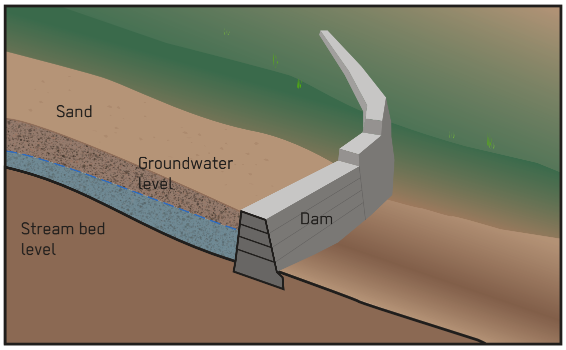
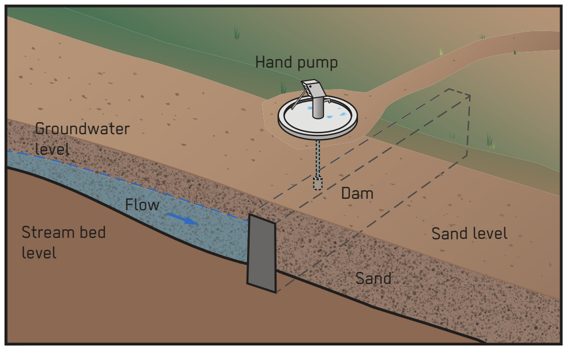
# Groundwater Dam

| Response Phase | Application Level | Management Level | Objectives / Key Features |
|---|---|---|---|
| Acute Response<br>Stabilisation<br>** Recovery | Household<br>** Neighbourhood<br>* City | Household<br>** Shared<br>* Public | Large water volumes stored in arid areas, drought mitigation |
| **Local Availability**<br>*** High | **Technical Complexity**<br>*** High | **Maturity Level**<br>*** High | |

SAND STORAGE DAM




SUBSURFACE STORAGE DAM




A Groundwater Dam is a structure that slows or stops the flow of shallow groundwater, most often in seasonal riverbeds, increasing the availability of shallow groundwater upstream of the structure. The technology is not suitable for the acute or stabilisation phases of emergencies, and is more suited to long-term drought mitigation.

There are two main types of Groundwater Dam, each suited to different initial site conditions. Sand storage dams (in the above figure on the left) are built in riverbeds where the volume of sand or other permeable material in an existing riverbed is not yet deep enough to store significant amounts of water. Most of the structure is therefore built (in stages) above the original riverbed. Each time a stage is constructed, sand that is washed downstream during flash floods then deposits behind the wall, which creates a new higher riverbed level upstream that holds water. These dams are usually built onto a rock layer, though can also be established with care onto an impermeable clay layer. Subsurface dams (in the above figure on the right) are built within riverbeds where the sand volume is already sufficient to store water. After a flooding event, the water behind the dam infiltrates, increasing storage. They can be built onto a rock or impermeable clay layer.

**Design Considerations:** A Groundwater Dam is a technology that is not suitable everywhere, and requires careful siting. Dams should be sited where the river has sufficient velocity to carry medium/coarse sand grains while minimising silt deposits. In practice, this means a site with a gradient between 0.13 % and 4 %, which will also likely keep the dam width to under 25 metres, reducing materials and labour. The exact location should not be close to a river bend or where old riverbeds might exist laterally through which groundwater can escape. A detailed site investigation is needed to ensure water losses do not occur through fractures when building on rock or through deeper sediments below the impermeable layer. Riverbanks should be high enough to prevent water bypassing the structure (i.e. height of dam + flood + 10 %). Siting the dam where the riverbed is narrower and where the basement rock or clay is shallower will ensure cheaper and quicker construction.
Careful design and construction are also important, especially for sand storage dams. For both dam types, erosion must be prevented around the edges of the dam. For subsurface dams, this means keying in the dam to the riverbank, whereas for sand storage dams, it entails the construction of wing walls. A good construction technique is

to start with the wing walls and work towards the centre, because if the wing walls are constructed last, community enthusiasm may lag considerably. The length of the wing walls varies according to the characteristics of the bank. For sand storage dams, there are further critical design issues to be aware of. For instance, the height of the dam wall to be built before each flood should not exceed the accumulation rate of coarse/medium sand during that flood event. The height will vary according to location and should be adjusted after the first flood event, though it is rarely more than 50 cm. If this is not done, ponding and siltation will occur, resulting in lower specific yield and higher capillarity, which in turn will reduce the extraction rate of wells and increase the evaporation loss. The spillway must also be designed to accommodate peak river flow and will therefore vary according to the site. Incorrect design will lead to erosion around the wing walls. Thirdly, where there is no rock bar immediately downstream of the dam, erosion can be prevented by placing large stones at the point below the spillway where floodwater will fall. These should be large enough to resist river flow. Water can be abstracted by scoop holes in the riverbed (which are prone to contamination), through riverbed wells **(see I.7)**, or by wells in the riverbanks. Certain designs for sand storage dams show a pipe taking water by gravity through the dam wall, but these can be problematic due to blocked intakes, broken taps and the possibility of a weakened dam wall.

**Materials:** Subsurface dams can be made of stone masonry or even clay, whereas sand storage dams are generally built of stone masonry. Subsurface dams made with clay are susceptible to damage, but can be functional if the top of the dam is 0.3 metres below the original sand bed and if concrete is used at critical points (foundation, upstream plaster, top of dam).

**Applicability:** Groundwater Dams are generally suited to arid areas with high evaporation rates and intense rainfall events. These areas tend to coincide with pastoralist areas prone to drought, where water availability does not always correlate well with pasture availability. Sand storage dams are suitable for riverbeds with insufficient sand as a storage medium, while subsurface dams are suitable where there is enough sand, but the subsurface water does not remain long enough (if water does remain, Riverbank Filtration **(I.6)** should suffice). The construction of Groundwater Dams can take a long time, especially for sand storage dams, so they should not be considered for the acute or stabilisation phases of an emergency.

**Operation and Maintenance:** If dams are properly constructed, then very little continuous O&M is required. Sand dams should be inspected for potential damage after floods and repaired. Building dams in stages over a period of years can also be more beneficial for the functioning of dam committees since communities are continually involved. Subsurface dams made from clay should be checked after the first flood events to ensure no damage has occurred. If a pump is used for abstraction, then appropriate pump maintenance is needed.

**Health and Safety:** Where excavation exceeds two metres for subsurface dams, trench shuttering should be used along with appropriate construction safety measures. Water quality should be controlled. If many herds of animals access the upstream river, nitrates from urine could become an issue, as may contamination from animal faeces. In volcanic sands, fluoride may build up in deeper parts of a sand reservoir.

**Costs:** The initial dam structure can be expensive and varies between projects according to site conditions, volume of excavation, type of structure, and labour. Sand storage dams can be more expensive than subsurface dams. Costs range from 3,500 up to 30,000 USD. The cost per cubic metre of water stored, however, is low.

**Social and Environmental Considerations:** The principle of Groundwater Dams is generally easily understood by users, as it builds on what they know already about water held within sand. Where dams are planned to aid pastoralists, full discussions on locations in relation to pasture and grazing rights of different groups will be required during the planning phase. The available water in Groundwater Dams is very much linked with seasonal rainfall, and they can play a key role in climate change adaptation and drought mitigation activities, as they provide increased storage and/or can help control groundwater table levels through managed aquifer recharge.

**Strengths and Weaknesses:**

(+) Low evaporation and better water quality than open water
(+) Produces large water quantities
(+) Low O&M requirements

(−) Requires expertise for good design
(−) Is a site-specific technology
(−) Can take years to properly build a sand storage dam, which clashes with short-term funding
(−) Possible water quality issues (e.g. from cattle)

→ **References and further reading material for this technology can be found on page 214**