Community engagement (UNICEF/Angola/2024/Jkiala)

TECHNICAL GUIDE TO SUPPORT THE DEVELOPMENT OF SIMPLIFIED SEWAGE COLLECTION SYSTEMS

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BRAZILIAN DELEGATION OF THE ANGOLA 2022 MISSION

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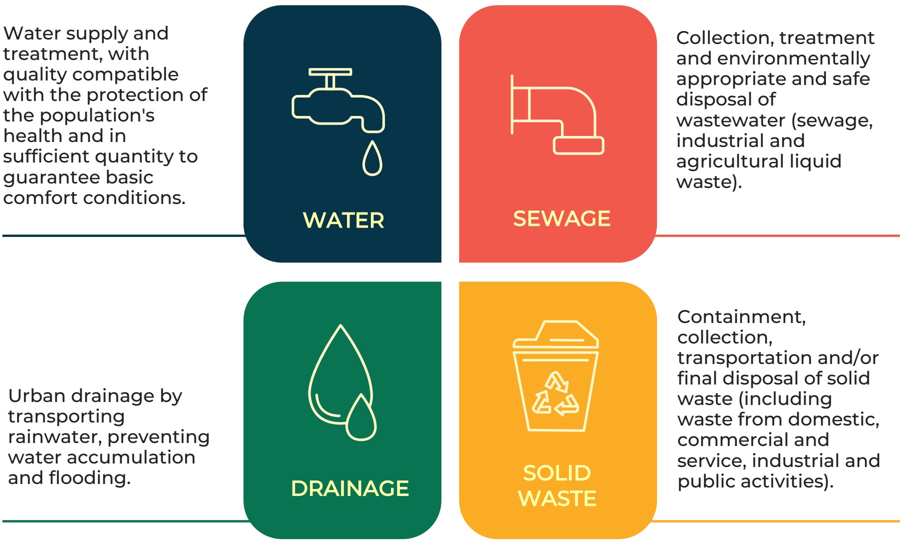
SUMMARY

I. BACKGROUND

The World Health Organization (WHO) defines sanitation as the control of factors of the physical environment of human beings, which exert or may exert harmful effects on physical, mental and social well-being.

According to the Brazilian plan PLANSAB (Brazilian Plan for Basic Sanitation, acronym in Portuguese), sanitation is the set of services and infrastructure for water supply, urban cleaning and solid waste management, sewage and urban rainwater drainage. Figure 1 discriminates these four major areas and their definitions.

Figure 1: Overarching areas of sanitation and their definitions.



With the understanding of the importance of sanitation, both for health and for the development of societies, various techniques have been proposed throughout history in order to improve the cost-effectiveness of building, operating and maintaining the related structures.

Specifically with regard to sewage collection, the aim of which is to “remove the wastewater collected from homes and transport it to a suitable location (treatment)”, in line with the urban planning of large cities, the most suitable solution used in this sub-theme has been Conventional Sewerage, which conceptually isolates domestic sewage from that which comes from other sources (industrial, for example) and from rainwater, and transports it using gravity to the place destined for treatment.

Historically, the demand for improvement of concepts, techniques and equipment applied to the implementation of a Conventional Sewage Collection System is associated with the search for local solutions, traditionally in developed countries, which are often associated with the premise of "cost-benefit in planned cities".

When it comes to cities/regions with "poor planning" (a common reality in countries of the Global South), there are a number of challenges associated to the implementation of Conventional Sewarage. In practice, these challenges tend to increase costs exponentially. In many cases, implementation becomes impossible and basic Sanitation may even be removed from the priorities of Government budgets.

In this context, at the beginning of the 1980s, an R&D group from CAERN (Companhia de Águas e Esgotos do Rio Grande do Norte), in partnership with specialists from UFRN (Federal University of Rio Grande do Norte, acronym in Portuguese), developed the concepts of Condominial Sewerage, testing it effectively in two low-income areas of the city of Natal, the capital city of that state.

Compared to Conventional Sewerage, the experience in Natal showed the same effectiveness (wastewater conveyance), but at a considerably lower cost, attracting the attention of researchers and government officials, particularly those involved in sewage collection solutions in developing countries.

With the further development and universalization of studies in the following decades, the term condominial sewerage was replaced with the term: Simplified Sewerage.

In the next chapter, the Conventional Sewage Collection System will be presented in more detail, emphasizing its characteristics and its differences from the Simplified Sewerage.

II. CONVENTIONAL SEWERAGE

1. Concepts

Conventional Sewage Collection System can be defined as "a set of pipes and structures that make the connection, through gravity, between the generating units (residences) and the treatment (or lifting, if applicable) units". This system can be subdivided into the following elements:

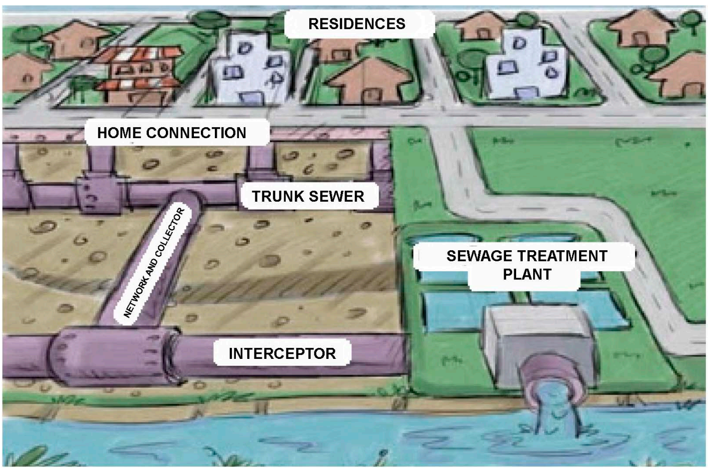
1. **Home connection** - set of pipes, parts, connections and devices, dedicated to making the connection between the private sanitation environment of the home and the public sewage collection system (basic network).

2. **Basic (collection) network** - subdivision dedicated to receiving sewage contributions along its length, usually with pipes with diameters less than 250 mm.

3. **Collector** - subdivision with the purpose of conducting larger flows more efficiently, with the premise of receiving contributions only from other collectors (basic network).

4. **Interceptor** - subdivision with the function of absorbing maximum flows, usually allocated along watercourses, springs, or the coast.

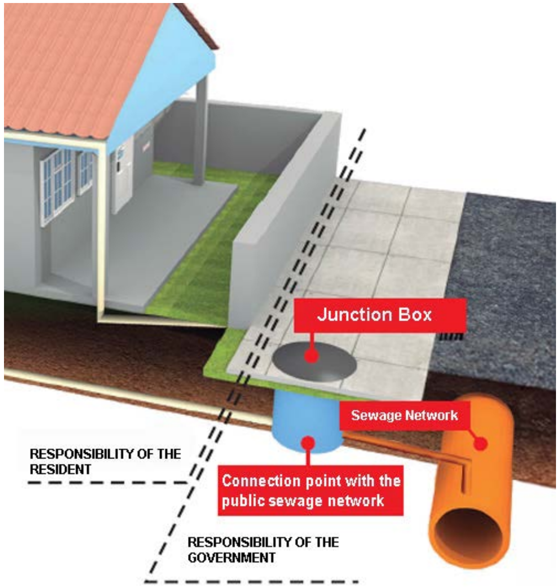
Figure 2 shows the layout of Conventional Sewerage elements.



It is worth noting that the home connection is preceded by an element defined as the **Junction Box**, whose conceptual importance lies in the fact that it separates responsibilities, namely:

- "from the Junction Box", the project, execution and maintenance are the responsibility of the Government; and

- "up to the Junction Box", all the responsibility falls on the resident



2. Project

Sizing Conventional Sewerage consists of objectively defining the allocation of pipe sections and manholes, taking into account hydraulic (flow, diameter, slope) and maintenance (cleanliness, safety) requirements, always seeking the best cost-benefit ratio.

In Brazil, the ABNT NBR 9649:1986 standard determines the conditions for designing a Sewage Collection Network Project (popularly known as Conventional Sewerage), such as minimum depth, minimum slope, minimum diameter and maximum speed, taking into account general aspects of the Brazilian reality, such as per capita consumption and climate.

With regard to the stages for preparing a Sewage Collection System project, which includes the Collection Network project, there is no universal roadmap that can be applied to any situation, and it is up to local governments, based on their experience, to define the flowchart to be carried out.

Below is another proposed roadmap to be analyzed:

1. Population Studies - survey and analysis of information related to the population to be served by the system to be designed. One of the products of Population Studies is the efficient definition of the project's coverage area.

2. Flow Studies - survey and analysis of the consumption patterns of the population to be served, allowing calculation of the flow to be collected/treated and its variability over time.

3. Topographic Studies - survey and analysis of information related to the land that will receive the system, notably streets, slopes and land occupation, having an influence on hydraulic calculations and consequently on the total cost of the work.

4. Treatment Plant - definition of the technology to be used and the design of the buildings and equipment that will make up the treatment plant.

5. Collection Network - definition of the path and depths of the pipes, as well as the allocation of manholes and equipment.

6. Budget - Survey of the quantities and costs of execution of the work.

7. Auxiliary Documents - expropriation memorial, Operation Manual.

Social work mitigates inequalities, offers opportunities and guarantees basic rights to citizens, contributing to the construction of a fairer and more equitable society. It is operationalized in different social policies, but needs to be thought of in a comprehensive, articulated and total perspective with and for the territory of action.

3. Challenges

In peri-urban regions of developing countries, it is common to find areas with a high population density living with the lack of consistent urban planning.

Once the option of relocation of the population is waived, in order to obtain good service rates with the implementation of a Conventional Sewage Collection System, the following is required:

- the opening/widening of roads, in order to allow the flow of vehicles for the execution of the work, and for maintenance of the system;

• significantly deeper networks, in order to compensate for the non-use of the natural fall of the land, usually occupied by private land;

• the multiplication of pumping stations, when the option of deepening the network is excessively onerous.

Figure 4 shows a typical image of a Conventional Sewerage construction site; the challenge of replicating the execution techniques in this image in peri-urban areas is clear.

Figure 4: Construction work for the implementation of Conventional Sewerage

As mentioned in the previous chapter, it is not uncommon for all these actions to make the implementation of this collection system model extremely expensive, sometimes making it unfeasible, or to the removal of Basic Sanitation from the Government budget priorities.

Finally, this context leads to the consideration of the Simplified Sewage Collection System as an alternative.

The next chapter will look at some of the concepts that guide the Simplified Sewerage .

III. CONVENTIONAL SIMPLIFIED SEWERAGE

1. Concepts

Based on the literature, it can be said that there is NO concept that summarizes the knowledge necessary for the design of a Simplified Sewage Collection System, nor a single application formula.

For the purposes of this Manual, the following description is used:

Domestic sewage collection system by gravity for small flows, collectively designed for a better constructive and economic solution, adapted to the needs, perspectives and local context.

In this concept, certain elements stand out:

• “collectively conceived” implies a unity of thought arising from a series of conversations and a common desire;

• "adapted to the needs” speaks of an environmental awareness of the importance of sanitation;

• "... to the perspectives” indicates the knowledge and ability to select from possible sanitation solutions; and

• "... to the local context” translates the particularity of the solution adopted, associating it directly with the interests of the beneficiaries.

The premise is an ideal partnership between the government and an engaged and environmentally conscious local population. In this partnership, the design, execution and management of sewage collection must be transferred to the community.

In order to realize this premise and achieve its sanitation objectives, the government places itself in a position of responsibility for empowering, facilitating and supporting residents' decisions, concentrating its efforts on promoting and maintaining this partnership as close to the ideal as possible.

2. Project

Similar to Conventional Sewerage, the Simplified Sewage Collection System consists of a set of pipes and structures, sized to meet hydraulic and maintenance requirements, sending wastewater to its destination.

Within Simplified Sewerage, the structures that interconnect the pipes are called Drain Boxes.

As for the size of the system, the following distinctions are made:

- **Small Systems**

In small systems, in which the maximum flow collected in the entire Q1 network is less than the maximum flow capable of being conducted with the minimum diameter Q2, the Simplified Sewerage must empty into a projected Treatment Plant (sump, for example), and its sizing resembles that of the collection network of a residence.

- **Hybrid Systems**

Taking on the task of supplying higher flows also increases the risk of possible overflows caused by obstructions in the network, as well as the complexity of the interventions to be carried out to maintain it.

In this scenario, the premise of transferring responsibilities to residents can cause more inconvenience than benefits, making it difficult for larger systems to be sustainable.

Thus, as the proportions of the system increase, the project must evaluate the application of a Hybrid System, dividing the entire Region served into smaller areas, similar to condominiums.

Internal to each area, an independent Simplified Sewerage will be indicated, which will be able to drain the entire area at a single point; this point is conveniently referred to as the Junction Box.

Each area, through its respective Junction Box, will drain into a Conventional Sewarage system which will conduct all wastewater collected in the Region to the projected treatment plant.

Again similar to Conventional Sewerage, the Junction Box can be used as a point of separation of responsibilities, namely:

- up to the Junction Box, Simplified Sewerage managed by residents; and
- from the Junction Box, Conventional Sewerage managed by the Government.

3. Advantages and Challenges

As advantages of the implementation of Simplified Sewerage, we can list:

- **Lower cost** - since the low flow volumes allow the adoption of smaller diameters, as well as the non-use of traffic routes, it allows the adoption of less robust (and less expensive) structures.

- **Faster completion** - consequence of the shorter time required to define the project, and the multiple work fronts at the time of execution.

- **Social Development** - Strengthening the local economy, timely in the selection of construction materials and labor.

In addition to the hydraulic solution, the effectiveness of the implementation and, above all, the maintenance of the Simplified Sewerage depend heavily on two other pillars, which overlap and support each other: community engagement and environmental education.

On the one hand, since the system's pipes sometimes have to pass through the private areas of residents' homes, they need to agree to this knowingly, and even consider giving up part of their privacy for the sake of the system's efficiency.

The government is therefore faced with the challenge of continuously promoting and strengthening these two pillars, which should guide government planning in the area of sanitation (wastewater), including the identification of needs, the allocation of resources and the schedule of activities.

It is worth noting that in the literature there are several cases of failure in the implementation of the Simplified Sewerage; in these, the causes invariably converge on two points:

1. a low rate of environmental education of residents, demonstrated mainly by the deposit of inappropriate objects in sanitation facilities, and the infiltration, purposely or not, of rainwater into the network;

2. a lack of desire to collaborate with the defined solution, seeing more inconvenience than benefit in the attribution of maintaining the system, a situation that generates conflicts both within the community and with the Government often with the request for the Government to take on the responsibility of maintenance.

These highlights serve to show the importance of Community Engagement and Environmental Education policies in the daily life of the community to be benefited, using strategies such as: awareness seminars, school competitions, public events, etc.

Figure 5: The inclusion of content related to Environmental Education in schools is one of the main tools for changing the attitude of the community.

The next chapter explains the different aspects of the preparation of a Sewage Macro-plan, considering the implementation of the Simplified Sewerage techniques.

IV. MACRO-PLAN

In order to draw up a Sewage Macro-Plan for a given city/town, after assessing the size of the system (population studies), the following should be indicated:

- the treatment plant(s) (and pumping, if necessary);
- the Conventional collection sections; and

The design and dimensioning of the Plants and the Conventional Collection Network follow the theory studied in universities, and are note covered in this manual.

The details of the hydraulic project of the Simplified Sewage Regions can follow the roadmap below:

1. Fragmentation of the region into areas
2. Meeting with residents
3. Project Design

1. Fragmentation of the Region into Areas

1.1. Concepts

The main objective of this stage is to better manage the processes by grouping residents into smaller parcels, which are consequently less complex to administer, known as Simplified Collection Areas.

Conceptually, as a result of fragmentation, each area will be treated separately. Thus, despite the similarities, the project must take into account that the decisions of the residents of a given area are influenced by the reality within that area, regardless of the neighboring areas, even if they are nearby.

Therefore, decisions such as the best solution for routing the networks, the ideal location for the Junction Box, the materials to be used, and the work regime for maintaining the system, can be different from one area to another.

1.2. Sizing

Of strategic importance at this stage, the definition of the boundaries of the areas initially seeks to meet two criteria:

• **Hydraulic** - the limits of the area consider a limit size of the population, and consequently of the flow to be collected, which cannot be higher than the maximum flow capable of being conducted with the minimum diameter in all sections within the respective area; and

• **Logistics** - considering that the decisions of residents internal to an area impact the residents of the respective area, a population size limit will also reduce the likelihood of conflicting interests in decision making, as well as the impact they may have.

It is worth noting that there is no numerical limit or indication for the area dimensions to be adopted, respecting the peculiar characteristics of each Region.

Thus, in addition to the flow studies conducted by the engineering team, a social work stage should be part of the Macro-plan, with the aim of evaluating the natural subdivisions of that region in the field, indicating the best way to fragment it.

EXAMPLE

Figure 6 shows a fictitious map which will be used to exemplify the process of fragmentation of areas.

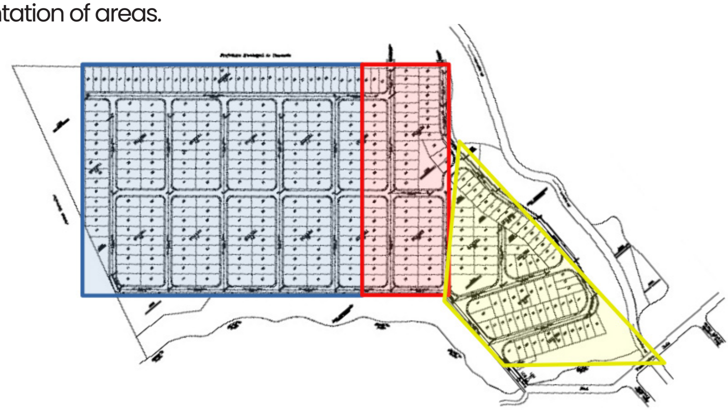


Figure 6: A fictitious example of Area fragmentation.

1. In a survey of social work, three ethnic groups occupying the region were identified, each concentrated in the indicated areas.

2. The flow study showed that both the red and yellow areas have maximum flows lower than that capable of being conducted with the minimum diameter, but the blue area has a higher flow (precisely 2.5 times).

Thus, considering the two studies of the previous paragraphs (in addition to the natural fall of the land not presented here), it was decided to create five simplified collection areas in this region, as represented in the map in figure 7, each with its junction box that will later flow into the projected Conventional Sewerage.

Figure 7: Solution proposed for fragmented areas.

Finally, it is worth noting that there is no impediment to indicating areas of different configurations and sizes, as long as they effectively meet the two criteria mentioned, and possibly others that the managers of this stage may deem important in addition to the observations in this Manual.

1.3. The Basic Project

Once the simplified collection areas have been identified, the Macro-plan must contain an "initial proposal" of its elements. In other words, as well as pointing out a solution for the conventional network and the plants, it should also indicate an alternative route for the simplified network for each simplified collection area.

This proposal is called the Basic Project. For Simplified Networks, the Basic Project must be developed with a level of detail and precision that allows the residents to be assessed, including an estimate of costs (parameterized).

The sizing of the Simplified Networks will be discussed in section 3 of this chapter.

In the next step, among other actions, the section of the Basic Project related to area "X" must be presented and discussed with "the residents of area X", in order to define whether the initial proposal prepared by the Government is in fact the best and should be executed, or what improvements can be made.

2. Meeting with residents

Once they have the Basic Project, and are aware of a satisfactory level of community engagement and environmental education among the residents, the managers of this stage should bring them together to collectively define, for the interior of their respective area, topics such as:

What is the alternative to be used?

What is the route of the network?

Who will execute the work?

Who will operate the system?

How will the cost of the work/maintenance be paid? And etc.

In addition to the presentation of the Basic Project, the dynamics of the meeting should encourage residents to give their opinion on the proposal, commenting on facts, present and future, which may not have been considered or updated, discussing more realistic and/or economical alternatives.

2.1. Alternative Routes

The layout of the Simplified Networks can use four alternative routes, and the parameters for choosing can be summarized in the following three ways:

• **feasibility** - whether the configuration of the houses and the slope of the land allows us to consider such an alternative or not;

• **convenience** - when comparing viable alternatives, the homeowner feels more comfortable with a given alternative; and

• **cost** - although feasible and minimally convenient, the cost of an alternative influences the final choice.

The following are the alternative routes for Simplified Networks:

• Through the road (alleys)

Among the alternatives, it is the one that provides the least disruption with works/maintenance, minimally invading the private routine of residents; however, it may require measures to protect the structures against the probable overloads of traffic, present and future, making it a more expensive option.

• Through the sidewalk

This alternative avoids traffic overloads, but poses challenges for road crossings. In addition, depending on the configuration of their homes, residents may be resistant to aesthetic interventions on their sidewalks. The cost of reconstruction may also be a concern.

- **Through the garden**

If the configuration of the plots allows for this alternative, it is generally the most economical; however, as it enters the residents' private environment, they may be reluctant to allow access to their gardens, especially when considering the inconvenience caused by possible overflows.

- **Through the yard**

Topographical studies may indicate this alternative as the most economical; however, it is expected to be met with greater resistance from residents, both in terms of allowing access for maintenance and the consequences in the event of overflows. Invariably, this resistance has led to reduced monitoring of misuse of the network.

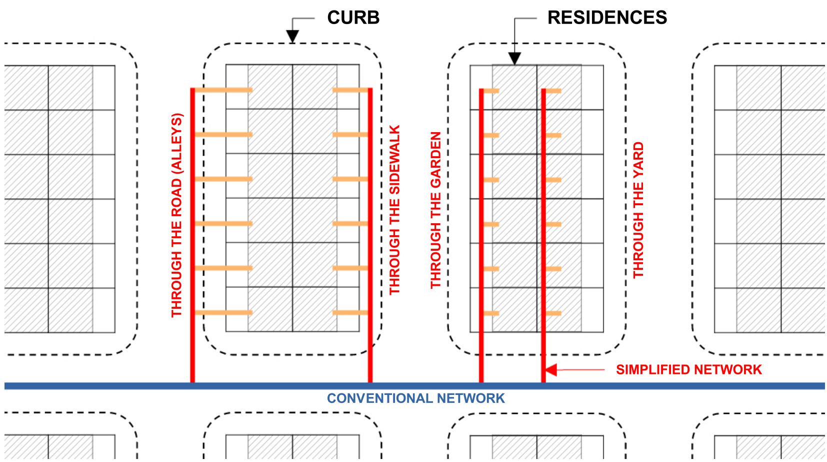


Figure 8: Provision of alternative routes for Simplified Networks.

2.2. Cost survey

The Basic Project of the internal network to an area must present to the interested parties the estimated costs with the work and with the maintenance of the recommended solution

The **costs of the work** include: acquisition and laying of pipes and connections, acquisition/construction of drain boxes, cost of labor (in the case of contracting), demolition and reconstruction of pavement/flooring.

Maintenance costs include: acquisition of appropriate maintenance tools and equipment, acquisition of spare parts/material, cost of labor (in the case of contracting), estimate of the periodicity of services.

In addition to the cost of the option indicated in the Basic Project, the parameterized costs of the other alternative routes must be surveyed, so that, if there is more than one viable alternative, the population can financially evaluate the most convenient option.

2.3 Definition of duties

With regards to the Management Model, which summarizes the duties and responsibilities for the construction and maintenance of the Simplified Sewage Collection System, there is no single rule of application, and it is up to the managers to propose and together with the population define the model to be adopted.

As mentioned above, the ideal model indicates government responsibilities from the Junction Box onwards, and before that - in other words, inside the areas - the design, construction and maintenance are the responsibilities of the residents of the respective area, who need to be fully qualified for such tasks, and always under government supervision.

However, considering the reality of the residents after all the efforts to promote community engagement and environmental education, in order to maximize the system's adherence and effectiveness, the government should consider incentives for the population to achieve this goal, generating models suited to the local culture and the reality of the Region.

Finally, regarding the independence of the Simplified Collection Areas, the managers of this stage must evaluate the practicality of the variability of the allowed model options: a single model for all areas; or a single model for areas in the same Region; or options indicated for selection by residents; or unrestricted freedom in choosing the model, etc.

The following are situations that may occur and some actions that can be incorporated into the Management Model by subject:

- **Execution of the work**

The population may understand that "it is not able/available to perform the work". To get around this situation, the following actions can be taken: training programs in construction-related techniques offered by the government; the appointment of a resident, whether previously trained or not, to execute the entire network in the respective area; the hiring of a person/company from outside the area to execute this service.

- **Maintaining the network**

Similarly, related actions can be taken if the population understands that "it is not able to perform the system maintenance services", such as proposing courses by the Government, assigning a qualified resident, or drafting a contract for the provision of this service.

- **Financial investments**

The population may argue that "they do not have the financial capacity to afford the work". Initially, the Government must assess the percentage of residents who are affected by this situation. Based on this information, the Government will be able to plan actions such as financing lines, social incentives, social programs, etc., without losing sight of the social justice and sustainability of the model to be adopted.


Community engagement (UNICEF/Angola/2024/Jkiala)

Figure 9: Meeting with the residents of the Mulenvos community to implement the simplified sewage system.

2.4. Manual of Conduct

The Manual of Conduct refers to the policy on residents' rights and duties in relation to the Sewage System, in particular, considering the level of participation of residents who are served by the Simplified Sewerage, it should include topics to reinforce environmental education and community engagement, as well as issues such as legal actions, labor rights, decision-making panel, etc.

Although the government is responsible for drafting the Manual of Conduct, meetings with residents seem to be a unique opportunity to collect information and opinions, generating a more appropriate and realistic text.

2.5. Closing

If there is no consensus at a first meeting with the residents of area X, new meetings should be scheduled, spaced out over an appropriate period of time to allow for reflection.. At these new meetings, the residents will have to discuss the pending issues, until they define the route of the Simplified Network that will actually be carried out, known as the Executive Project.

After the definition of the Executive Project of all Simplified Networks, the Macro-plan should be revised. In fact, given the possible changes in the flows generated by the Simplified Collection Areas and in the depths of the Junction Boxes, the need to recalculate the diameters and depths must be evaluated, both in the Basic Network (Conventional) and in the plants.

The Executive Project should also include instructions for carrying out the work (including in the Simplified Collection Areas) summarized in an Execution Manual, indicating construction techniques for the Simplified Network to residents, such as: opening/closing trenches, leveling, transporting/storing pipes, tools used, protective equipment, etc.

3. Executive Project

Although the low flow seems to dispense with greater technical rigor in the specific dimensioning of a Simplified Network (similar to a residential collection network), this is recommended so that there is a documented memory, and to provide input for the definition of local parameters and control of works.

It is understood that only on the basis of experience and the promotion of specific research will the government have the basis to define the level of rigor needed to update this Manual.

The fundamentals and calculations used in the Simplified Network project are presented below.

3.1. Brazilian Standard

As mentioned earlier, the sizing of Simplified Networks is in no way different from the sizing of Conventional Networks. Thus, based on the Brazilian standard ABNT NBR 9649:1986, the hydraulic sizing of the network must observe the following considerations:

1. For ALL sections of the network, the initial and final flows (Qi and Qf) must be estimated. It is recommended that, in any section of the collection network, the lowest flow value to be used in the calculations is equivalent to an instantaneous peak flow resulting from the flushing of the toilet (in Brazil, 1.5 L/s).

2. The commercial diameter to be used is DN 100, smaller diameters will NOT be accepted (and larger diameters should be avoided - a parameter not included in the standard).

3. The minimum slope must be checked using the average tensile stress criterion of minimum value ct = 1.0 Pa, calculated for initial flow Qi and Manning's coefficient n = 0.013. The minimum slope I0, minimum that satisfies this condition can be determined by the approximate expression:

$$I_{0,mín} = 0.0055 \times Q_i^{-0.47}$$

being I0,min in m/m and Qi in L/s.

4. The maximum permissible slope is that for which there is a (maximum) flow velocity v = 5 m/s. When the final velocity vf is greater than the critical velocity vc, the greatest admissible slope should be 50 % of the collector diameter, ensuring ventilation of the section; the critical velocity is defined by:

$$v_c = 6(g \times R_H)^{1/2}$$

where g = gravity acceleration (9.80665 m/s2) and RH the hydraulic radius of the pipe section in m.

5. The water depths must always be calculated assuming uniform and permanent flow, with the maximum value calculated for the final flow Qf equal to or less than 75% of the diameter of the collector.

6. The Drain Boxes (as well as the Junction Box) shall be designed so that the water level elevation at the exit is above any incoming water level elevation

3.2. Data for Sizing

The input data for calculating the Sewage Network obtained empirically or by estimation (future data) will be presented below:

- C - return coefficient defined as the average ratio between the volumes of sewage produced and water actually consumed (-)
- Pi - initial population (inhab)
- Pf - final population (inhab)
- qi - initial per capita contribution (L/inhab.day)
- qf - final per capita contribution (L/inhab.day)
- ki - maximum daily flow coefficient (-)

$$k_1 = \frac{k\_Maximum\ daily\ flow\ in\ the\ period}{Average\ daily\ flow\ in\ the\ period}$$

- k_2 – maximum hourly flow coefficient (-)

$$k_2 = \frac{Maximum\ hourly\ flow\ on\ the\ day}{Average\ hourly\ flow\ on\ the\ day}$$

- L – network length (km)
- Tinf – infiltration contribution rate (L/s.km)

3.3. Flow Rates

Qinf – Infiltration contribution (L/s)

$$Q_{inf} = L \times T_{inf}$$

Qi – Initial flow of a section of the network (L/s)dfgd

$$Q_i = k_2 \times \frac{C \times P_i \times q_i}{86{,}400 + Q_{inf}}$$

Qf – Final flow of a section of the network (L/s)

$$Q_f = k_1 \times k_2 \times \frac{C \times P_f \times q_f}{86.400 + Q_{inf}}$$

3.4. Pipe Diameter

Given by Manning's formula, considering n = 0.013 and the 75% filling of the pipe section, the optimal diameter d0 of a given pipe is given by the equation:

$$d_0 = 0.3145 \times \left(\frac{Q_f}{\sqrt{I_0}}\right)^{\frac{3}{8}}$$

where Qf is expressed in m3/s and d0 in m.

Check that the value is less than the minimum diameter indicated for simplified networks (DN 100 mm).

If higher, managers must evaluate the feasibility of reducing the dimensions of the contributing area in question, reducing the population and consequently the flow Q_f.

3.5. Calculation Spreadsheet

The dimensioning of the Sewage Network can be condensed with the resolution of a spreadsheet similar to the one presented below and its 18 columns. In fact, the roadmap drawn by this spreadsheet is similar to that used by several network sizing programs.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collector	Section	PV upstream PV downstream	Length (m)	Cont. Lin. (L/s.km) Ini / Fim	Cont. Tre. (L/s) Ini / Fim	Q Point (L/s)	Q upstream (L/s) Ini / Fim	Q downstream (L/s) Ini / Fim

- Columns (1), (2) and (3) assist in the identification of the section to be sized.

- Column (4) records the length of the section.

- Column (5) informs the linear contribution Tx calculated for the start and end of the system analysis period, using the equations:

$$T_{x,i} = \frac{K_2 Q_i}{L_T} + T_{inf} \qquad T_{x,f} = \frac{K_1 K_2 Q_f}{L_T} + T_{inf}$$

Column (6) informs the contribution of the QTx section calculated for the start and end of the system analysis period, using the equations:

$$QT_i = T_{x,i} \times L_T \qquad QT_f = T_{x,f} \times L_T$$

• Columns (7), (8) and (9) present the flows related to the section as follows:

- the point flow rate in column (7), recorded manually;

- the upstream flow rate in column (8), recorded by analyzing the upstream PV; and

- the flow rate downstream in column (9), equal to the sum of columns (6), (7) and (8). In accordance with section IV.3.1, it is recommended that it be greater than the flow rate resulting from flushing a toilet (in Brazil, 1.5 L/s).

(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Diameter (mm)	Declive **(m/m)**	Land elevation upstream/ downstream	Elevation G.I. Upstream/ downstream collector	Rec. Col. (m) upstream/ downstream	Trench depth (m) upstream/ downstream	Y/D start/end	V (m/s) start/end	T.Arr. (Pa) Vc (m/s)

• The column (10) records the diameter of the section, in this case 100 mm.

• Column (11) informs the slope of the section that will be the highest value between:

- economic slope of equal value to the slope of the land, avoiding the unnecessary deepening of the section.

- satisfies the minimum tensile stress condition presented in section IV.3.1.

• Column (12) records the elevation of the land.

• Column (13) gives the elevation of the bottom of the trench.

• Column (14) records the covering of the trench, calculated by the difference between columns (12), (13) and (10).

• Column (15) records the depth of the trench, calculated by the difference between columns (12) and (13).

• Columns (16), (17) and (18) record the water depth, speed, tensile stress and critical speed related to the section, in order to meet the conditions presented in section IV.3.1.

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