# A notebook for the

# diagnosis and maintenance

## of gravity-flow water systems

This practical guideline aims at helping persons in charge of organising and conducting (or facilitating) diagnoses of gravity systems. It presents a definition of what is meant by diagnosis, and situates the diagnosis in the different steps of a preventive maintenance process. After giving a general overview of the different components of a gravity system, a description of what must be looked at for each component is described. A summary table, in the form of a check-list is presented on the last page

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# What is a diagnosis?

A diagnosis of a gravity-flow system is an inspection of all the elements of the system (spring, pipeline, water points) to identify possible problems or risks, to assess their probability, and determine the consequent priorities to be given.

The diagnosis compares « how the system is » as regard to « how the system should be ». Starting with these differences, a list of remedial actions can be recommended in order to implement the required maintenance and bring the system (back) to an optimal state.

# The diagnosis and the preventive maintenance process

***The different steps: from the decision to conduct a diagnosis to the final validation:***

## 1. Decision to conduct a diagnosis

To trigger the maintenance of the system, someone needs to take the initiative to plan a diagnosis of the system. The optimal frequency depends on different factors (number of users, number of water points, length of the pipeline, exposure to erosion...). But for all systems, it is necessary to conduct a diagnosis at least once per year.

## 2. The diagnosis of the system

The diagnosis can either be done directly by one or several trained person(s) of the village or may require the support of an external experienced person.

## 3. Reporting the recommendations

Communicating the results of the diagnosis is crucial to enable the Water Association and the users to get a clear picture of the state of their system and of the possible needs of intervention. Typically, the report includes:

- a brief presentation of the system and of the person(s) involved in the diagnosis + date
- the status of the yield and the water quality,
- a description of the risks or defaults observed on the system,
- the state of the protection perimeter of the spring,
- a list of recommendations,
- the proposed solutions and options, the priorities, an estimation of the budget range and an indicative schedule.

## 4. Action & budget plan

After the delivery of the diagnosis report and its validation by the Water Association, this latest has to present it to the users and get their consent on the measures to be implemented. From there, a precise action & budget plan can be established and scheduled.

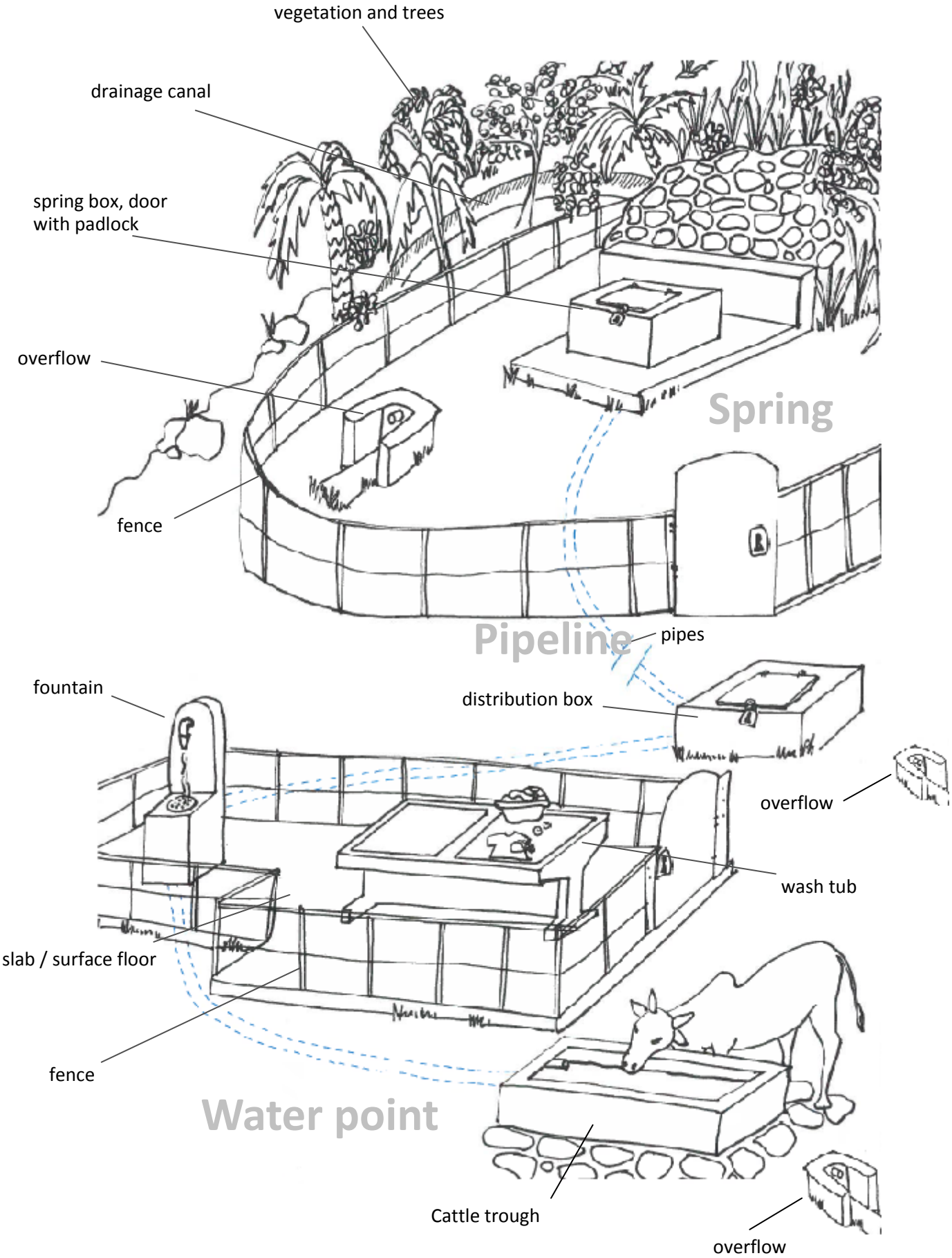
## 5. Operating the maintenances

The required material is purchased and the maintenances are operated, possibly with the support of a local artisan, or a local contractor or expert for technically complicated operations.

## 6. Validation that the recommendations have been applied

This phase is essential to guarantee the quality of the work, especially when operated by an external contractor. The Water Association and possible a representative of the Federation and Water Office (mainly for heavier maintenance operation) should give a formal validation of the work.

# General overview of the components



# Description for each component

## The spring and its surrounding

### ▪ Manhole door, padlock and outer part of the box

The **door** allows a controlled access to the inside of the spring box. It must be closed with a **padlock** to prevent unauthorised access and must be hermetic to animals (birds, insects) and surface water infiltrations.

**Possible problems and solutions**

| | | |
|---|---|---|
| Lock not available or not functional | ⇨ | Introduce or replace lock/padlock |
| Rusting of metallic door surface & joints | ⇨ | First clean the rust with metallic brush. Apply antirust paint |
| Breakdown /dislocation of hinges and joints (metal-concrete) | ⇨ | Welding of broken joints/hinges and assembling it to the box. (Boring and refilling of concrete may be involved) |
| Major crack on masonry / plastering damaged | ⇨ | Repair broken/cracked part with cement |

### ▪ Inside the spring box

Inside the box, the water flows on a clean, smooth, and firm surface before being taken in the distribution pipes through one or several intake pipes. If there is more than one intake pipe, a regulation can be placed with small pieces of pipes in order to adjust the flow at the desired quantity in each of the pipes. One or several overflow pipes (depending on the yield) evacuate the excess water outside the box.

**Possible problems and solutions**

| | | | |
|---|---|---|---|
| **Floor surface** (inside the box) | Floor surface full of mud, debris, sediments, and other dead or live worms/insects | ⇨ | Regular cleaning/washing schedule required |
| | Floor surface deterioration by wear and tear | ⇨ | Apply cement mortar screed if the depth of deterioration is less than 5 cm. Otherwise apply concrete patching |
| | Tree roots are developing inside the box | ⇨ | Regular cleaning/washing schedule required |
| **Overflow pipe** (inside the box) | No pipe inserted or broken/damaged | ⇨ | Introduce or replace the piece of pipe (usually 10 cm of 75mm pipe) |
| | Pipe too short or too long | ⇨ | Cut if the pipe is too long or replace is too short. |
| | *The intake of the overflow pipe should be at 10cm up from the floor.* | | |
| **Supply water intake pipe** | No pipe (water enters at surface level) | ⇨ | Introduce piece of pipe |
| | Pipe is too long (> 5cm) | ⇨ | Cut the pipe to appropriate size |
| | Unequal distribution between the different intakes | ⇨ | Replace or adjust intake pipe at equal level |
| | *The water intake should be at 3 to 5cm up from the floor.* | | |

## Outlet of the overflow and drainage of excess water

The **overflow** freely evacuates the excess water and allows washing out the sediments that accumulate inside the box. The outlet of the overflow is anchored in masonry and allows the water to flow out freely. If necessary, a grid is placed to avoid frogs and likes to enter into the pipe. After the outlet, the water is **drained** in a canal further to avoid having stagnant water close to the spring box

### Possible problems and solutions

| | | |
|---|---|---|
| No or very poor/weak anchorage | ⇨ | ▪ Introduce or repair the anchorage |
| Pipe end submerged by water/mud | ⇨ | ▪ Dig or increase drainage canal to allow the water to flow out freely. Improve canal slope if pipe submerged |
| Pipe end buried by soil/vegetation | ⇨ | ▪ Clean canal if it is filled with mud/vegetation |
| Pipe clogged | ⇨ | ▪ Unclog the pipe using long iron bar |
| Frogs or likes are present in the pipe or in the box | ⇨ | ▪ Install a grid or tight piece of iron bar to prevent frogs entering into the pipe |

## Protection of the spring environment

- **Earth retaining structures** are located above the spring box and protect the box from overtopping of soil and prevent land slide that can harm the structure. These structures can be composed of dry or masonry wall, gabions or vegetalised wall. The protection canal diverts the flow of upstream surface water away from the structure and the surrounding.
- **Antierosive measures** including diversion canal in the upper part contribute to decrease the speed of the surface water and to limit soil erosion.
- **The fence and protection perimeter** prevent unwanted or unauthorized entrance of people and animal. It also secures and protects the perimeter of the spring against any pollutant. The vegetalisation of the spring watershed facilitates water infiltration in the water table and contributes to preserve the spring and to prevent yield reduction.

### Possible problems and solutions

| | | | |
|---|---|---|---|
| **Earth retaining structures** | Structure overtopped by surrounding soil | ⇨ | Remove the soil that overtopped. Introduce measures to reduce soil movement |
| **Protection canal** | Broken/damaged/ poor/ weak protection canals and cut off drain at the upstream of the structures | ⇨ | (Re)dig a large and solid protection canal |
| | Sign that indicate there is erosion flow toward the structure & surrounding | ⇨ | Introduce or repair the erosion protection works |
| **Fence - protection perimeter** | Fence not available or not strong | ⇨ | Make or repair the fence |
| | Upstream side of the spring not sufficiently protected and vegetalised | ⇨ | Enlarge the protection perimeter. Plant vegetation and reforest the spring watershed |
| | Trees that pump too much water exist in the close vicinity of spring | ⇨ | Progressively replace trees that risk the system (i.e. eucalyptus) by more adapted varieties |
| | Trees that can damage the structure with their root system exist at close distance of the spring box | ⇨ | Cut the rooting part that risks the system. Keep the spring surrounding clean. Avoid development of small trees just close to the spring box |

## Water quality and quantity inspection

**Spring Yield Inspection**: the system has to supply a sufficient and reliable yield.

Significant amount of yield reduction can be verified by:

- Measurement of the yield : it can be done by calculating the time necessary to fill a bucket of a known volume. To obtain the yield in litter per second (l/s), divide the bucket volume by the calculated time in second.
- Investigating possible seepages around the foundation of the spring box
- Interview of land owner and local people

In order to preserve the yield of a spring, solutions can be undertaken to better protect and treat the "recharge area", mainly by planting adapted trees and vegetation.

If water is flowing or seeping outside the spring box, an extension of the retention wall may be necessary, but such solutions usually require the rehabilitation of the entire spring box.

**Quality Inspection:** the system has to supply safe and uncontaminated water to the users. During the diagnosis, one will observe the temperature of the water (it should be fresh), its turbidity and its taste. If any doubts, further analysis will be necessary consisting in bacteriological analysis (+possibly chemical) as well as pH and turbidity measurements

If physical, chemical and bacteriological standards of water quality are not met, solution might be found in

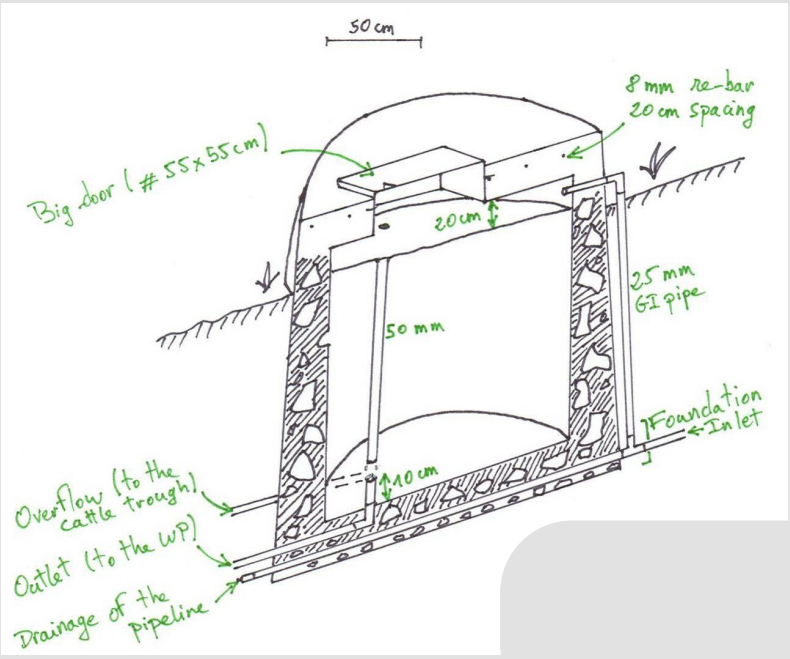
- Enlarging the spring protection perimeter
- Isolating contamination sources (such as latrines , animal grazing, open defecation areas in the spring environment)

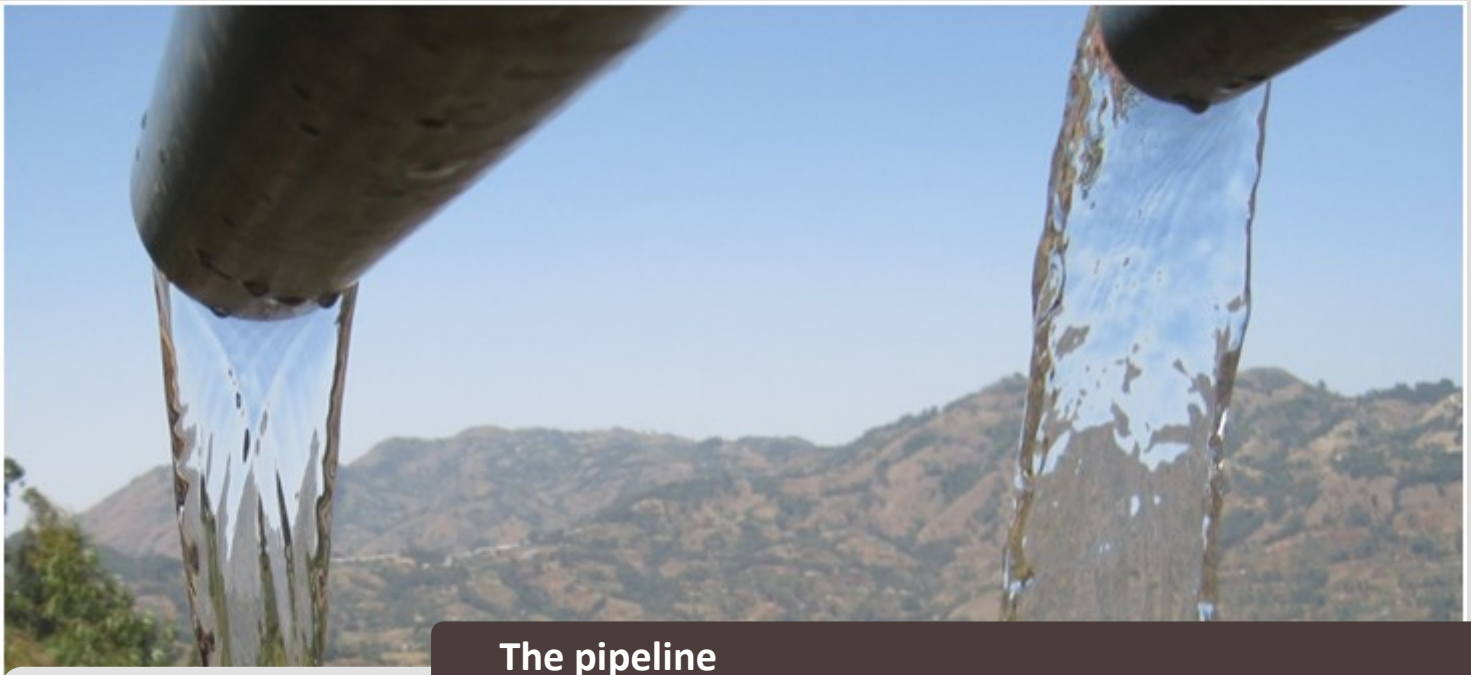
If the problem remains, chemical treatment has to be applied to the reservoir (if any) or/and at household level

## The reservoir

At reservoir level (if any), one will control the cleanliness of the inside part, the absence of leakage and the state of the masonry, the fence, the state of manhole door which should be locked and waterproof, the functionality of the overflow and the drainage of excess water when the reservoir is full.

**Possible problems and solutions ⇨ see outside part and inside part of the spring box**



## The pipeline

The diagnosis of the pipeline ensures that the water is carried from one point (the spring or a distribution box) up to another (usually, a water point) without affecting both its quantity and its quality. For that, it is necessary to inspect the pipeline and its surroundings all along the line, with a particular attention given to exposed areas like stream or gulley crossing. One should make sure that the pipes are well buried and protected (pipes cannot be exposed). Leakages can be detected by observing possible trace of moistures on the floor around the pipeline and by comparing yield at the intake and outlet of a set of pipes.

### Possible problems and solutions

| | | |
|---|---|---|
| **Buried pipes** | Breakdown or leakage that causes drying or reduction of flow in the line ⇨ | Repair or replace the pipe (usually by cutting the defect part with a piece of pipe and the corresponding coupling) |
| | Exposed pipes (not covered below sufficient depth) ⇨ | Burry the exposed part of the line with compacted soil, or stone/gravel + compacted soil + stone again on the top |
| | Risk of land slide ⇨ | Introduce dry masonry structure to stabilize the slope, plant vegetation to stabilise the soil |
| **Over hanging or surface laid pipes** | Anchorage problems ⇨ | Repair masonry; consolidate the structure of the anchorage with iron bars if necessary. |
| | Suspension cables and joint problems ⇨ | Retight/replace suspension cables. Protect them with barbed wire to avoid any persons accessing the cables. |
| | Pipe breakdown or damage at the overhanging section ⇨ | Replace the damaged pipes. Pass PVC/HDP pipe inside galvanised pipe of higher diameter for the exposed pipeline section to ensure durable protection. |
| | **If complicated refer/consult higher technical/engineering level** | |

# The water point

## The fountain

The fountain is usually composed of:

- **A slab** on which the fountain stands . The slab allows the users to walk on a clean, firm and not slippery floor in order to fetch water easily . A major role of the slab is to drain out the water from splashes or heavy rains to ease the access. The slab must be easy to wash regularly.
- **An outlet pipe giving** a continuous flow of sufficient water that can easily be fetched (non-splashing and controlled flow). When there is a reservoir, a tap (local or talbo) is installed.
- **A standing concrete column** that must be well anchored to protect the pipe from any damage.

### Possible problems and solutions

| | | | |
|---|---|---|---|
| **Slab (floor surface)** | Surface water evacuation problem | ⇨ | Improve the slope of the floor surface. Ensure that the flowing water is well drained (also around the slab) to avoid stagnant water around the water point. |
| | Surface not clean | ⇨ | Regular washing/cleaning schedule required |
| | Deterioration/crack on the surface | ⇨ | Cement screed or concrete patching depending on the depth of deterioration |
| **Fountain outlet, taps and valves** | Clogged pipe (no or partial flow) | ⇨ | Unclog using wire or iron bar and opening the end cap |
| | Broken/lost end pipe | ⇨ | Repair or replace the broken or lost part |
| | Taps/valves not functional, leaking or faulty | ⇨ | Repair or replace the broken or lost part |
| **Flow conditions** | No or decrease flow / intermittent flow | ⇨ | Check upstream on the pipeline<br>Unscrew the flush valve on the side of the slab to evacuate possible accumulated sediments. |
| **Standing concrete column** | Minor damage and/or cracks | ⇨ | Apply cement mortar plastering and rendering |
| | Major damage and severe deterioration | ⇨ | Heavy repair or rehabilitation required |

## The wash table

For the wash table, one will check that its surface is smooth washing the laundry; that the main concrete structure is not cracked or damaged; and that the excess water evacuates properly from the washing tub and the floor and does not stagnate around the water point

### Possible problems and solutions

| | | | |
|---|---|---|---|
| **Washing surface** | Surface water evacuation problem | ⇨ | Improve the slope of the floor surface |
| | Deterioration/crack on the surface | ⇨ | Redo the plastering. First, make the floor rough so that the plaster can properly adhere on it. |
| **Evacuation and drainage** | Clogged pipe for the evacuation of excess water | ⇨ | Unclog using wire or iron bar |
| | Stagnant water around the wash table | ⇨ | Improve the canal to drain the water out of the water point surrounding |
| **Main concrete structure** | Minor damage and/or cracks | ⇨ | Enlarge the crack and apply cement/concrete patch on it. |
| | Major damage and severe deterioration | ⇨ | Heavy repair or rehabilitation required |

## The cattle trough

Beyond checking the state of the masonry and the cleanness of the trough and access path for the cattle, one will ensure that water is always full in the trough (unless it is drained for cleaning) and that the excess water evacuates well, and that the water is clean. Particular attention will be given to the cleanliness of the water to prevent the development of leeches and worms that can be brought by some of the animals.

**Possible problems and solutions**

| | | | |
|---|---|---|---|
| **Pipe, overflow and drainage** | Overflow pipe absent or damaged | ⇨ | Replace the piece of pipe |
| | Overflow pipe hard to remove | ⇨ | Polish the end of the pipe with paraffin wax (from candles) |
| | Pipes are exposed to the air | ⇨ | Burry the exposed part of the line with compacted soil + stone on the top |
| | No or very poor/weak anchorage | ⇨ | Introduce or repair the anchorage |
| | Pipe end submerged by water/mud or buried by soil/vegetation | ⇨ | Dig canal or clean it to allow water to evacuate freely. Improve canal slope if pipe submerged |
| | Clogged pipe for the evacuation of excess water | ⇨ | Unclog the pipe using long iron bar |
| **Cleanness and accessibility** | Cattle trough not clean (sediment, leeches) | ⇨ | Regular washing/cleaning schedule required |
| | Mud and stagnant water around the cattle trough | ⇨ | Improve drainage canal and make stone pavement around the trough |
| | Poor access for the cattle | ⇨ | Enlarge the path, decrease slopes, place stone pavements |
| **Main concrete structure** | Minor damage and/or cracks | ⇨ | Enlarge the crack and apply cement/concrete patch on it. |
| | Major damage and severe deterioration | ⇨ | Heavy repair or rehabilitation required |

# Technical check list

| ELEMENT | PART | TO BE CHECKED | OK ☑ | OK ☒ |
|---|---|---|---|---|
| SPRING | Manhole door, padlock, outside part of spring box | A padlock is functional | | |
| | | The metallic door is well painted, with no rust and not hole | | |
| | | The door is well fixed on the hinges and open/close correctly | | |
| | | No cracks are observed on the outside part of the concrete box | | |
| | | The plastering of the outside part of the concrete box is smooth | | |
| | | The concrete box is hermetic to any external water infiltration | | |
| | The inside part of the spring box | The surface floor is clean (absence of any sediment) | | |
| | | The surface floor is smooth with no deterioration | | |
| | | No roots are observed inside the box | | |
| | | The pipe section used as overflow intake is well installed | | |
| | | The size of the overflow pipe section above the surface floor = 10cm | | |
| | | This overflow pipe section can easily be removed and re-installed | | |
| | | The size of the intake pipe section above the surface floor = max 5cm | | |
| | | If several intakes: the intake in each pipe is equal or corresponds to the desired yield | | |
| | Overflow outlet and drainage of excess water | The overflow outlet is well anchored | | |
| | | Water can flow out freely at outlet (pipe not submerged by water, mud, vegetation) | | |
| | | Excess water is not clogged inside the overflow pipe | | |
| | | Excess water is well drained after the overflow | | |
| | | No tack of frogs or likes in the in the overflow pipe | | |
| | Protection of the spring environment | The spring box is not overtopped by surrounding soil | | |
| | | The vegetation in the 3m circle around the spring box is cut | | |
| | | A good protection canal diverts runoff water at upstream of the spring catchment | | |
| | | There are no sign of erosion that could affect the spring catchment | | |
| | | A fence avoid unauthorised persons to enter the spring catchment area | | |
| | | The upstream side of the spring is protected by vegetation and adapted trees | | |
| | | There are no trees growing just near to the spring box | | |
| | | A perimeter around the spring is defined | | |
| | | In the perimeter, absence of contamination sources: latrine, open defecation, animal grazing | | |
| | Water quantity and quality inspection | No water is seeping outside the box | | |
| | | The yield of the spring is stable as compared to previous years | | |
| | | The water appears to be clean, cold and not turbid | | |
| | | Previous/recent water quality tests have shown absence of coliforms | | |
| PIPELINE | Walking all along the pipeline shows: | Absence of leakages (no moisture observed on the pipeline) | | |
| | | No pipes that should be buried are exposed to the air | | |
| | | No risk of landslide or erosion | | |
| | Stream crossing, surface laid pipes in rocky places | Exposed parts of the pipeline are well anchored | | |
| | | Suspended cable to suspend pipes over stream crossing are well maintained | | |
| | | Suspended and exposed pipes are well connected, with no leakages or disjoint | | |
| WATER POINT | Fountain | No puddles of water on the slab, surface water evacuates well out of the slab | | |
| | | The surface of the slab is kept clean (no mud or dirt) | | |
| | | No cracks or deterioration observed on the slab (surface is smooth) | | |
| | | The washout pipe is easily accessible | | |
| | | Fountain outlet is not broken and well adjusted above the receiver pipe | | |
| | | Water flowing in the fountain is well absorbed in the receiver pipe, which is not clogged | | |
| | | Taps (if any) are working properly, with not leakage or faulty | | |
| | | The flow at fountain level is normal | | |
| | | No cracks or deterioration observed on the fountain concrete structure | | |
| | Wash table | No puddles remaining on the wash table surface (water well drained) | | |
| | | Excess water evacuates freely (evacuation pipe not clogged) | | |
| | | The surface plaster is smooth (no crack or deterioration) | | |
| | | No stagnant water observed around the wash table | | |
| | | The table structure has no crack or deterioration | | |
| | Cattle trough | The water arrives well in the cattle trough | | |
| | | The water inside the trough is clean (no presence of leeches or sediments) | | |
| | | The overflow pipe is present and can be removed/re-installed easily | | |
| | | Excess water evacuates freely (overflow pipe not clogged) | | |
| | | The cattle trough concrete structure has no major cracks or deterioration signs | | |
| | Pipe, overflow, drainage and surrounding | Overflow outlet is well anchored | | |
| | | Water can flow out freely at the outlet (pipe not submerged by water, mud, vegetation) | | |
| | | No pipes are exposed to open air | | |
| | | The fountain (and wash table) is protected by a fence | | |