water source on the practicality of each design.

Note: In an urban context surface water bodies will almost certainly be contaminated and require a high level of treatment before use. Groundwater and water from government distribution networks may also be contaminated. If planning on constructing a well to source groundwater, the location is very important to ensure the water is not contaminated.

<table>
<thead>
<tr>
<th>Step 4: Select technologies for water supply and treatment</th>
<th>Focus Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Think together with community about the technological requirements and logistics around getting water from its source to the user (For example: is construction of a well required, might a pipeline be more effective in the long-term compared to carrying the water, does an intake for a river or lake need to be built.). Many different technologies exist to allow water to be taken from a natural source and into a piped network. Some of these technologies are listed below, however to make a choice as to which one will be used it is necessary that those involved in planning familiarise themselves with the designs of the different technologies available.</td>
<td></td>
</tr>
</tbody>
</table>
| • **Springs**  
  • **Ponds, Lakes and Reservoirs**  
  • **Streams and Rivers**  
  • **Rainfall catchments**  
  • **Groundwater** |
| • Select and consult with communities the technology that will make part of the water supply system and seek their acceptance and approval. |
iii. Sanitation Systems and Hygiene Infrastructure

Improvements to sanitary infrastructure can have significant benefits towards the environment and the health of the population. Inadequate excreta disposal can have severe long-term impacts to the local environment, especially through pollution of groundwater. Common health issue such as diarrhoea can be avoided through sanitary wastewater design, construction, maintenance and education.

Communities should be educated in the importance and use of sanitary wastewater technology. Identifying maintenance requirements and ensuring its implementation is important to the continued success of wastewater development. Potential reuse of excreta through fertilisation or energy generation should also be considered.

Planning for Sanitation and hygiene infrastructure

---

**Step 1 Identify the community's wants, needs and the background conditions**

Determining together with the community their wants and needs is essential otherwise systems will be proposed that are not appropriate for the people. This process should emphasize access for disadvantaged groups such as women, children and the disabled.

As a first step discussions with the communities should be undertaken around the following considerations:

**Cultural Factors**

- What are their privacy requirements?
- Would they prefer separate male/female facilities?
- Where would they feel safe using facilities?
- Are there any taboos or beliefs against disposing of human waste?
- Does the community have a preference for wet or dry toilet hygiene? Is there enough water available for a wet solution?
- What are their washing and anal cleansing practices.
- What type of waste does the community produce that needs treatment/containment?
- Human waste
- Kitchen waste
- Hand washing/bathing water
- Education – Does the community understand the importance of sanitary infrastructure? Are education programs needed to instruct residents on correct usage? Will residents
continue to use these systems in the future? Are they accepting of future maintenance requirements?

- What disadvantaged groups are in the community? What barriers do they experience with sanitary infrastructure.

### Background Conditions

- Groundwater levels: What is the depth to groundwater? Is groundwater sourced from a nearby well? Will excrement disposal methods pollute the groundwater?
- Subsurface materials: What is the strength of the subsurface geology? Will any required excavations or pits be self-supporting?
- Water availability: Is water needed as part of the wastewater process (e.g. flushing)? Can sufficient water be sourced throughout the year?
- Sustainability: Is there capacity to reuse sewage effluent as fertiliser? Is there capacity to generate biogas from waste?
- Existing infrastructure: what is the proximity to existing wastewater infrastructure or dump site– Is connection to existing wastewater infrastructure a possibility? Are potential latrine sites accessible by vehicle (e.g. truck, cart) to be emptied?
- Financial constraints: What technologies are feasible? Unfeasible?
- Constructability: Are the needed construction resources (i.e. concrete, timber) available locally? Are skilled labourers needed to construct the system? Do residents have the ability to assist in construction?
- Maintenance: Does the wastewater system require regular maintenance (i.e. removal of settled sewage from a septic tank)? Can residents maintain the units themselves?
- Flooding: Is the area prone to flooding or a fluctuating groundwater table? Can measures be taken to negate the impact of a flood on the wastewater system?
- Space availability: Do families live in single-family or multi-family compounds, single-storey or multi-storey buildings?
- What is the typical size of a plot or family compound? Is there sufficient space for every household to build a latrine? Is there sufficient space to build a second latrine when the first one is full? Is there public space that could be used?

### Step 2 Identify and Select Excreta Disposal System

This step involves identifying and selecting an appropriate system of collection of human excreta. This includes both the collection system (e.g. Latrine) and the disposal system (e.g. pit, septic tank or piped wastewater system).

**a. Connection to Sewer System or On-Site Systems**

In an urban environment the first decision to make is whether to connect to an existing sewer system, such as a public city-wide government sewer system or to use on-site systems (e.g. pit latrines, composing latrines or septic tanks). This decision may not be applicable if no such system exists within proximity to the community.

If a suitable sewer system exists it is likely that connection to this system will be the optimal long-term option for the community if the following criteria are satisfied. If some of the following criteria are not satisfied it is possible that connection to a sewer is still the best option but this would require detailed consideration by an experienced person:
There is sufficient water in the expected waste flow that waste will flow along pipes into the sewer system. In general, this will only be the case if there is sufficient piped water available for flush toilets and sullage from kitchen and bathroom activities and if this water is combined with the human waste.

The sewer system is sufficiently close to the community that the cost of pipe connections is not prohibitive. Pipe work can be relatively expensive and even construction over a relatively short distance may make on-site systems more cost effective.

The sewer system is not uphill from the community such that pumping is required to get the waste to the sewer.

The sewer system has capacity to receive the waste from the community. Consultation with the relevant authority is required to determine this.

The sewer system is reliable. For example if the sewer is blocked or non-operational waste may back up the pipes into the community and discharge to the surface or into people’s homes.

The sewer system has appropriate treatment systems before discharge. For example if the system discharges untreated into an inland waterway the community should be aware that their waste would be contributing to environmental and human consequences downstream of the discharge point.

b. Select the Type of Excreta Collection System

Connection to an Existing Sewer System

For connection to a sewer system collection will involve either family or communal latrines connected to a water supply and a flushing operation. Key information relating to these connections are listed below:

- Connection should be undertaken by qualified persons only as improper connection could result in water from the sewer backing up into the community and posing a major health risk.
- If the community is located downhill from the sewer system pumping will be required.
- Sizing of pipe sand pumping systems should be undertaken by a qualified and experienced person.
- Regular contact with the relevant authority for the sewer system should be undertaken.
- Pipes should be located underneath water supply pipelines, not above.

Connection to an existing sewer system should be undertaken by qualified people only and should be done in consultation with the relevant authority.

Step 3 Identify Ongoing Maintenance and Waste Disposal Requirements

For most types of latrines ongoing maintenance is required for example:

- For pit latrines waste needs to be removed or new pits need to be dug when pits fill up with waste.
- For composting latrines vaults need to be emptied and reused for fertiliser.
- For septic systems the solid waste needs to be removed and disposed of.
- For connection to an existing sewage system status of that system and the communities connection pipes should be monitored, particularly for blocking.
For all systems general cleaning, care and maintenance need to be undertaken. It is essential to plan how waste should be disposed of. Often a key consideration in selecting infrastructure is to select an option that has minimal ongoing waste disposal requirements (e.g. composting toilet). Waste should be disposed of in an economical way but also in a way that does not pose a detrimental effect to public health or the environment.

### Step 3 Identify Hygiene Improvement Infrastructure and Programs

Provision of hygiene infrastructure can often have significant benefits to community health and sometimes with significantly lower construction costs than waste disposal. Recommended hygiene improvements include:

- Provision of hand washing facilities at all latrines
- Provision of washing stations for bathing
- Provision of areas for menstrual hygiene such as areas to wash menstrual products.
- Community sanitation and hygiene education programs
- Training on management of proposed waste management facilities.

### Step 4 Determine Location and Quantity of Excreta Disposal and Hygiene Infrastructure

Provision of excreta disposal and hygiene infrastructure at a family level (e.g. one latrine and washing station for each family) is highly preferable over community based latrines. This has been shown to have improved outcomes in terms of level of use, safety, maintenance and effectiveness. It allows a family to look after their own facilities and to take ownership of them. Where community facilities are provided the following should be satisfied:

- Minimum of one toilet for each 20 people in the community.
- Separate internally lockable toilets for women and men.
- Toilets are no more than 50 metres from dwellings.
- Access for vulnerable groups such as women, children and the disabled must be provided for.

Environmental considerations must be taken into account when placing latrines that discharge contaminants to the environment such as pit toilets or septic systems. Where the water table is high (wet season less than 1.5 m below bottom of pits) specialized consideration must be undertaken before locating pit toilets or septic systems. When the water table is not high pits should be located

- At least 30 m from surface water features.
- At least 30 m from groundwater bores (potentially more in sandy or cracked soil types)

### iv. Earthworks, Roads and General Civil Works

Civil works such as roads, site grading and earthworks, along with infrastructure such as foundations, provide essential framework to the community. Roads provide safe access to the community while providing a designated space for vehicles, improving pedestrian safety within communities. Site grading and earthworks are essential to ensure adequate drainage from the site, which is crucial to prevent damage to infrastructure and to maintain public health. Developing proper foundations ensures that infrastructure in the community can be constructed safely and durably.
# Planning earthworks, roads, and civil works

## Step 1 – Map the existing community

<table>
<thead>
<tr>
<th>Activity</th>
<th>Planning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add existing road layouts to your map&lt;br&gt;(1:500 scale recommended)&lt;br&gt;- Draw any existing roads and walkways on your map&lt;br&gt;- Roads are primarily for vehicle traffic whereas walkways are for pedestrian traffic.&lt;br&gt;- Identify which travel paths and routes people use the most.</td>
<td>Determine how effective the existing road layout currently is.</td>
</tr>
<tr>
<td>Add any road drainage to your map&lt;br&gt;Draw in any existing drainage features, including naturally formed channels along the roads and any crossing structures such as culverts or bridges.</td>
<td>Develop an understanding of what surface water does on the roads.</td>
</tr>
<tr>
<td>Add existing land features to your map&lt;br&gt;Draw any significant land features such as hills, embankments, valleys, lakes or rivers.</td>
<td>Identify site constraints.</td>
</tr>
</tbody>
</table>

## Step 2 – Identify potential improvements

<table>
<thead>
<tr>
<th>Activity</th>
<th>Planning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify challenges on your map&lt;br&gt;On your map, mark places where:&lt;br&gt;- accidents have occurred.&lt;br&gt;- pedestrians feel unsafe.&lt;br&gt;- access to the community is insufficient.&lt;br&gt;- roads or lanes become congested.&lt;br&gt;- drainage problems such as flooding or washouts occur.&lt;br&gt;- unstable slopes occur (signs of slope collapse).&lt;br&gt;Identify any failed or failing sections of roads.</td>
<td>Help the community and the technical design team understand the priorities for infrastructure upgrades.</td>
</tr>
</tbody>
</table>

## Step 3 – Dream for the future site

Think holistically and together with the community about the
physical elements (road and footpath networks) that need to be improved to secure a good standard of living and sustainable livelihood.

Identify local, positive examples of good road and civil infrastructure that the community has that matches this vision.

As a group suggest the particular infrastructure that is needed to build the “ideal community”.

### Step 4 – Information collection and site walk

<table>
<thead>
<tr>
<th>Note the following information on your map:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Ground conditions – determine locations that are suitable for any new road or footpath infrastructure suggested in Step 3</td>
</tr>
<tr>
<td>- Evidence of drainage patterns</td>
</tr>
<tr>
<td>- Count the number of vehicles and pedestrians using the asset during the day</td>
</tr>
<tr>
<td>Consider the budget, materials and equipment available for the improvements.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Planning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Help to develop an understanding of the feasibility of the new or upgraded infrastructure from the community vision.</td>
</tr>
</tbody>
</table>

### Step 5 – Develop concepts with the community

<table>
<thead>
<tr>
<th>Using the information from steps 3 and 4, review the feasibility of the suggestions from the community’s vision.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undertake preliminary cost estimates of proposed upgrades to select the preferred option.</td>
</tr>
<tr>
<td>Sketch the preferred upgrades on the 1:500-scale map from Step 1.</td>
</tr>
<tr>
<td>Develop cross-section or perspective sketches for each section of improvements.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Planning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable the community to visualise the preferred option for the proposed improvements.</td>
</tr>
<tr>
<td>Produce maps and sketches of the community’s vision that will be further developed in the design stage.</td>
</tr>
</tbody>
</table>

### v. Electrical supply

Electrical supply provides essential framework to the community. Having access to affordable electricity has a number of clear benefits to communities such as health benefits, education benefits and growth of micro-enterprises which strengthen the economic prosperity of urban communities.
Components of an Electrical Power System

The following section is a brief guide to the major components of an electrical power system. Note that the intent of this section is simply to provide a general reference for later sections and should not be regarded as an exhaustive list.

Traditional electrical transmission and distribution is based on a top-down model (i.e. a large generating station flows down to feed many small loads). The three key elements of the system are:

1. **Generation**: Traditionally large scale power stations, but can be small scale localised generation, which may or may not be connected to the main grid. Refer to the planning section for more on this.
2. **Transmission and Distribution power lines**: Transmission lines get bulk power to the site, distribution lines split the power up into portions for each user. Primarily overhead wiring but may also be underground.
3. **Substations**: A site which effectively acts as the “junction” between transmission and distribution, consisting of transformers and circuit protection devices. On the smallest scale this may simply be a pole mount transformer with some fuses to protect the high and low sides.

Planning for electrical supply

<table>
<thead>
<tr>
<th>Step 1: Initial Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigate community needs / expectations from the project</td>
</tr>
</tbody>
</table>
Through collaborative dialogues with members of the community, gain an understanding of the requirements from an electrical infrastructure project. Determine the type of energy service demands required by the community, for example - light, entertainment, refrigeration, productive uses (e.g. to power machinery), etc.

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine the willingness to pay for the project</td>
</tr>
</tbody>
</table>
Determine the amount each household is willing to bear for energy consumption, capital costs and ongoing maintenance of the project. Collate data of existing electricity expenditure per household.

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Translate the community needs into electrical requirement</td>
</tr>
</tbody>
</table>
Based on the needs analysis, calculate an approximate estimate for the maximum electrical demand requirements of the project. For example, a community of 30 households requires lighting. Assuming two compact 8W fluorescents per household, the estimated total load demanded is approximately 240W.
Step 2: Data Collection

- Document the existing electrical infrastructure and services on site
  Survey existing electrical infrastructure and energy services available to the community. This may include existing access to grid supplies (formal or otherwise), diesel generator sets, etc.
- Investigate existing community practices relating to electricity
  Gain an understanding of electrical technologies that communities are already using and familiar with. Investigate whether local expertise exists for any of the relevant technologies, e.g. diesel generators, batteries, etc.
- Assess the available natural resources on site
  Investigate the availability of natural resources such as sun, wind, water flow, biomass residues, etc at the site.
- Investigate local political/ energy provider arrangement and managing such stakeholders
  Investigate potential for connection to main power grid and energy provider’s requirements for an application for connection. Existing informal electricity supplier is to be considered in any infrastructure development plans. Negotiations to including such stakeholders to operate and maintain new infrastructure provides them financial and legal incentives and also ensures long term viability of project. Alternatively, by passing existing informal electricity supplier will require consideration.
- Investigate the existing supply chains in the community for electrical equipment.
  Consider local markets for electrical goods available to the community. Consider logistical supply chains from nearest electrical goods markets and the range of available electrical equipment.
- Evaluate opportunities to exploit other existing or planned infrastructure
  Consider taking advantage of inter-disciplinary projects for efficient project delivery. For example, if a sewage treatment project is already being implemented, investigate whether canals and / or pipework could be used for pico-hydroelectricity generation, or whether sewage could be passed through anaerobic digesters to produce biogas.

Step 3: Technology Selection based on the “technology options table” provided below

Step 4: Preliminary Cost Estimate and Business Model

Development of a preliminary cost estimate and business models are critical to ensure financial sustainability of electricity supply projects.

(1) Key considerations and steps for a legal connection to the existing electricity grid are:
- Preparing and fulfilling energy provider requirements for an “application for connection” to the grid. This will require technical inputs such as Maximum Demand, Contract Maximum Demand and Billing Demand (see definitions).
  Maximum Demand is determined based on Step 1 - translating community needs into electrical demand requirements.
  Contract Demand = Maximum Demand + Additional Demand for Assurance and Future load growths (based on broader community planning)
- Negotiating metering rates and Billing Demand structure.
- Investigating the possibility of a communal meter for the community. This will lead to
Responsibilities for collecting utility bills from each household but may be cheaper than installing individual meter at each household.

- Initial network service fee and administration fees.
- Cost estimate for connection costs which may include design costs for electricity connections imposed by the electricity provider including full cost of supplying a connection.
- Agree and sign electricity connection contract.

(2) Key considerations for an electricity supply business model are:

Determine billing structure, ownership of electrical network and infrastructure.

Next, determine the operator/maintainer model. In a small community project with budget restrictions, it is determined that operational troubleshooting and maintenance are the bare minimum requirements for the continuous provision of electricity. These requirements can be fulfilled by hiring local electricians on a “as required” basis with a potential impact of prolonged power outage. However, a model must be determined for the stakeholder responsible for the provision of such technical support. Examples and key considerations for such models are as follows,

- Community based operator/ maintainer

  In this model the electrical network is handed back to the community along with provision of adequate technical support and training for ongoing operation and maintenance of electrical assets.

- Existing informal Electricity Supplier collaboration

  In this model negotiations with existing informal electricity supplier determine the level of responsibility and financial incentives available for their engagement.

Step 5: Project Sustainability

- Identify the supply chain for spare parts and skilled labour

  Considerations for source of spare parts and skilled labour. If local supply chains exist, e.g. local markets or travelling vendors, ensure that the design of the system is interoperable with available parts. If there are no existing supply chains, examine the possibility of developing a supply chain. Avoid equipment that is locked to a single vendor or require expensive specialists to maintain /repair, as well as supply chains that require long-distance / international freight.

- Determine the training needs for community members

  Based on the selected technology, determine technical training requirements to operate and maintain the project. Manufacturer’s maintenance manuals are to be collated for technical references for electrical equipments.

- Develop a project monitoring and evaluation plan

  Consider metrics to be measured. Determine the process of feedback collected from the project. Develop a process for making incremental improvements to the project based on continuous feedback and evaluation of outcomes.
<table>
<thead>
<tr>
<th>Technology Options</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal connection to existing electricity grid</td>
<td>A formal connection is obtained through an accepted “Application for electricity connection” to the existing electricity grid by the local electricity provider.</td>
<td>Potential to lead to legal land ownership rights. No capital, ongoing operational and maintenance costs. Cheapest and most reliable option.</td>
<td>Initial connection costs. Regulatory and political challenges to obtain a legal connection to the electricity grid.</td>
<td>Recommended option.</td>
</tr>
<tr>
<td>Pico-Hydro Generator</td>
<td>Pico-hydro power schemes are normally run-of-the-river schemes which operate by diverting part or all of the available water flow.</td>
<td>Cost effective than other methods. No battery storage is required. Low tech, easy to repair and transfer technical knowledge to local communities.</td>
<td>Requires an existing flow of water such as small stream. Requires more maintenance than photovoltaic modules. Assessing the resource require considerable experience.</td>
<td>Potential collaboration with Sewage team for project implementation.</td>
</tr>
<tr>
<td>Battery Powered</td>
<td>Batteries are charged at communal charging facilities. Communal charging station may be powered by PV system or by council supply.</td>
<td>Low tech, easy to repair and transfer technical knowledge to local communities.</td>
<td>The cost of batteries is relatively high.</td>
<td>Use of automotive batteries for electricity may already be an existing practice.</td>
</tr>
<tr>
<td>Generator (Diesel or Bio-Fuel)</td>
<td>Internal combustion engines which operate using diesel or bio fuels can be used rotate</td>
<td>Diesel engines are a familiar technology to many people and local knowledge networks and</td>
<td>Investment cost is relative high. If operated using diesel, the operation costs are relatively high.</td>
<td></td>
</tr>
<tr>
<td>Solar Panels</td>
<td><strong>Solar system consists of solar panels, solar inverters and batteries.</strong> During the day time PV panels provide electricity to households. Excess power will be stored in battery. During the night time batteries discharge and provide electricity to houses.</td>
<td><strong>The PV modules are extremely reliable and durable.</strong> Systems can be added to in a modular fashion, thus allowing for capacity increase as the user’s financial capabilities.</td>
<td><strong>The cost is relatively high, but may still be least cost for small loads.</strong> Proper sizing of systems require considerable experience and skill. Proper installation is very important, requiring trained technicians. Requires battery replacement at frequent intervals <strong>Most components (e.g. array, charge controller, inverter, etc) are black-boxes and difficult to repair.</strong> Unlikely for a local supply chain to already exist to procure spare parts.</td>
<td></td>
</tr>
</tbody>
</table>
ATTACHMENT 2: TECHNICAL GUIDELINES FOR THE DESIGN OF INFRASTRUCTURES

i. Drainage and Flooding

This section provides the general steps to follow when designing a drainage system. The advice that follows will be helpful if you identified during the planning process that drainage improvements will help to alleviate flooding problems. It will also be helpful if you are planning a new community area and want to design a new drainage system. If you wish to adapt an existing drainage system with some modifications and improvements, then the steps that follow may help you to design any modifications. If the main problem is regional/large flooding then some advice is provided in this chapter. There are a few key concepts to understand when designing the drainage network.

A catchment is an area of land, where all water that falls flows to a common point at lower elevation. Catchments are best illustrated by a picture:

\[ Image: A catchment (Flood SITE, 2008) \]

In the picture above, you can see:

- flow arrows (dashed lines with arrow head)
- drains or flow paths (solid lines with arrow heads)

Catchments are important to understand as they help to plan where a drainage network goes and to work out how much water goes to each part of the drainage network.

It is helpful to think of drains as being of different types, according to their size and function:

- Primary drains: flow across the city. They are large, and often built by government. They collect water from many drains and take it to the river.
- Secondary drains: Small drains that catch water from a few blocks of houses. They are a small network in each community. They can be improved without a lot of money, using simple techniques and hand-tools.
**Tertiary drains:** Very small drains outside houses in laneways. When designing drains for community-level projects, you will largely be dealing with secondary and tertiary drains, though you may connect these drains to a primary system at the bottom end of your site / project area.

Reference documents: drainage is a complex subject. For more detail and special considerations, refer to detailed texts such as *Surface Water Drainage for Low Income Communities* (WHO, 1991)

**Potential Steps in the Design Process**

**Step 1: Determine the flood water levels**

It is important to know the height that regional flood levels reach when designing a drainage system (refer to the planning chapter for definitions of regional flooding). If pipes and channels are lower than this height, they will not be able to drain water in flood events. In other words, if the drainage system is located below the level a river reaches during a storm there will be nowhere for the water to go. If possible, the lowest point in the drainage system should be above the regional flooding level. To determine the flood water levels:

1. Contact local governments, councils or planning agencies. If the site is near a major river or creek, there may be flood studies which will have this information.
2. If no information is available, conduct a site walk. There are a few ways to find out the flood levels on site:
   a. Look for flood water marks on building walls. Measure the depth of these using a tape measure and mark on the map.
   b. Speak to community members. Ask them to describe water depths from previous regional floods in terms of their body (e.g. knee deep, waist deep) or their surroundings such as houses. Were other communities under water at these times also? Mark these depths on the map.

Once you have knowledge of the flood levels:

If you can build the pipes and channels to a level higher than the flood levels regularly experienced by the community, then building the drainage system should work and you can continue to Step 2 now.

If the main problem is regional/ large scale flooding from a river or lake, some points for further consideration are provided below:
<table>
<thead>
<tr>
<th>Options</th>
<th>Further Information</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Build up the floor levels of houses | If houses are flooded over their floors by a few centimetres up to half a metre, this may be worth considering. In such cases, it may be possible to temporarily build the floor levels up by filling with fill material and monitoring over a period of time. If the community finds that they are benefiting from having higher floor levels, then over time the houses may need to be rebuilt with permanently higher floor levels. | - Can improve health, safety and wellbeing of community members whose homes are regularly flooded by small amounts of water  
- Allows for temporary testing of the solution before implementing on a permanent basis | - Disruptive to the community  
- Does not resolve flooding of roads and other non-habitable areas  
- Permanently raising floor levels of homes is expensive |
| Fill the land to a higher level | This might be possible for new communities where homes have not yet been built. By filling the land to a higher level, flood water does not reach the community. | Makes land that would otherwise be unsuitable for living on habitable | - Filling of areas that naturally flood is generally not a good idea because it can force flood water to go elsewhere, often making flooding worse for other communities on the river.  
- Expensive unless suitable fill material is readily available |
| Building levees to protect the community | This might be an option when a community is already established in an area or can be planned before the community is built. Levees are generally earth | Large areas of land are not required to be raised as they are protected by the levee  
Excludes flood | - Levees require expert design and maintenance once they are built to make sure that they don’t fail.  
- If a levees fails the |
<table>
<thead>
<tr>
<th>Other housing options</th>
<th>Move the community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankments that are built along a river to stop flood water from flowing into the ground behind.</td>
<td>If an existing community experiences large scale and devastating floods on a regular basis, in some cases planning to move the community over a period of time needs to be considered.</td>
</tr>
<tr>
<td>Water from the community</td>
<td>- Eliminates large scale flood risks by removing people from flood vulnerable areas.</td>
</tr>
<tr>
<td>Flooding experienced by the community can be worse than if there was no levee there at all.</td>
<td>- Once carried out, no ongoing expense in managing flood risks and flood infrastructure.</td>
</tr>
<tr>
<td>- Like the land filling option, by forcing flood water to go somewhere else, they can make flooding worse for other communities.</td>
<td>- Disrupts entire community with potentially major social impacts.</td>
</tr>
<tr>
<td>Other housing options</td>
<td>Move the community</td>
</tr>
<tr>
<td>If the community has not yet been built, there are options for designing houses so that they aren't as easily flooded or so that they aren't damaged too much when they are flooded (e.g building homes higher with underfloor voids that flood water can pass through)</td>
<td>- Can improve health, safety and wellbeing of community members whose homes would otherwise be flooded regularly.</td>
</tr>
<tr>
<td>- Can improve health, safety and wellbeing of community members whose homes would otherwise be flooded regularly.</td>
<td>- Require specialist design input.</td>
</tr>
<tr>
<td>- May not meet community needs and expectations.</td>
<td>- Can be expensive depending on the option.</td>
</tr>
<tr>
<td>- Can be expensive depending on the option.</td>
<td>It is very important to note that managing regional flooding is something requiring specialist help and input. If a community is affected by flooding from rivers or lakes on a large and serious scale, it is often advisable to work with experts and with government to address the</td>
</tr>
</tbody>
</table>
Step 2: Confirm the catchment areas

During the planning stage (Step 1 and 2), you prepared a map of the area including information about where the water flows, what the catchment looks like and where the drainage goes at the moment, if there is any.

Now it is time to add more detail.

The catchment area is the area from which rainfall will flow into the site. It is important to understand the catchments to help plan where your new drainage system will go.

You have already determined a rough catchment area from the planning exercise. The below will help you to confirm it. To determine the catchment area:

A. Check the highest points on the map from which water runoff will drain to the community, using the best information you have. This could be from government maps, from technical survey data or by marking the approximate locations of these points from site walks.

B. Join these points to draw a continuous boundary. Divide the catchment up into equally sized squares on the scaled map.

C. Calculate the catchment area by counting the number of squares and multiplying this by the area of each square. GIS software can also be used for more accurate measurements if available.

If you don’t have any maps to help you to scale and measure data, another way to estimate areas is to keep walking uphill from the drainage feature in the steepest direction and measure how far it is (if you know how long each of your strides is, you can estimate a length). Square this number and use the result for your catchment area. So, if you walk 30 metres up the hill, then the estimated area is 900 square metres (0.09 ha).

The figure below shows how you can use and refine your map from the planning stage to confirm your catchment areas using ground level information such as contours and flow arrows.
An example of catchments drawn using contours and flow arrows

If there is an engineer who can help to calculate flows and sizes for your drainage pipes, guidance on how to do this is provided in the drainage appendix and you should refer to this now. If this is not possible, continue directly to step 3.

**Step 3: Draw the existing drainage network**

Take the map of the drainage in the area that you drew during the planning stage. Make sure that you have all the information that you have gathered on it.

Check to make sure you have drawn any underground drains. If there are underground drains, you will usually be able to find manholes or grates at points along the drainage line. Make sure you mark where these are.

If they are open drains, you will be able to see them. Follow them down hill and mark them on your map.

**Step 4: Select and draw the proposed drainage network**

Using the information from step 3, mark down areas where proposed drainage will be required.

The layout of the new drainage:

- May follow the existing drainage lines if there are any. This is unless the layout of the community is changing a great deal or you have identified problems with the locations in the previous steps.
- May change from the existing network in problem areas or if the catchments drawn in the previous steps show that the locations could be improved
- Will often travel alongside roads
- Needs to be located so that flow can get into the drain
- Can be located to collect runoff that would have alternatively have to a place you don’t want it

Use your map of catchments, flow arrows and existing drains to help you decide where this is. Make sure the water can be collected by the new drainage before passing through people’s homes or other areas where large flows of water are not wanted.

To decide on which type of drainage to use, some important considerations are below:

<table>
<thead>
<tr>
<th>Type of drainage</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open channels</strong> - lined or un-lined open drain usually with sloping sides</td>
<td>Highest flow capacity</td>
<td>Potential drowning hazards, especially for larger flows</td>
</tr>
<tr>
<td></td>
<td>Lowest cost</td>
<td>Standing water may encourage mosquito breeding</td>
</tr>
<tr>
<td></td>
<td>Allows greater fall than underground drainage systems</td>
<td>Requires compaction and in some cases lining to prevent erosion</td>
</tr>
<tr>
<td></td>
<td>Easy to maintain</td>
<td>Take up surface space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Careful consideration of road crossings and property access is required so that members of the community don’t block the drains inadvertently</td>
</tr>
<tr>
<td><strong>Pipes</strong> - a system of underground pipes and manholes</td>
<td>No surface space taken up</td>
<td>More expensive</td>
</tr>
<tr>
<td>Note: Due to the high risk of blockage pipe networks are often not recommended</td>
<td>No standing water on ground surface with health and safety implications</td>
<td>Blockage is very common and often makes the system have not benefit at all. In developing countries many pipes systems are completely blocked.</td>
</tr>
<tr>
<td></td>
<td>Damage from vehicles is less likely than for open channels if properly constructed.</td>
<td>Difficult to maintain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower flow capacities than channels</td>
</tr>
</tbody>
</table>
Less fall available than channels due to depth below ground surface
Require drainage pits which adds to the cost
More sophisticated building techniques are involved.

<table>
<thead>
<tr>
<th>Subsoil - underground pipes with small perforations (holes), backfilled with material that water can infiltrate</th>
<th>Cheaper than piped drainage</th>
<th>Lowest flow capacities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Allow for ingress of surface and ground water without drainage pits</td>
<td>Requires trench backfill material (can use coarse waste material to reduce costs)</td>
</tr>
<tr>
<td></td>
<td>Well suited for small drainage applications</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface grading - changing the profile or slope of ground to reduce ponding or change the direction that water flows</th>
<th>Can be cheaper to regrade ground surface away from development than providing formalised drainage</th>
<th>Difficult in congested communities (little space available to grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Requires less material than piped and subsoil trench solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Note that this may be required alongside the above drainage systems to get runoff to drain to the systems rather than away from them.</td>
<td></td>
</tr>
</tbody>
</table>

**Sizing**

**Sizing for open channels**

In the absence of detailed design calculations, the figure and chart below can be used to size open channels. It is always better to get the advice of someone with knowledge of drainage if possible.
Using the catchment areas for each drain that you calculated in the Step 2, obtain the channel size from the table above.

The bank side slope of 1 in 4 means that for every 1 m deep the channel is, each bank will be 4 metres wide.

If your channel is very flat from top (upstream) to bottom (downstream), the channels will need to be bigger. If you don’t have enough space to make the channel side slopes 1 in 4, you may be able to make them a little bit shallower. However, your channels will need to be deeper or with wider bottoms and may need to be lined (see below).

Another way to estimate the size of channel you need is: if there are existing drainage channels in the community or communities nearby that work well and don’t flood, then look at the size of those channels together with the size of the catchment flowing to the channels (see Step 2). Compare this information to the table above. Try to work out if the table above is about right or are the channels too big or too small.

**Sizing for Pipe Systems**

If you are using piped drainage, an approximate guideline for sizing of pipes is shown below:

<table>
<thead>
<tr>
<th>Channel Dimensions</th>
<th>0.05</th>
<th>0.1</th>
<th>0.5</th>
<th>1</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Width (b)</td>
<td>0.2</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Top Width (t)</td>
<td>1.8</td>
<td>1.9</td>
<td>3.1</td>
<td>3.7</td>
<td>6.6</td>
</tr>
<tr>
<td>Depth (d)</td>
<td>0.2</td>
<td>0.2</td>
<td>0.35</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Side Slope (x)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Due to construction difficulties and the high likelihood of blockage pipe systems are often not recommended and specialist advice should be obtained before installation.*
Guideline drainage pipe sizes

<table>
<thead>
<tr>
<th>Catchment Area (ha)</th>
<th>0.05</th>
<th>0.1</th>
<th>0.5</th>
<th>1</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe diameter (mm)</td>
<td>225</td>
<td>300</td>
<td>600</td>
<td>750</td>
<td>1350</td>
</tr>
</tbody>
</table>

If you have very flat pipes, the sizes will need to be bigger. Pipes are often expensive to buy and to build and are more difficult to maintain. It is always better to get advice from a specialist before using pipelines.

Grading

For pipes, the minimum slope should be a rise of about 1m for every 100 m (i.e. 1%)

For channels, the idea slope is about 0.5m to 1m for every 100m if the overall slope of the ground allows it.

It is important during the design stage to check that the drainage you plan to install can grade continuously towards the receiving water body or connection to the downstream drainage system. Ideally this should be carried out with survey equipment.

Existing and proposed drainage network

At the end of step 4, you should have a layout plan of your proposed drainage network. Check that you have enough space available to build drains of the size needed.
Other Considerations

Steep slopes
For steep slopes, methods to slow down the flow of water may be needed. For channels steeper than 1%, some form of lining will be required to prevent soil erosion. Some options for channel lining include:

- Turf or grass - roots allow soil to remain in place
- Compacted gravel or stone
- Concrete liners - generally only used for channels steeper than 5%. Small weepholes (approximately 10mm diameter) must be provided on the sides of the liner to ensure groundwater can enter the channel. Consult the reference document mentioned at the start of this section for more information.

![Diagram of lined and un-lined drains](image)

Examples of lined and un-lined drains (Surface Water Drainage for Low Income Communities, WHO, 1991)

Using the road for drainage
Where communities are built alongside the road, there may be no space available to provide drainage next to the road or elsewhere. In some cases, it may be possible to use the road itself as a drain. This should be done with consideration of the road works being carried out. This option is not suitable for very steep roads.
ii. Water supply

The purpose of the design section is to provide general information on how to design the chosen system.

Key components of design for water supply systems

![Step 1: Design system of distribution, storage and supply → Step 2: Design technologies for supply → Step 3: Design technologies for water treatment → Step 4: Compile design documentation]

Step 1: Water Distribution

The aim of a distribution system is to connect the different elements of a network together and ensure that desired flow rates can be achieved across the system. This will generally be a pipe network connecting source to treatment to storage to users.

This section will describe distribution system layout and design, and the physical design of tap stands. Pipeline hydraulics and hydraulic design require specific engineering expert design and will not be covered in this module.

Simple pipelines connecting storage tanks to tap stands (standpipes) can be quickly installed. Larger distribution systems will take more time to design and develop, but are able to reliably distribute substantial quantities of water over large distances and are well suited to meeting the needs of relatively large concentrations of users.

The aim of a pipe based distribution system is to connect the different elements of a distribution system together and ensure that desired flow rates can be achieved across the system. The optimal configuration and layout of a given distribution system will be determined by local conditions, but some general principles can be applied in developing the layout of a system.

Wherever possible, gravity should be used to power distribution either by selecting a source above areas where water will be distributed, or, where that is not possible, by pumping water to raised storage facilities from where it can then be distributed by gravity (Figure 1).

![Figure 1. Typical small distribution system]
The amount of water that passes through the entire system during a day will be the same through all stages, the rate at which it flows, however, will depend on the hours of operation for each section. Pumping mains and distribution mains are likely to work in short concentrated bursts during the day (during times when the pump is operating in the case of pumping mains, and the hours of peak water demand or distribution point operation in the case of distribution mains) and will therefore have to carry larger peak flows, requiring larger diameter pipes.

**Service pipe layout**

A branch or a ring style distribution main can be used (Figure 2). In general, branch systems are used for emergency systems because they are easier to construct, use less pipe and can be added to as growth occurs.

- **Public stand pipe**
  The public standpipe is a tap and sink from which the public can access drinking water.
It may be necessary to have valves at intervals along the pipeline to control the flow of water. These valves are preferably situated in a chamber built of concrete or cement blocks for protection and access. The chamber must allow opening and closing of the valve using a suitable spanner. The valve is backfilled around the body to just below the top body flange and the brick chamber is set around the upper part and covered with a hinged cover so that an operating tee key or spanner can be lowered on to the valve cap when it is necessary to operate the valve.

![Diagram of valve chamber]

Selecting pipeline routes

**The provisional route of a pipeline can identified by:**

- The number and location of distribution points
- The location of water sources
- The location of storage and treatment facilities

The optimum route between these points can now be selected. Efforts should be made to reduce the length of pipe used, and in this way reduce costs. Attention should be given to selecting routes that:

- minimize the number of difficult crossings (such as roads and gullies) a pipe will have to make;
- avoiding steep slopes which will require pipes to be anchored;
- avoid rocky ground, due to the difficulties involved in trench digging;
- are easily accessible e.g. along paths

Outline planning can be based on a rough map of the area, but more detailed hydraulic pipeline design will require a topographical survey of proposed pipeline to be made.

In addition to these factors, consideration should be given to land use, ownership and where necessary authorization should be sought.
Step 2: Select technologies for water collection and distribution

a) Connection to existing water supply system

The first step in connecting to an existing water supply system is to discuss with the relevant authority which manages the system. They may be able to provide guidance on connection to the system and may install a distribution system for the community (usually for a cost).

It is likely that a sub-distribution system will be required for the community and this is dependent on the layout of the community as well as the hydraulic conditions in the main system.

b) Spring catchments (for groundwater)

The essential nature of a spring is that water appears flowing freely at ground level and has to be “captured” in order to be stored and used. This catchment involves a structure to direct the water from the spring to a storage chamber, from where the water can either be collected directly by the users or piped (normally under gravity) to a distribution system.

As shown below in Figure 3.2, springs occur where water which has been flowing along through an aquifer appears at ground level. Rainwater infiltrates into the soil and passes through a permeable stratum. The water continues to seep downwards until it reaches an impermeable layer, flowing along the top of this layer until it reaches the surface. This is known as a gravity contact spring. There are other types of spring also (fracture and tubular, back-stowing, mountain slide and artesian).

The main advantages of a spring catchment are that it can provide a plentiful supply of clean water and, with a distribution system, can bring water directly into a village using a system requiring little maintenance, the costs of which are comparatively low. The disadvantages are that a system is not easily extended to cater for increased use, as this could involve the capture of a new spring, essentially a whole new construction project, and the flow in the spring can be influenced greatly by rainfall levels.
c) Bored wells (for ground water)

Bored wells (also called tube wells) are wells of a small diameter (500mm and less), which do not allow direct access for maintenance purposes. These wells are generally distinguished by the technology used in their construction, and the various types of bored well may be listed as follows: driven tube well, bored tube well, jetted tube well and mechanically drilled borehole.

d) River/Dam intake (for surface water)

An open water supply (usually existing) where water is continually available. A pump will usually be required to extract water from the source. Water treatment will need to be considered.

e) Roof catchment (for Rainwater Collection)

Involves capturing and storing rainwater that falls onto roofs of buildings or other surfaces where rainwater can be collected.

d) There are also technologies available for water storage including

- Reservoir tanks
- Storage tanks

Step 3: Design Technologies for Water Treatment

Water treatment is important as water in its natural state is rarely pure, due to natural impurities or pollutants from human activity. Impurities vary depending on the water source, in Cambodia; it is likely the water source could be groundwater, surface water or rainwater. Water treatment technologies can include:

- **Sedimentation**: The quality of surface water can be significantly improved by allowing it to pass through calm conditions so that the suspended matter and associated bacteria sink to the bottom. This not only improves the appearance of the water, but also the effectiveness of subsequent treatments.

- **Filtration**: Slow sand filtration provides a simple, effective and reliable process for treating water.

- **Disinfection**: Disinfection is to neutralise the pathogens which may be present in the water supply. If the source water is very clear and clean looking, it may be the only form of treatment required.
iii. Sanitation Systems and Hygiene Infrastructure

During the planning process the type number and location of excreta disposal and hygiene infrastructure should have been selected. This section provides general guidance on how to design the selected infrastructure. Design is highly dependent on the type of infrastructure chosen, and as there are many potential types it is not possible to cover all in detail. Therefore key types have been identified with preliminary design information provided.

Step 1 Identify the Waste Loading Rate
In designing a waste management system it is critical to understand the rate of waste loading. Waste can be classified as follows:

- **Solid Waste**: Such as solid human excrement and anal cleansing material. It has been estimated that this waste will accrue in a pit latrine approximately at the rate of 60 litres per year for each person using the latrine.

- **Liquid Waste**: Such as urine or water from kitchen and bathroom activities. For systems that receive water from kitchen and bathroom activities this volume can be high. It can be approximately estimated by assuming that 90% of the total water demand becomes wastewater. Total water demand can be estimated as per the recommendations provided in the water supply section.

The ratio of solid to liquid rate varies greatly depending on the type of facility and the water supply available. For example, for a community with piped water in the kitchen and bathroom and flushing toilets over 90% of waste could be water, whereas for a community with no piped water supply and pit toilets it is possible that the major source of liquid in the waste is from urine.

Based on recommendations presented in the planning system the type of waste disposal system selected should be appropriate for the nature of the waste generated.

Step 2 Determine Design Details for Selected Infrastructure
Connection to Sewer

Connection to an existing sewer should be undertaken by an experienced person. Key steps involve:

- Ensuring the downstream system has capacity to handle the new flows (based on discussion with relevant authority)

- Estimating the flow rate in the system (allowing also for rainfall infiltration)

- Estimating the pipe size required.

Discussion with the authority responsible for the sewer is critical in these design elements.
On-site Systems

There are a variety of on-site systems available with several variations of each type. The below table presents a summary of the main advantages and disadvantages of selected on-site systems. Further research should be undertaken to identify other potential systems and variations on the below systems. However, the table below will allow preliminary consideration of key advantages and disadvantages to help in selection of a system.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit Latrines</td>
<td>A latrine located over a pit excavated in the ground. Liquid waste soaks out of the pit into the surrounding soil. Solid waste remains in the pit and partially decomposes. Several variations existing including: · Ventilated Improved Pit (VIP): Air flow is encouraged in a way that removes odour and flies. · Double pit latrine: Increases waste storage capacity by providing two pits · Elevated pit latrine: Where the groundwater table is high. · Pour-flush latrine: Provides an odour seal but requires water for flushing. · Deep trench latrine: Allows for several communal latrines adjacent to each other and above a common trench.</td>
<td>· Relatively cheap and quick to construct. · Can be largely constructed by local labour and functioning of system is easy to understand. · No water required for operation.</td>
<td>· Pit needs to either be emptied or sealed and a new pit constructed. Can be costly, hazardous to health or take up a lot of space. · Pathogens can soak out of the pit and enter the groundwater therefore contaminating sources for drinking. · Significant odour can be present. · May not be feasible in situations of unstable or very hard soils or high water table. · Not suitable for large volumes of sullage.</td>
</tr>
<tr>
<td>Composting Latrines</td>
<td>Urine is diverted from solid waste and disposed of separately. Solid waste is stored in a chamber underneath the latrine. After a period of time the chamber is sealed off and a second chamber is then provided to store waste.</td>
<td>· Usable fertilizer produced. · Minimal risk of contamination of groundwater. · No disposal of hazardous waste required.</td>
<td>· Maintenance and ongoing care is required such as adding sawdust or other material to the waste. · Capacity constraints – likely not to be able to receive the same rate of...</td>
</tr>
</tbody>
</table>
used. Over a further period of time the waste in the first chamber decomposes to a level where it is no longer dangerous and can be used as fertilizer. It is then emptied, the second pit sealed and the process continues. Although diversion of urine is ideal, for some composting latrines urine is not diverted. This may be based on community preference.

| Septic Systems | Wastewater, including sullage is conveyed in pipes to a septic tank. This tank separates liquid and solid wastes. Solid wastes remain in the tank whilst liquid waste is discharged from the tank and disposed of via an infiltration area. | · Can receive a significant loading of waste. · Can receive sullage such as wastewater from kitchens and bathrooms. · Relatively low odour if managed appropriately. | · Liquid disposed of via infiltration system is contaminated and could result in contamination of surface water or groundwater. · Clean out of septic tank required to remove solid waste – can be hazardous. · Significant construction costs involved. · Regular water supply required to convey waste through pipes into tank. |
The following sections in the above document are recommended to provide the required
design guidelines for the major on-site systems discussed in the planning section of this
document:

- Sections 5.1, 5.2, 5.4, 5.5 – Pit Latrines
- Section 5.3 – Composting Latrines
- Sections 5.6, 5.7 Septic Tanks
- Sections 7.1 – 7.6 – Technical information of latrines and pits
- Section 7.7 – Technical information on septic systems

Step 3 Develop Design Documentation
Once the design has been developed the following design documentation should be
developed:

- Design drawings
- Bill of quantities
- Construction instructions as required
- Construction specifications
- Quality assurance and review procedure
iv. Earthworks, Roads and General Civil Works

This section outlines potential steps to consider when developing the design of roads, earthworks and general civil works.

In general, the design of civil site works can be summarised by the stages presented in the following table. This table lists the stages in the design process and provides an indicative timeline to demonstrate how these stages overlap.

![Table](source: Building Rural Roads, International Labour Organization, 2009)

**Terminology**

**Survey**: Collection of information relating to the positioning of different elements of the site. Often the output of a survey is a drawing(drawn to scale) showing the location, size and elevation of all major features of the area (eg. roads, walkways, trees, houses, pipes, drains etc)

**Alignment**: Horizontal or vertical position of the asset in relation to other existing or proposed features.

**Excavation**: Removal of soil/other material from existing to lower existing levels or to provide a trench for installation of services.

**Fill**: Placement of material from another location to change the existing surface levels.

**Embankment**: A constructed wall or bank of material (commonly earth or rock) for a particular purpose such as to provide a flat road surface below.

**Slope Stabilisation**: Installation of features such as rocks to make a slope more stable such that it is less likely to erode or slide away.
**Longitudinal Section:** A profile of the proposed asset showing elevation (vertical) along the route.

**Chainage:** Length of road, or other feature, usually measured along the centreline of the proposed asset.

### Potential Steps in the Design Process

![Flowchart showing the steps: Step 1 - Field surveys and information collection, Step 2 - Concept or scheme design, Step 3 - Detailed design, Step 4 - Drawings and specifications, Step 5 - Cost estimates.]

**Step 1: Field Surveys and Information Collection**

The first stage in the design process is to collect information, including applicable design standards, any existing maps, aerial photos or plans that are available, and a survey of the existing site conditions.

The site survey will include recording the existing surface levels of the site, soil conditions, drainage patterns and the location of any existing infrastructure, such as buildings and houses. The output of the site survey will be a map that can be used as a base plan for developing the road alignment design, alternatively aerial imagery could be used.

In the instance that new roads will be proposed, the new alignment needs to be planned by the community (based also on the site survey) during the community mapping stage.

When the works include rehabilitation of existing roads, it is common practice to maintain the alignment of the existing road to avoid the acquisition of new land. The field survey should identify any areas of the existing alignments in which ground conditions are unsuitable for roads, paths or foundations.

Construction access to road works must be considered. With primary aims being effective access of vehicles and people, whilst minimising disturbance and safety risks for the community.

**Step 2: Concept Design**

At the concept design stage, the preferred options that were proposed during the community planning stage are developed using the site information and constraints provided from the field surveys.

The following sections outline some elements of civil works that need to be considered as the design is developed.

**Earthworks**

The most common form of earthworks is the preparation of a level base on which infrastructure can be constructed. It consists of both excavation and building up earth fills.
and includes transport, loading, unloading, spreading and compaction of soils. Earthworks often account for a significant proportion of construction cost for new developments.

Earthworks are a major activity during the construction of roads and when constructing the drainage system.

General site grading is important to ensure adequate drainage throughout the site. Grading must consider the overall site drainage (as developed in Section 2.2) to prevent localised flooding, as well as the road alignment.

In some instances, earthworks may require slope stabilisation or embankments to provide restraint against instability.

**Roads**

Roads can include:

- **Footpaths** - a relatively narrow pathway catering for pedestrian traffic. They can be sealed or unsealed.
- **Unsealed road** - a road for vehicle traffic where the surface is typically graded and compacted dirt or rock. These are cheaper than sealed roads but are rougher to drive on, not as good for drainage and involve more ongoing maintenance.
- **Sealed road** - a road for vehicle traffic where the surface is sealed with a construction material such as asphalt or concrete. Underneath this seal the surface is compacted and a road base material is placed. Sealed roads are more expensive than unsealed roads but provide the best outcome for drainage, usability and ongoing maintenance.

There are several important considerations when developing the road design. Ideally the alignment will follow existing topography to minimise the earthworks, and therefore cost of construction. The alignment must also consider drainage conditions and accommodate the overall site drainage design (refer Section 2.2). Refer to Box X: Good Road Alignments for more information.

**Box X: Good Road Alignments**

The determination of a good alignment is more dependent on experience and good judgement by the designer than the availability of advanced surveying and processing equipment.

By selecting an alignment which follows the terrain and minimises earthworks, both initial construction costs as well as future maintenance requirements can be reduced. This includes design principles such as:

- Crossing ridges at their lowest point or through the lowest pass;
- Circumnventing hills rather than going straight over;
- Avoiding deep cuts, thereby reducing earthworks and avoiding to destabilise side slopes;
- Avoiding excessive fills by realigning the road, preferably to locations where a cut-to-fill is sufficient;
- Finding the highest lying ground when passing through flood-prone terrain;
- Avoiding steep road gradients;
- Avoiding rocky terrain or areas with difficult soils;
- Locating good river crossings where there are limited risks of future scouring and erosion.

When determining the optimal road alignment it is important to assess how each road section will perform in terms of future maintenance requirements. The most effective preventive maintenance measure lies in the actual design of the road.
The road alignment is only one element of road design that needs to be considered as the design develops. Other components of road design which need to be considered are listed in the following table.

| Geometry  | · alignment  
| · profile  
| · cross-section |
| Pavement  | · soil conditions  
| · gravel or other surface |
| Drainage  | · culverts and drifts  
| · mitre drains  
| · catch water and cut-off drains |
| Structures | · type and size  
| · location |
| Junctions | · location  
| · type of connected road |
| Climate   | · rainfall  
| · flood patterns  
| · adjacent water management |
| Traffic   | · annual average daily traffic |
| Maintenance | · details of routine maintenance i.e. names of petty contractors  
| · details on rehabilitation and urgent maintenance works, e.g. date, location |

Foundations

The following diagram outlines the process for foundation design.

**Step 3: Detailed Design**

During the detailed design stage, the concepts are developed even further such that adequate information is provided to construct the works.

The detailed design of a civil works project involves a substantial amount of work and will require considerable staff resources either from in-house technical units or from external consultants.

Equally, detailed designs have a certain shelf life before they become obsolete and need to be updated (involving additional resource intensive surveys and redesign work).

**Step 4: Drawings and Specifications**

Once the road layout has been confirmed, design drawings of the alignment will be produced. The drawings will show the plan view of the alignment as well as a longitudinal section along the alignment. Information about road curvature, earthworks (cut to fill, embankments, etc.) and drainage structures (if applicable) is then plotted in the road alignment drawings at its exact chainage along the road alignment.
These drawings, combined with the technical specifications, will form the construction documentation that specifies how the design is to be built.

**Step 5: Cost Estimates**
Cost estimation is an essential step which forms the basis for proper budgeting and financial planning.

### v. Electrical supply

The design stage of an electrical supply project must be undertaken by a professional design engineer. It is potentially dangerous and not recommended to undertake any electrical installation activities without professional guidance.

Principle stakeholder must engage an electrical services consultant to undertake the electrical design work, this section of the manual will outline the key considerations and cost impacts associated with the electrical portion of an infrastructure development project.

**Key Considerations**
Within the design stage of any infrastructure project there are a number of key considerations from an electrical perspective. These are summarised in the table below:

<table>
<thead>
<tr>
<th>KEY CONSIDERATION</th>
<th>HOW CAN THIS BE ADDRESSED IN A HUMANITARIAN PROJECT?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety of final installation</td>
<td>- Ensure designs meet or exceed local (and international where applicable) standards</td>
</tr>
<tr>
<td></td>
<td>- Ensure consideration given to ongoing maintenance, accessibility etc</td>
</tr>
<tr>
<td>Fit for purpose (capacity to handle planned load)</td>
<td>- Accurate load assessment</td>
</tr>
<tr>
<td></td>
<td>- Consideration of future growth</td>
</tr>
<tr>
<td></td>
<td>- Consideration of system uptime and reliability (particularly with regards to renewable generation)</td>
</tr>
<tr>
<td>Site specific challenges</td>
<td>- Design for extreme weather conditions of the area if any</td>
</tr>
<tr>
<td></td>
<td>- Consideration of location of existing infrastructure and resulting effects on project cost</td>
</tr>
</tbody>
</table>
The following section shall detail some potential steps for the consideration of the infrastructure planner. Note that the following is not an exhaustive step-by-step list of tasks for the design process, but rather a guide to best practice that should be referred to when engaging a services consultant.

Steps below are applicable for all technology options outlined in the planning section. Implementing the first option of connecting to the main grid will require engaging a qualified electrical designer to design the reticulation system within the community, i.e. wiring and associated circuitry from the electricity provider’s point of connection to individual households.

As there are a number of fundamentally different design considerations depending on the project itself, two sample scenarios with major differences in power needs have been identified and shall be referenced throughout this section. These are:

**Scenario 1:** Project to build a community hall. The hall is to be supplied from existing power infrastructure as well as a small backup diesel generator for emergency supply.

**Scenario 2:** Small scale project to supply “battery charging stations” to various locations within the community. These are to be supplied by solar PV panels which are not connected to the main grid.

**Step 1: Site Survey**

During the planning phase it is envisioned that preliminary site surveys should already have taken place to determine feasibility of the proposed infrastructure development. Once the design team has been engaged by the client, it is recommended that additional site surveys be undertaken. The purpose of this is to allow site specific challenges to be identified by the services consultant, as well as to develop the strategy for bulk electrical supply to the project (as distinct from small power wiring and subdistribution within the project). As this usually forms the largest cost component to the project from an electrical perspective, it is absolutely essential that the strategy be well defined at this early stage.

💡 **The biggest cost component of electrical supply is bulk supply, i.e. transformers and cabling to get power to the site.**

In order to manage the risk taken on by the builder (and subsequent cost to the project), it is also important at this stage to coordinate the proposed strategy for electrical supply with other proposed or existing services (gas, water, sewage, fuel pipelines, new civil works etc).
While these considerations become less significant in Project Scenario 2 as cabling is fairly localised, the introduction of solar PV as an example creates other site specific considerations that must be assessed, including solar irradiance, shadowing from surrounding structures etc.

**Step 2: Return Brief (Translate community needs into electrical requirements)**

Once the services consultant has been engaged to undertake the design, it is recommended they will provide what is known as a return brief. This document should include as a minimum:

- The proposed scope of works. It is important that this is very well defined and understood by all parties.
- Overall strategy for provision of electrical supply to the project.
- Requirements for supply authority approval
- Rough cost estimates

Once all parties have agreed upon an approach, the concept design stage can be initiated.

**Step 3: Concept/ Schematic Design**

The concept design stage generally involves the following components:

- Estimation of electrical loads. This can be based on a number of metrics including past projects, demand per square metre figures, or other standard calculations
- Preparation of schematic drawings (Single Line Diagrams, Preliminary Layout Drawings for small power and lighting)
- Liaison with local authorities (e.g. Cambodian Distribution Authority)

It is also important at this stage to evaluate the risk posed by environmental factors e.g. landslides, flooding etc.

💡 The fundamental design question to ask in concept design stage is: “will the proposed installation have the capacity to deal with a defined set of planned or anticipated future loads?”

The drawing below shows what a typical concept stage sketch might look like, detailing various options for supply as well as the locations of any existing services or major items of interest:
Single line diagrams similar to Fig 2 in section 6.4.2 should also be developed by the services consultant during this stage. Once supply options have been finalised, loads can be estimated and equipment roughly sized according to this demand (e.g. to take the simple example of Scenario 2, it may be determined that the charging station will accommodate four 12V lead acid DC batteries and two AC general purpose outlets at a total diversified load of 40A, and this allows the selection of a 12kW inverter, and a 5x4 array of 500W solar panels as a rough guideline).

**Step 4: Detailed Design Development**

The detailed design development stage is where the detailed drawings and specifications are prepared. It is important to note in the case of a humanitarian project that these detailed drawings will likely need to be interpreted by local builders, and should therefore be very clear and explicit in their intent, and not rely on interpretation of the English language. Bubble notes and the like should be minimised. At this point consideration should also be given to engaging a third party to undertake peer review of the design. This will give the best chance of any compliance or engineering design issues being identified prior to construction.

By this point in the design process electrical loads should ideally have been finalised, and all equipment sizes can therefore be determined from this. The major design tasks at this stage are summarised below.

The following considerations are applicable whether connecting to the main electricity grid or selecting another technology option from Table 1 in the Planning section.

**Selection of Sub-main Cables**

- In addition to the bulk supply to the site, power must also be reticulated throughout the site to the final loads.
● On a simple scale this may be simply a main switchboard (commonly known as a “fuse box”) supplying all the lighting and power circuits, or there may be a number of intermediary “distribution boards” which split power into smaller and smaller portions before being distributed to the final circuits.
● Cables must be appropriately sized for the load application. If a cable is undersized, or is installed in a manner such that heat cannot dissipate from the cable, overheating can occur and can set fire to the surrounding structure.
● To avoid this situation, loads must be calculated as accurately as possible, and sufficient spare capacity designed to accommodate future loads. There are various local and international standards which determine the acceptable current carrying capacity of a given cable.

Selection of circuit protection devices

● Circuit protection devices ensure that if a cable is either overloaded (i.e. too much load being connected) or experiencing a fault (e.g. short circuiting to earth) that both equipment and the safety of the surrounding structure and persons is maintained. Fundamentally at low level these consists of fuses, circuit breakers and Residual Current Devices (RCDs).
● These devices are usually housed within what is known as a switchboard, simply a junction point where one cable is split into many smaller cables.
● Both switchboards and protective devices must be rated to handle the faults that can occur on the relevant cables.
● Circuit breakers must also “discriminate”. This simply means that tripping of circuits happens in a prescribed order, in order to minimise the effects of a fault on the overall installation.

Miscellaneous items

● Where lighting design is included as part of the scope of works, calculations must be done to determine that levels of illuminance, uniformity, glare etc are appropriate to the application.
● Where installation methods are not clear/do not follow established norms, drawings showing this detail should be prepared in order to ensure this is carried out on site, particularly where it is required for design to function as intended.
● Method of cable installation and fixings should also be detailed.

The following considerations are applicable if selecting one of the options from Table 1 in the Planning section except Option 1 connecting to the main electricity grid.

Selection of generator plant

● Backup generators, PV arrays, hydro generators etc must all be sized appropriately and protected against faults as mentioned previously.
● Spatial provisions and consideration of placement, ventilation if required etc.
● Where multiple sources are present, synchronisation of these sources must also be considered, and analysis of power distortion performed.
Step 5: Construction Tender

Once detailed design has been completed (depending on the procurement model utilised), typically a combined set of drawings and specifications will be put out for builders to tender for the construction contract. Depending on the scale of building works the principal (whether an NGO, developer or government) may decide to directly employ its own local subcontractors and manage the building works themselves. If this is the case, while there is not a tender stage as such, there are regardless a number of considerations to be addressed in any infrastructure project prior to the construction phase.
ATTACHMENT 3: MATERIALS AND LABOUR COST-ESTIMATION

Step 1: Identify Design Items to Cost

The first step to creating a cost estimate is to itemize the things that you want to include in the cost estimate. The extent of this will depend on the design stage. If it is early in the design stage, the list of items will not be very detailed, if it is at the construction stage, the list of items should include everything that will be needed to construct the design.

1a. To identify the items that need to be costed, work systematically through the design and list all of the works that need to be done, and all of the materials that will be needed. For example for a water supply project from a rainwater tank, you could start listing the works from the water source, through the end-use of the water. See the example below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit of measurement</th>
<th>Quantity</th>
<th>Cost per unit</th>
<th>Cost (U$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gutter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downpipe from roof</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainwater tank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete base for tank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overflow pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete overflow drain to ...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water outlet pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe from pump to tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household tap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1b. Make sure that all the items that are shown in the drawing are listed in the items list.

**Step 2: Calculate units of materials**

2a. Decide what the appropriate unit of measurement is for each item. Items might be measured in

- number (e.g. one water tank),
- length (e.g. meters of pipe),
- area (e.g. area of concrete base),
- volume (e.g. cubic meters of excavated material),
- time (e.g. hours of labour).

If there is any doubt about what the best unit of measurement is for any material or resource, it is a good idea to contact a local supplier and ask them what measurement unit they use when selling that product. e.g. a supplier might sell wooden planks as individual planks (number) or per meter (length).

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit of measurement</th>
<th>Quantity</th>
<th>Cost per unit</th>
<th>Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gutter</td>
<td>Meters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downpipe from roof</td>
<td>Meters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter</td>
<td>Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainwater tank</td>
<td>Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete base for tank</td>
<td>meters squared</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overflow pipe</td>
<td>Meters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete overflow drain to ...</td>
<td>Meters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water outlet pipe</td>
<td>Meters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump</td>
<td>Number</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Step 3: Calculate the quantity of each item

The quantity of each item must be measured in the unit of measurement that was chosen in Step 2. In this step, methods for measuring different measurement units will be described.

a) Number
Things that are measured by number are generally products that can be bought as single pieces, for example, a tap, a pump, a sink etc. "If a discrete item is listed twice in the item column, repeated listings can be removed and combined into one item. The quantity required should reflect how many of the item are needed in total. For example if two taps are required in a design, and it is listed twice in the item list, the second listing can be removed, and the number of taps required in the quantity column will be 2. —wording could be better..." Count how many of that item are required in the design and write that number into the quantity column.

b) Length
Depending on the level of design and the format of the design documentation, there may be more than one way to measure length.

i. If the item can be shown on a GIS plan that is to scale, GIS software could be used to measure the length of an item. This is the preferred method. For example, measure the length of a proposed pipe line between a water well and a storage tank with the measurement tool in the GIS software.

NOTE: If drawings are not to scale this method should not be used.

ii. If the accurate length of an item is not shown on a design drawing (for example, if the design drawing is only a typical drawing, and not specific to your situation), you may need to measure the required length of the pipe at the site. This can be done by pacing out the distance that the pipe will need to cover, and counting the number of paces taken (1 pace equals approximately 1m), or preferably by using a measuring tape on site.

iii. Sometimes a ‘best guess’ estimate needs to be made when neither of the above methods can be used. For example, if a site specific drawing of a rainwater tank connection to a household tap does not exist and the exact length of pipe required cannot be ‘paced out’ or measured on site. A ‘best guess’ estimate should always overestimate the length required while trying to be realistic. Think carefully about coming to a realistic estimate. e.g. a household pipe will not be longer than the width/length of the house.
c) Area

The formula to calculate an area is

\[ \text{Length (m)} \times \text{width (m)} = \text{Area (m)} \]

The methods for measuring area are very similar to measuring length. The preferred method is to measure areas from accurately scaled design drawings. If these do not exist, pace out, or measure the length and width of the desired areas on site with a measuring tape where possible. If this is not possible, make a realistic and conservative (a little bit overestimated) best guess.

d) Volume

The formula to calculate a volume is

\[ \text{Length (m)} \times \text{width (m)} \times \text{depth (m)} = \text{volume (m)} \]

The method for measuring volume involves one extra step to measurement of area. Once the area has been determined, a depth value needs to be estimated. Volume is the typical measurement for items such as excavation and fill.

i. Excavation (or “cut”) and fill quantities can be determined with GIS software if contour data for the existing surface and the design surface levels are available.

ii. If these volumes cannot be calculated with GIS software, depth for excavation and fill must be estimated from design drawings or as best guess estimates. For example, excavation to lay a 300mm diameter pipe must be deeper than the pipe diameter itself to allow for some cover to the pipe. In general for a pipe under a road the excavation depth for the trench would equal: pipe diameter (0.3m) + cover over the pipe (0.6m) = 0.9m

e) Hours

Items that are measured in hours are typically hours of labour, however they may also be used for items such as equipment rental etc.

If hours of labour or other item that requires a time measurement are to be included in the costing, the contractor or supplier should be contacted. Ask them how long they estimate their work will take. It is a good idea to ask a number of contractors or suppliers to ensure that the estimates are reasonably consistent.

Once the quantities have been estimated, your costing table should be filled in up to column 3.
<table>
<thead>
<tr>
<th>Item</th>
<th>Unit of measurement</th>
<th>Quantity (examples only)</th>
<th>Cost per unit</th>
<th>Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gutter</td>
<td>meters</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downpipe to rainwater tank</td>
<td>meters</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter</td>
<td>number</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainwater tank (200L)</td>
<td>number</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete base for tank</td>
<td>meters squared</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overflow pipe</td>
<td>meters</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete overflow drain to...</td>
<td>meters</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water outlet pipe</td>
<td>meters</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump</td>
<td>number</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe from pump to tap</td>
<td>meters</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household tap</td>
<td>number</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Step 4: Calculate the cost per unit**

A number of resources can be drawn on to develop realistic costs for items.

4a. Contact as many local suppliers as possible to obtain quotes for materials, contacting many suppliers allows you to verify that the quotes are reasonable and to choose the best cost option.
i. Ask the supplier if ‘bulk purchase’ discounts are available. Note that prices may change depending on the quantity of the item needed.

ii. Ask all the suppliers to give you the cost in the units of measurement that you have used so that the quotes from different suppliers can be compared easily. E.g. ask for the price of 150mm diameter plastic pipe in meters

iii. Ask the supplier if the product/item you have chosen is the best option for the design purpose. Suppliers are often useful resources with good knowledge of their products, it may be beneficial for the project and future projects to talk to the supplier about alternative, cheaper but equally effective products. E.g. different types of pumps/tanks/concrete mixes.

iv. Ask the supplier about installation and or labour costs where relevant

4b. If local suppliers cannot easily be contacted or if only one supplier is locally available, alternative resources to gauge realistic costs might be:

i. Past construction case studies

ii. Local contractors/builders

iii. Cost resource books from libraries or universities

Ensure that the information from these alternative sources are relevant to your context (e.g. Cambodian prices for small/medium scale infrastructure).

4c. All quotes should be filed and stored for reference for future projects. Experience with construction projects is valuable for estimating costs for items including materials and labour etc.

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit of measurement</th>
<th>Quantity (examples only)</th>
<th>Cost per unit (US$) (examples only)</th>
<th>Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gutter</td>
<td>Meters</td>
<td>10</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Downpipe to rainwater tank</td>
<td>Meters</td>
<td>0.3</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Filter</td>
<td>Number</td>
<td>1</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Rainwater tank (200L)</td>
<td>Number</td>
<td>1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Concrete base</td>
<td>meters squared</td>
<td>4</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Step 5: Calculate total cost for each line item

The total cost for each item is simply calculated by multiplying the quantity of each item by the cost per unit:

\[
\text{Quantity (unit varies)} \times \text{Cost per unit (US$)} = \text{Cost (US$)}
\]

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit of measurement</th>
<th>Quantity (examples only)</th>
<th>Cost per unit (US$) (examples only)</th>
<th>Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gutter</td>
<td>meters</td>
<td>10</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Downpipe to rainwater tank</td>
<td>meters</td>
<td>0.3</td>
<td>2.5</td>
<td>0.75</td>
</tr>
<tr>
<td>Filter</td>
<td>number</td>
<td>1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Rainwater tank (200L)</td>
<td>number</td>
<td>1</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Concrete base</td>
<td>meters squared</td>
<td>4</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Item</td>
<td>Unit</td>
<td>Quantity (examples only)</td>
<td>Cost per unit (US$) (examples only)</td>
<td>Cost (US$)</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------</td>
<td>--------------------------</td>
<td>------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Overflow pipe</td>
<td>Meters</td>
<td>0.1</td>
<td>2.5</td>
<td>0.25</td>
</tr>
<tr>
<td>Concrete overflow drain to ...</td>
<td>Meters</td>
<td>5</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Water outlet pipe</td>
<td>Meters</td>
<td>0.2</td>
<td>2.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Pump</td>
<td>Number</td>
<td>1</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Pipe from pump to tap</td>
<td>Meters</td>
<td>5</td>
<td>2.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Household tap</td>
<td>Number</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The sum of the Cost column will equal the subtotal for the project.

**Step 6: Estimate contingency**

The contingency factor is an added cost to account for potential inaccuracies in the costing calculations or to cover unforeseen additional costs. As a general rule; a high contingency factor (e.g. 30-50%) indicates that the level of detail and accuracy of the cost estimate is fairly low (concept design phase). A low contingency factor (e.g. 10-20%) indicates that the level of detail and accuracy of the costing is fairly high (e.g. construction phase).

Add an appropriate contingency factor to the subtotal to obtain the total cost for the cost estimate.
<table>
<thead>
<tr>
<th></th>
<th>meters</th>
<th>0.1</th>
<th>2.5</th>
<th>0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overflow pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete overflow drain to</td>
<td>meters</td>
<td>5</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Water outlet pipe</td>
<td>meters</td>
<td>0.2</td>
<td>2.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Pump</td>
<td>number</td>
<td>1</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Pipe from pump to tap</td>
<td>meters</td>
<td>5</td>
<td>2.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Household tap</td>
<td>number</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
<td></td>
<td>274.60</td>
</tr>
<tr>
<td>Contingency Factor (30%)</td>
<td></td>
<td></td>
<td></td>
<td>82.40</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>357</td>
</tr>
</tbody>
</table>
ATTACHMENT 4: TECHNICAL GUIDELINES FOR CONSTRUCTION OF INFRASTRUCTURES

i. Drainage and flooding

Safety

Always follow all general construction safety guidance. This includes:

- Making sure that anyone who helps with constructing the drainage has been briefed in the task they are doing and in safe ways of working.
- Making sure that machinery such as excavators are only operated by trained people. When machinery is in operation, everyone else should remain a safe distance away.
- When using hand tools and equipment, it is a good idea to:
  - Have a knowledgeable person decide what level of skill is required to use the equipment. This will depend on how difficult and dangerous it is to use.
  - Make sure that anyone who could be using the equipment has had training from a knowledgeable person in how to use the tool, things that can go wrong and how to avoid things going wrong.

Areas of excavation should always be cordoned / taped off. The local community should be made aware about the activities and children should never be allowed anywhere near the construction site. In addition to this, when building drainage you are working in areas where water goes. Always work during dry weather when there is no chance that anyone can be affected by water from rain events. Only carry out shallow excavation of open channels no more than 1 m deep. Construction of pipelines and deep excavation should only be done with specialist help and no-one should enter manholes or pipes without qualification.

Construction steps for drainage

1. Step 1: Setting Out
2. Step 2: Removal of waste / vegetation and cleaning of existing drains
3. Step 3: Excavation and shaping
4. Step 4: Drain lining/laying
5. Step 5: Maintenance
Three types of drains are considered in this section, open earthen drain, prefabricated open drain, and underground drainage pipe. Each type is discussed under the heading “Type of Drains”.

Whichever type of drain is selected, it is important that for a drain to efficiently convey stormwater runoff to the point of discharge (or the waterway), a drain needs to be constructed with an appropriate gradient (slope).

Practical means to achieve correct gradients are discussed under the Heading “Setting Out”, the tools required for the setting out of works are listed under “Construction Tools”. These tools are ranging rods, boning rods, spirit level, string line, and construction templates.

**Step 1: Setting out**

Setting out involves marking where the centre lines of each section of drain are going to go. This exercise helps to make sure that everything designing during the design stage can practically be installed on site.

Divide the drainage into sections where sections are divided by changes in direction and changes in drain slope. The sections can be marked at each end with marker boards and the centre line of the drain marked with wire as indicated in the figure below.
As part of the overall construction works you should have found information about existing service lines and marked where these are so that they are not accidentally damaged during construction.

**Step 2: Removal of waste / vegetation and cleaning of existing drains**

Clear the area that you are going to excavate of rubbish, and vegetation. Remove rubble or boulders that might get in the way or that pose a danger of tripping.

Clear existing drains of rubbish and debris. Only work during dry times and make sure to wear suitable protective clothing.

**Step 3: Excavation and shaping**

From the centre line marked during step 1, mark the edges of the area to be excavated. For a pipe this will be the trench width (at least 400mm wider each side than the pipe diameter). For an open drain this will be the width of the channel.

You can use marker boards and plumb lines to help (refer to the *Site Supervisor* handbook referenced at the beginning of this chapter).

Excavate the channels starting from the downstream end (at the point of discharge) to the upstream end. It is important to get the slope (chosen during the design stage) correct and make sure that it is constant. Without a smooth gradient, the drainage won’t work properly and ponding may occur. To achieve the right gradient for an open channel, a simple method is to control the slope using a water hose as excavation proceeds. However, this method uses a lot of water and requires connection to a water source. A better way is to use the marker boards with levels set out in Step 1 or one of the other methods suggested in the *Site Supervisor handbook*.

Depending on the drain type, the exact drain shape may need to be created. For open channel with side slopes, use a template as shown below:
Step 4: Drain lining / laying

Concrete pipes

The laying of concrete pipe is similar to the laying of prefabricated drain described above, with the exception that the open trench has to be backfilled. In addition, in Cambodia pipes need to be joined together with cement every 1 meter.

Once backfilled to a depth of at least 500mm, it is most likely that trucks and heavy machinery will drive over the pipes. It is therefore important that there is adequate backfill over the pipe, and the fill has to be properly compacted. Without adequate fill and compaction, pipes will shift under load, and gaps will form between pipes which will require frequent repair.

Maintenance

Maintenance of drainage systems is essential to keep them functioning correctly. This includes:

- keeping them clear of rubbish and obstructions
- checking for erosion of open drains and considering lining if this occurs
- checking for ponding and regrading sections of open drains if this occurs
Drain clearing needs to be considered when planning for and implementing a waste management plan for the community. For open drains, it is worth considering whether the community, with appropriate training and protective wear, can be engaged to help maintain a short section of the drainage channels.

It is also important to understand that open drains are a hazard as people; particularly children may fall into them with a risk of injury or drowning. Prior to the drainage being installed and once it is in place, it is a good idea to keep talking to the community about such issues so that they care informed. By involving the community all the way from planning stage to operation stage, they can be kept advised and update to date.

ii. Water supply

Safety

Throughout all construction activities, safety measures should be taken to minimise risk. The main risks when carrying out construction of large structures or buried structures are:

- Excavation
- Trench collapse (particularly after rain)
- Confined spaces (including trenches)
- Asphyxiation (gasses, low O2)
- Plant movement (struck by vehicle)
- Fall from heights (into excavation, from scaffolding)
- Structural collapse (particularly temporary works - concrete support dorme work)
- Injury from misuse of tools

To avoid injury to labourers and member of the community, safety measures can be implemented, including:

- Wear protective clothing (hard hats, strong shoes, gloves)
- Cordon off construction area, obstructing pedestrians from dangerous areas such as excavations
- Ensure construction site is kept tidy to avoid tripping and other unnecessary accidents
- Have medical assistance available should the need arise
- Seek technical advice and obtain professional assistance wherever needed (particularly with excavations and heavy structures)

Construction steps for water supply:
Step 1: Construct system of extraction/distribution

Groundwater

The following details are can be utilised to dig a well up to 5m deep. This method requires less technical expertise than alternatives mentioned in designed chapter. See supporting documentation for construction information on driven tube well, bored tube well, jetted tube well, augured well and bored well.

- Construction of a hand dug well involves assembling all necessary personnel, materials, and tools; preparing the site; excavation of the well shaft; and lining the shaft.
- As the depth of excavation increases, shutters should be used as temporary lining
- Permanent casings and liners along the entire depth of the excavation should be PVC or black steel
- A permanent ring-shaped seal, surrounding the permanent casing, should extend to a minimum depth of 5m to prevent contamination near the surface. This can me made of concrete or cement.
- Plumb-bobs should be used to ensure correct alignment.

Surface water

Construction of a pumping system that utilises water from bodies of water can be a difficult process due to the unique challenges presented by laying pipe underwater. Care should be taken to ensure the construction process is well thought-out and planned.

Key steps are as follows:

- Prepare the intake pipe with a screen
- Attach the intake pipe to a float and anchors, to allow the pipe to float under the surface in a ‘flexible’ arrangement. Alternately, you can encase the pipes in concrete to ensure a ‘rigid’ arrangement. (see below figures)
- Dig trenches and install pipeline as per pipe distribution section
- Install pumping system
Rainwater collection

The construction of a roof catchment in an individual home does not require skilled workmen and can be installed by a family at a modest cost.

Key steps as follows

- Construction of the roof catchment structure
- Installation of gutters and downpipes to the storage container (see images on how to make gutters from bamboo)
- Construction of a means to dispose of the foul flush

Pipe Networks

The construction of a pipe network requires significant planning, labour and time. The following list outlines the key steps in the process.

- Setting out pipeline trenches
- Removal of waste and vegetation
- Locating and marking of existing service lines
- Trench excavation
- Trench bed preparation
- Pipe laying on trench beds
- Pressure testing of sections
- Trench backfilling
- Pipeline marking
- Disinfection of pipelines

Step 2: Construct system of water treatment

Constructing a slow sand filter

This information describes the construction of a small slow sand filter made from materials such as bricks or mass concrete. Larger filters require reinforced concrete and technical advice from an engineer.

Key steps:

- Structure: Mark out site and ensure elevations are accounted for to allow for gravity flow through the filter, excavate space for filter, setup form work, concrete foundation and build walls
- Underdrainage system: Space laterals at 1-2m (can use tiles), cover underdrainage system with gravel (120mm of course gravel 18-36mm, 60mm of 6-12mm gravel, 60mm of 2-4mm gravel and 60mm or 0.7-1.4mm gravel)
- Sand bed: should range between 1 -1.4m. Ensure sand is of high quality. May require washing first.
• The outlet pipe should be fitted with a valve to control the flow and its diameter should be the same as the inlet to the filter bed.

Constructing a disinfection unit

A floating bowl chlorinator is used to add chlorine at a constant rate to water in a tank or low pressure pipeline, often used in disinfecting water in wells and small reservoirs.

Key steps:

• Prepare 200 Litre barrel for storing chlorine solution
• Place small outlet hole in side of barrel 6mm in diameter
• Place another hole 10mm in diameter at bottom of the barrel
• Make a floating bowl as seen in figure below
• Install into tank
• Fill tank with one percent chlorine solution

Step 3: Maintenance

The continued operation and success of a water treatment technology is dependent on ongoing maintenance from the community. Planners should ensure at handover that responsibility for maintenance is designated to members of the community, and that they have the knowledge and means to do so. Funding of the maintenance requirements is important. Developing means of revenue raising and community support will ensure the constructed technologies will not fail. The creation of schedules may allow for accurate and organised methods of maintenance, and ensure potential issues are observed and fixed before failure of a water supply system.
iii. Sanitation and hygiene systems

Safety

All construction work involves risks to the safety of the community and of those installing the systems and must be managed appropriately. Risks particular to installation of sanitary and hygiene works include:

- Collapsing walls of excavations including pits
- Falling into pits
- Contact with waste material during maintenance activities.

All excavations should be protected or covered as soon as possible and management of waste should be undertaken by those familiar with the risks and the appropriate safety measures.

Components of Sanitary and Hygiene Construction

In general construction of sanitary and hygiene systems can involve the major components identified in the table below. The table also provides information about obtaining appropriate general advice for recommendations on the construction procedure:

<table>
<thead>
<tr>
<th>Item</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of pipework</td>
<td>See water supply section of this document</td>
</tr>
<tr>
<td>Excavation of pits</td>
<td>See job sheet below from Beush and Winsvold, 2002 “Super Handbook”</td>
</tr>
<tr>
<td>Construction of tanks such as septic tanks</td>
<td>See job sheet below from Beush and Winsvold, 2002 “Super Handbook”</td>
</tr>
<tr>
<td>Installation of Latrine Slabs</td>
<td>See section 7.4 of P. Harvey 2007, Excreta Disposal In Emergencies, A Field Manual:</td>
</tr>
<tr>
<td>Construction of latrine superstructures</td>
<td>See job sheet below from Beush and Winsvold, 2002 “Super Handbook”</td>
</tr>
</tbody>
</table>

Many of these items can be constructed largely by local labour; however qualified oversight is required for all elements.
**WORK METHOD for Pit Latrines:**

Identify the soil conditions (if conditions are poor like sandy or stony soils the pit has to be lined).

Set out the edge lines for excavation using the profile boards. If lining is required add the thickness of the pit walls to the excavation width. Typical diameters are:
- unlined pit in stable ground = 100 cm
- lined pit in soft ground = 140 cm

Excavate step by step. The excavated material has to be hauled to the top with buckets. A tripod or a simple winch is useful to haul the material safely from deep pits.

Ensure that the internal dimensions and form of the pit is uniform from top to bottom. Shape pit walls. Deposit the excavated material safely away from the pit (at least 5 metre distance).

Haul the excavated material to an approved dump place or use for other construction work if required.

---

**Note:** Ensure stability of pit walls before excavating below 1 m deep.

---

**LABOUR:**
- 1 Gang Leader
- Labourers

**TOOLS AND EQUIPMENT:**
- Tape measure
- Plumb-bob
- Tripod (if available)
- Rope and buckets
- Shovels and hoes
- Pick-axes or forked hoes

**MATERIAL:**
- Pegs and strings

**ASSUMED PRODUCTIVITY:**
- Excavation: m³/day/labourer =

**ACTUAL PRODUCTIVITY:**
- Excavation: m³/day/labourer =
WORK METHOD:
Note: There are various types of septic tanks that can be constructed. This job sheet describes the details of a common type. The size depends on the number of toilets which are connected to the septic tank, and the number of people using these toilets.

Construction:
Use the profile boards with wires and plumb bob to establish the 4 corners of the septic tank.
Establish the bottom level of the slab; use reference point from profile board.
Place hardcore layer of approximately 15 to 20 cm, compact wall.
Add lean concrete layer of approximately 5 cm thickness.
Cast bottom slab (add crack reinforcement, e.g. weldmesh), trawl slab top smooth.
Construct lower concrete dividing wall; ensure that the wall can be tight into outside walls.
Construct outside walls, preferably using cement blocks. Leave grooves for the 2 baffles and dividing wall. Plaster walls inside if not made of concrete.
Construct the formwork for the 2 reinforced concrete baffles and the dividing wall and cast concrete.
Construct formwork for slab. Add reinforcement. Provide openings (manholes) for access, min. Ø 60 cm.
Cast concrete, trawl top smooth and cure for 20 days. Remove the formwork from the slab and baffles.

LABOUR:
1 Gang Leader
1 Mason
Labourers

TOOLS AND EQUIPMENT:
Tape measure
Plumb-bob
Masonry tools
Shovels
Watering can

MATERIAL:
Hardcore, ballast, sand, cement and cement blocks
Weld mesh, RE bars
In-/outlet "T" pipes
Timber for formwork
Nails and wire

ASSUMED PRODUCTIVITY:
Day work =

ACTUAL PRODUCTIVITY:
Day work =
**JOB SHEET**

<table>
<thead>
<tr>
<th>SANITATION</th>
<th>SUPERSTRUCTURE</th>
</tr>
</thead>
</table>

**WORK METHOD:**

Note: Superstructures are required for pit latrines to ensure the privacy of the users. The construction standard depends on the funds available. In an urban setting, where latrines are extensively visited, it is advisable to construct permanent structures of good quality which can be easily cleaned and maintained. This job sheet describes a permanent structure built with bricks or cement blocks.

**Construction:**

Build walls with bricks or cement blocks along the edge of the slab (can be used as foundation).

Leave openings near the top in all 4 walls for ventilation and light.

Add timber frame and door.

Plaster inside of cubicle walls with cement mortar and trowel smooth (for easy cleaning). In case you need to economise, plaster only 100 cm from the bottom.

Point the joints outside and above the plastered section of 100 cm.

Fix ventilation pipe with fly screen on top. Seal with Band-Aid around the pipe on the roof and with cement on the floor slab.

Provide a cover for the squat hole (can be made from timber).

Paint walls and door if timber is available.

Note: Superstructures can be constructed of locally available material where appropriate.

![Diagram of sanitation and superstructure](image)

**LABOUR:**

1 Gang Leader
1 Mason
Labourers

**TOOLS AND EQUIPMENT:**

- Tape measure
- Plumb-bob
- Masonry tools
- Shovels
- Watering can

**MATERIAL:**

- Sand
- Cement
- Bricks or cement blocks
- PVC pipe, Ø 12 cm
- Wire mesh
- Timber brusses
- Corrugated iron sheets
- Nails and wire
- Timber door and frame

**ASSUMED PRODUCTIVITY:**

Day work =

**ACTUAL PRODUCTIVITY:**

Day work =
iv. Roads and earthworks

Safety

Safety is a key concern in construction of civil, earthworks and road works. An example of key safety requirements is listed below. Before commencing work safety risks should be identified and eliminated or managed, including briefing of all workers. An example of key safety recommendations is below:

- Minimise work around earthmoving equipment and vehicles. Authorised people only in the vicinity of equipment and safety briefing of all operators.
- Minimise excavation depths and provide embankment stabilisation for all excavations of over 1 metre deep. Do not keep deep excavations open overnight and supervise all open excavations.
- Consider safety of the community when selecting the location of roads. Avoid busy pedestrian areas. Encourage responsible driving.

Potential Steps in the Construction Process

Potential steps in the construction process for civil and earthworks are detailed below, focussing specifically on construction of a road.

Step 1 – Site Clearing and Grubbing

Site clearing is the first operation to be carried out during construction. It consists of all preparatory activities before excavation and fill works commence for the road formation and drainage structures. Clearing is carried out covering the entire site area. In general, it can include the following tasks:

- Bush clearing;
- Tree and stump removal;
- Grubbing (removal of roots, grass and other light vegetation);
- Topsoil removal; and
- Boulder removal.

Step 2 – Earthworks and Road Formation

The first step in the development of the earthworks is to establish a level sub-base on which the roads can be built. This involves excavation and fill works to achieve the design levels. Fill works must be built up in well-compacted layers.
Once the level sub-base has been developed, side drains are installed. Materials from the side drain excavation are then used to develop the road formation (camber or crossfall). This formation also requires compaction.

**Step 3 – Drainage**

The next step in the construction process is to install the drainage. Water is the main contributor to the wear and damage of low-volume roads. This damage can be reduced if the flow of water is controlled, so ensuring sufficient site drainage is crucial.

The drainage installation includes culvert laying and water-crossing construction such as foot bridges and box culverts.

**Step 4 – Road Pavement and Surface Finishing**

The final step in the construction is to add the road pavement or finished surface. There are several types of finishes available (refer to the Technical Appendix for surfacing design information).

*Hand-packed Stone*

Construction of hand-packed stone surfacing includes placing natural stones on a sand or gravel bed with the top stone surface set to the final cross fall level. Large stones are packed together with smaller stones hammered into place. The surface is then blinded with a gravel/sand/clay mixture and the finished paving is compacted by roller.

*Clay Brick or Concrete Block Paving*

The construction of paving using burnt clay bricks or concrete blocks consists of laying the bricks on a layer of clean sand on the road base. This pavement has a load carrying capacity, is durable and can be upgraded to asphalt standard.

*Surface Dressing*

Surface dressing consists of a thin film of bitumen applied mechanically or by hand onto the road surface (well compacted gravel base course) and covered with a layer of stone chipping, then lightly rolled. Used as an initial surface for a road pavement. Multiple coats may be applied.

This method can also be applied to upgrade stone, brick and block pavements.

*Gravel Surface*

For a gravel road surface, a compacted gravel layer is added onto the base course. The gravel must be an approved material.

A gravel surface finish is more maintenance intensive than the other pavement options, and is therefore not the best alternative for urban areas. However, it is often the only affordable option available within the vicinity of the site.
Quality Control

Quality control is an important part of the construction phase. During road construction, some tests to ensure quality control include road dimension tests to measure the completed works, road profile tests to measure the completed base and surface layer, gravel source tests to check the suitability of a gravel source for base or surface layers and gravel layer tests to confirm thickness and degree of compaction.

Safety

Safety is the primary consideration for any construction works. Some basic, essential safety measures can include personal protective equipment such as:

- On-site first aid kit;
- High-visibility (yellow/orange) vests for labourers;
- Protective goggles for stone cutting, chiseling, grinding, and welding;
- Gloves for handling chemicals, waste and other hazardous materials;
- Face masks when working in dust and smouldering waste; and
- Helmets when working on sites where there is a danger of falling objects, e.g. in deep drains, digging pit latrines, work in quarries, etc.

The Site Supervisor should also know where the nearest hospital / clinic is and where an ambulance or quick transport can be found. It is also advisable that the Site Supervisor has first aid knowledge.

Special safety measures are required when deep trenches have to be dug, for example for culverts or structures. The space is often restricted and it is not possible to dig trenches with safe slopes. Depending on the material (natural soil slope) and the depth of the trench, strutting may be required to avoid collapsing trench sides. The construction of strutting has to be done carefully and requires experience builder.

For road construction, whenever work is being carried out on or close to the carriageway, adequate measures have to be taken to warn and protect both road users and workers by ensuring that:

- the necessary temporary traffic signs and protection are provided and correctly located on site for the duration of the work;
- all equipment and vehicles are parked off the carriageway or behind protective barriers and signs, when not in use;
- no material is to be left in a dangerous location and that the road adjacent to the work site is kept clean and swept of any debris arising from the work;
- all excavations are protected for the benefit of all road users, equipment and workers;
- all operators are trained in the operation of their equipment;
- operators and labourers are informed of the potential risks of and procedures for working with or close to machinery;
• traffic control operations are carried out properly and that road users are not unnecessarily delayed;  
• where work on the carriageway or shoulder remains unfinished overnight, then proper warning lights re to be arranged and, if necessary protected; and  
• all sites are to be left tidy and cleared of debris when the work is completed.

Traffic Control

Wherever possible, diversions should be established so that traffic can be directed away from the road section under rehabilitation or regravelling. Properly installed road signs, which clearly show the diversion, are essential and the road or road section under work needs to be blocked by adequate barriers and signals.

After the diversion has been completed and before work starts, warning signs, barriers and cones must be placed around the work area.

However, very often it is not possible to divert traffic as the road network is not dense enough and the construction of diversions is too expensive. Therefore, roads are to be kept open to traffic. Work should be carried out on one side of the road at a time allowing traffic to pass on the other. Before work starts, warning signs, barriers and cones must be placed around the work area.

Common Tools

The following table outlines some common tools for labour-based road and civil works.

<table>
<thead>
<tr>
<th>Common Tools Used for Labour-based Road Works</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearing</td>
</tr>
<tr>
<td>bush clearing</td>
</tr>
<tr>
<td>grass cutting</td>
</tr>
<tr>
<td>tree and stump removal</td>
</tr>
<tr>
<td>grubbing</td>
</tr>
<tr>
<td>boulder removal</td>
</tr>
<tr>
<td>Earthworks</td>
</tr>
<tr>
<td>excavation</td>
</tr>
<tr>
<td>hauling</td>
</tr>
<tr>
<td>spreading</td>
</tr>
<tr>
<td>compaction</td>
</tr>
<tr>
<td>Gravelling</td>
</tr>
<tr>
<td>excavation</td>
</tr>
<tr>
<td>spreading</td>
</tr>
<tr>
<td>Setting Out</td>
</tr>
<tr>
<td>line level, ranging rod, profile board, measuring tapes, axe, hammer, chisel, string and pegs</td>
</tr>
</tbody>
</table>

For certain construction activities involved with roads and civil works, particularly hauling of materials and compaction, high labour productivity and good quality of work can be difficult to achieve using only manual labour and hand tools. In such cases, using light construction equipment can increase the efficiency of work.
v. Electrical supply

This section of the document outlines potential key considerations in implementing a finalised design. The scope of this document is to simply provide an overview and should not be taken as an exhaustive guide.

Grid Connection Considerations

Key considerations when connecting to electricity grid are:
- Prevent malpractices such as by-passing electricity meters. Therefore it is recommended to ensure installation of electric meters in a secure location.
- Easy access must be provided to electricity provider to collect meter readings.
- Clearances must be maintained from electrical overhead lines as per electricity provider rules and requirements. This may involve relocating or removal of structures and vegetation around overhead wires.
- Engaging electrical contractor for wiring up to the electricity provider’s point of connection and within households.

Safety Considerations

It is highly recommended that all electrical design and construction works be carried out by qualified persons. Unsafe electrical installations can lead to fires that can cause damage to property and persons, fatalities due to electrical shock among others.

The following items may be included in a checklist of discipline specific safety considerations:
- Are construction site switchboards properly constructed and set up?
- Are circuit breakers fitted to design specification?
- Is construction wiring of quality and installed to be protected from mechanical damage and away from heat and water sources?
- Are flexible extension leads being used safely?
- Are the correct types of socket outlets being used?
- Are electrical tools and flexible extension leads in a safe condition?

Construction Considerations

Provision of a site supervisor able to be a technical overseer. The person in charge would be responsible for the following:
- To ensure that the project conforms to engineering design and acceptable quality of electrical equipment such as circuit breakers, electrical cables and wiring quality. Raising defects where this is not the case.
- To ensure that the project is delivered to the users satisfaction.
- To ensure that during the process of construction, the environmental and safety considerations conform with the relevant codes and practises.

Provision of technical overseer to be involved during commissioning of electrical system. The responsibilities and competencies of this person would include:
- Ensuring electrical equipment is energized in a safe manner;
- Ensuring equipment works to its specification;
- Creating and carrying out testing procedures;
- Troubleshooting;
- Liaising with project engineers
- Training maintenance and operative staff as required.

Common issues with electrical construction:
- Poor electrical wiring usually bunched up in an unorganised fashion. Good quality wiring that conforms to safety standards is vital for safety. Poor wiring can increase chance of fire, power surges and other serious consequences.
- Substandard electrical equipment such as circuit breakers being used instead of ones procured;
- Unsafe practice of using “nails” instead of fuses to cut costs.
- Installing electrical cables near water pipes or a source of heat.

Contractor Selection Considerations

Key considerations in selecting electrical construction contractors and technical overseer,
- Previous experience in similar projects.
- Technical proficiency and/or qualifications.
- Health and safety documents.

General Discipline Specific Considerations

Transformers
Transformers are the most expensive element of any electricity supply project. Transformers contain large volumes of mineral oil which could be highly toxic if leaked to the surrounding environment. Thus, appropriate handling practices should be observed during maintenance and installation of these equipment.

Regular inspection checks

Equipment in an electrical supply installation should be subject to regular condition assessment checks. Ambient conditions, loading levels and attack from pests could hamper the useful life of the system components.

Equipment and personnel protection

Protection to personnel and equipment in electrical installations are provided through Circuit Breakers (CB) and Earth Leakage Circuit Breakers (ELCB). It is vital that every household in the community have their own CB and ELCB.

In addition to providing safety, these devices also help isolate parts of the system which can help immensely during troubleshooting faults in the system.
<table>
<thead>
<tr>
<th>Model</th>
<th>Description/ Key Considerations</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal connection to grid.</td>
<td>Establishment of a formal connection to the electricity grid. Operation and maintenance to the Point of Connection or PCC.</td>
<td>Reliable electrical supply at a minimum cost.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance of electrical equipment such as wiring and circuit breakers beyond this point is the responsibility of the customer.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing local informal electricity provider engagement</td>
<td>Outsourcing the operation and maintenance to an existing informal electricity provider.</td>
<td>Ensures that the equipment is operated and maintained in an optimal fashion.</td>
<td>The installation would be run in the operator’s best interests over those of the community.</td>
</tr>
<tr>
<td></td>
<td>Incentives for efficient operation and maintenance of electrical infrastructure.</td>
<td></td>
<td>Tariffs might be higher as the operator would be passing on the overhead costs to the customers.</td>
</tr>
<tr>
<td>Local community operator and maintainer</td>
<td>Local person from the community is responsible for operation and management of the electricity infrastructure.</td>
<td>Low overheads</td>
<td>TBC</td>
</tr>
<tr>
<td></td>
<td>Community technical capability development.</td>
<td>More sense of ownership of the electrical assets by the local community as someone in their own community operating it</td>
<td></td>
</tr>
<tr>
<td>House No.</td>
<td>Name of HH head</td>
<td>N. of family members</td>
<td>Main Occupations</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------</td>
<td>----------------------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# FORM 2: MARKET MATERIALS SURVEY

## DATE OF SURVEY

**SURVEYED BY**

<table>
<thead>
<tr>
<th></th>
<th>Shop 1</th>
<th>Shop 2</th>
<th>Shop 3</th>
<th>Shop 4</th>
<th>Shop 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Address</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contact person</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contact phone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## PART B: COSTS OF MATERIALS

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit</th>
<th>Quantity</th>
<th>Price per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>shop 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shop 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
## FORM 3: BILL OF QUANTITIES (BOQ)

<table>
<thead>
<tr>
<th>Material/Labour</th>
<th>Unit</th>
<th>Quantity</th>
<th>Cost per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administration fees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>Unit</td>
<td>Quantity</td>
<td>Price per unit</td>
</tr>
<tr>
<td>----------</td>
<td>------</td>
<td>----------</td>
<td>----------------</td>
</tr>
<tr>
<td>(e.g. cement)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal**

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Unit</th>
<th>Price per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g. wood)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal**

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Unit</th>
<th>Price per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g. iron sheets)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal**

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Unit</th>
<th>Price per unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g. WC)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Subtotal**

**TOTAL COST**
<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>FORM 5: COST ESTIMATION FOR HOUSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALLS</td>
<td></td>
</tr>
<tr>
<td>FOUNDATIONS</td>
<td></td>
</tr>
<tr>
<td>ROOF</td>
<td></td>
</tr>
<tr>
<td>TOILET</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Cost</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Materials:</td>
<td></td>
</tr>
<tr>
<td>Labour:</td>
<td></td>
</tr>
<tr>
<td>Administration fees:</td>
<td></td>
</tr>
<tr>
<td>Transport costs:</td>
<td></td>
</tr>
<tr>
<td>Interest rate (for loan):</td>
<td></td>
</tr>
<tr>
<td>Storage costs:</td>
<td></td>
</tr>
<tr>
<td>Total Cost</td>
<td></td>
</tr>
</tbody>
</table>