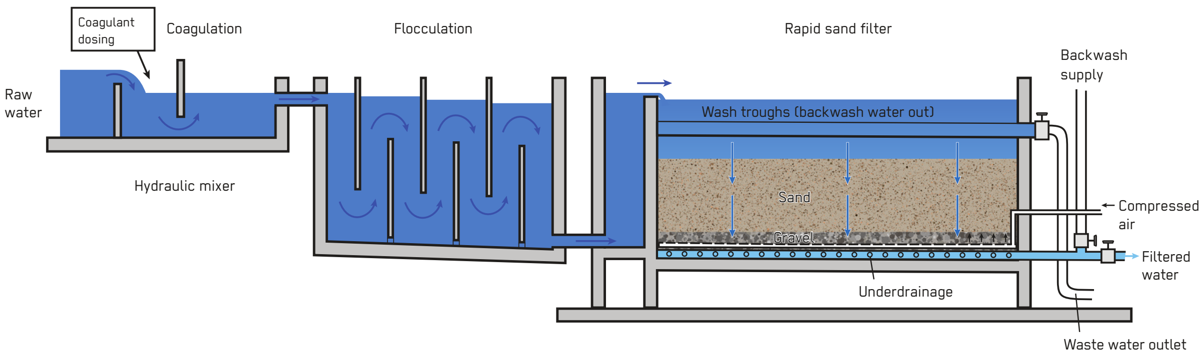
Assisted Sedimentation with Filtration

Response Phase	Application Level	Management Level	Objectives / Key Features
** Acute Response ** Stabilisation ** Recovery	Household ** Neighbourhood ** City	Household ** Shared ** Public	Turbidity removal, pre-treatment, coagulation and direct filtration
Local Availability	**Technical Complexity**	**Maturity Level**	
*** High	*** High	*** High	



Assisted Sedimentation with Filtration is a pre-treatment step used to remove suspended solids from water with varying levels of turbidity (or 'muddiness') to prepare it for a final disinfection step, such as Chlorination (T.6). It can be used in all phases of an emergency.

For raw water containing fine colloidal matter that only slowly settles or does not settle at all, the addition of chemicals is required to speed up the process. This is known as both 'Assisted Sedimentation' (since the natural Sedimentation process is accelerated) or as 'coagulation and flocculation'. In this process, the chemical coagulant added to the water destabilises the electrostatic charges of colloids so they come together to form larger particles (flocculation) through mechanical mixing. In a standard treatment process, these particles would be settled out using Sedimentation (T.4), though this can be omitted by directly filtering the flocs using Rapid Sand Filters **(T.2)** in a process also known as 'direct Filtration'. When compared to a conventional plant with the same flow rate and raw water quality, Assisted Sedimentation with Filtration can provide better turbidity removal at a lower cost. This is a process that is usually done at larger scale, though packaged plants used in acute emergencies often include coagulation using a hydraulic mixer followed by a pressurised rapid sand filter. Coagulation and flocculation followed by Microfiltration **(T.3)** or Ultrafiltration **(T.10)** can also be used, though this is referred to as membrane Filtration with in-line coagulation.

Design Considerations: The aim of direct Filtration is to reduce turbidity to a level suitable for subsequent treatment steps. This is usually Chlorination **(T.6)**, so a turbidity of less than 5 NTU is required. During this pre-treatment, bacterial concentrations are also reduced and there is a considerable improvement in colour, taste, odour and levels of metals such as iron, manganese, fluoride and arsenic. Direct Filtration works well where raw water quality is relatively constant and with an average turbidity of around 25 NTU (with peaks up to 100 NTU). Where turbidity is higher or more variable, more coagulant may be needed, which will form more flocs that can clog the filter faster. An alternative for water with a higher turbidity of around 100 NTU (with peaks up to 200 NTU) is to combine Rapid Sand Filtration **(T.2)** with a hybrid form of an upflow Roughing Filter **(T.1)** with higher flow rates than usual. For water with an even higher turbidity, standard Roughing Filters **(T.1)** or conventional (Assisted) Sedimentation **(T.4)** can be used.

The Assisted Sedimentation and Rapid Sand Filtration processes are similar to conventional treatment processes **(see T.2 and T.4)** with some differences. For the coagulation stage, smaller quantities of coagulant are required, which reduces cost, and sometimes a polymer is also added. The flocculation stage is similar, though can be omitted. The main difference with Rapid Sand Filtration is that since there is no Sedimentation basin, and flocs are stored within the filter bed instead, which requires a larger storage capacity. This is achieved by deepening the filter bed and including another larger-sized filter medium as the top layer (e.g. anthracite) which makes the filter more efficient compared with standard Rapid Sand Filters at the same loading because the flocs penetrate deeper into the bed, thereby making use of the entire depth (instead of trapping them only in the upper layers). The larger-sized top layer is made up of something with a lower specific gravity (the ratio of a material's density to that of water) so that the two layers retain their relative positions after backwashing.

The Filtration rates of dual-media filters tend to be higher than conventional Rapid Sand Filters, meaning less filter area is needed, though faster flow rates result in shorter filter runs, requiring more frequent backwashing that uses slightly more water (around 6 % of filtered water). The lower layer of sand in dual-media filters has an effective sand size (meaning 90 % of the sand used is larger) ranging from 0.45–0.8 mm (a bit smaller than for conventional Rapid Sand Filters), while the upper layer typically has an effective size of 1.0–1.6 mm. Both layers are relatively uniform.

Materials: Materials may include a pump, coagulant dosing mechanism, flocculation tank (optional), sludge disposal mechanism, chemicals for coagulation and possible pH adjustment, and for Rapid Sand Filtration **(T.2)**, a water inflow and outflow system with control mechanism, underdrain system, pumps (or raised water tank), filter media (sand plus a coarser medium) and (sometimes) a compressed air system for backwashing.

Applicability: This treatment process is suitable for all phases of an emergency. It can be very useful during the acute response, as it can be quickly started for bulk water treatment and where equipment and processes are not yet perfect (e.g. where the same tank is used for flocculation and Sedimentation). Having direct Filtration early in an emergency gives some leeway in producing clear water quickly despite small errors. Larger-scale units are possible in the recovery phase once there is time for adequate design and piloting, but consideration should also be given to possible alternative pre-treatment options, such as Roughing Filtration **(T.1)**, to reduce cost, ongoing reliance on chemicals and sludge removal issues.

Operation and Maintenance: O & M requirements are significant and similar to those for conventional treatment processes. These include checking the turbidity and pH before and after treatment, regular jar testing, modifying dosing, draining and cleaning tanks, disposing of sludge, storing and mixing chemicals, controlling flow, and backwashing solids. General plant maintenance will also be needed (e.g. pumps, mixers, valves, application of anticorrosive agents to metal parts, lubricating valves).

Health and Safety: Health and safety concerns are similar to those for standard treatment processes, including the need for further disinfection and the safe removal of sludge (e.g. landfill, disposal to sewers or coordination with wastewater plant sludge). Where aluminium sulphate is used as a coagulant, the aluminium in clarified water cannot exceed 0.2 mg/L for health reasons. When high, the required dose can be reduced by adjusting the pH of the raw water or by filtering through a Rapid Sand Filter **(T.2)**. Chemicals must be treated with care since they can be corrosive.

Costs: Comparatively, direct Filtration is cheaper than standard treatment processes, as fewer chemicals are used and there is less plant to construct. This can save up to 30 %.

Social and Environmental Considerations: Generally, this treatment process is well accepted by consumers and institutions, as the turbidity of water is visibly improved. Sludge produced during coagulation can cause environmental risks if disposed of near groundwater sources.

Strengths and Weaknesses:

- (+) Costs less than similar processes that include Sedimentation
- (+) Provides a quick start to bulk water treatment in emergencies where perfect conditions for flocculation and Sedimentation are hard to achieve
- (+) Has higher Filtration rates with dual-media filters over conventional Rapid Sand Filters

- (−) Limited to treating lower turbidity water
- (−) Requires skilled operator for dosage and chemical handling (highly depending on the raw water)
- (−) Requires continuous supply of power and coagulant, which might not be locally available

→ **References and further reading material for this technology can be found on page 217**