GUIDELINE

FOR THE

DESIGN; CONSTRUCTION AND OPERATION

OF **REED BEDS** IN THE U.A.E

July 2015

Issued by: Wolfram Sievert, Sievertconsult

Foreword

The product of Waste water treatment are valuable sources of water, nutrients and energy. To support the Emirate's sustainable development goals waste water should be recycled not only in the major urban areas of the country but also in the rural areas. The current practice of septic tanks in combination with soak away not only wasting the high value resource of water but creating also a health risk for the population (sewage spills, ground water pollution). As the transportation of sewage from remote areas to central treatment plants causes negative impact on the environment (air pollution by trucks) or is economically inviable (construction of long sewer network) decentralized sewage treatment systems are the solution.

If space is available reed bed treatment systems are the most reliable, longest lasting, lowest energy consuming and most easy to operate decentralized waste water treatment system and give the chance to treat and reuse waste water even in the most remote areas of the U.A.E. in a sustainable way.

A positive side effect of the reed beds is the creation of a green area acting as wildlife habitat and green belt.

Several guidelines for the design and construction of reed beds are already available from various countries, but those guidelines focus on the treatment of waste water for the purpose of safe discharge into a receiving water body and not for the direct reuse for irrigation. To match with the high standards of irrigation water in the U.A.E. an advanced design is required which is given with this guideline.

Author

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List of revisions

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User Notice

This guideline is the result of honorary, technical-scientific / economic collaboration and based on the experience with over 20 reed beds in the U.A.E. over the last 10 years. Anyone is free to use the worksheet. An obligation to use can, however, from laws or regulations, contractual or other legal reason arise. .-

This Standard is an important, but not the only source for professional natural waste water treatment solutions.

With its application no one avoids responsibility for his own actions. This is especially true for the proper handling of the indicated margins in the guideline.

1. Area of application

This guideline gives a common base for the design, construction and operation of reed beds in the U.A.E. for the treatment of domestic sewage for the reuse of irrigation.

Reed Beds can also be specified as horizontal or vertical subsurface flow wetlands.

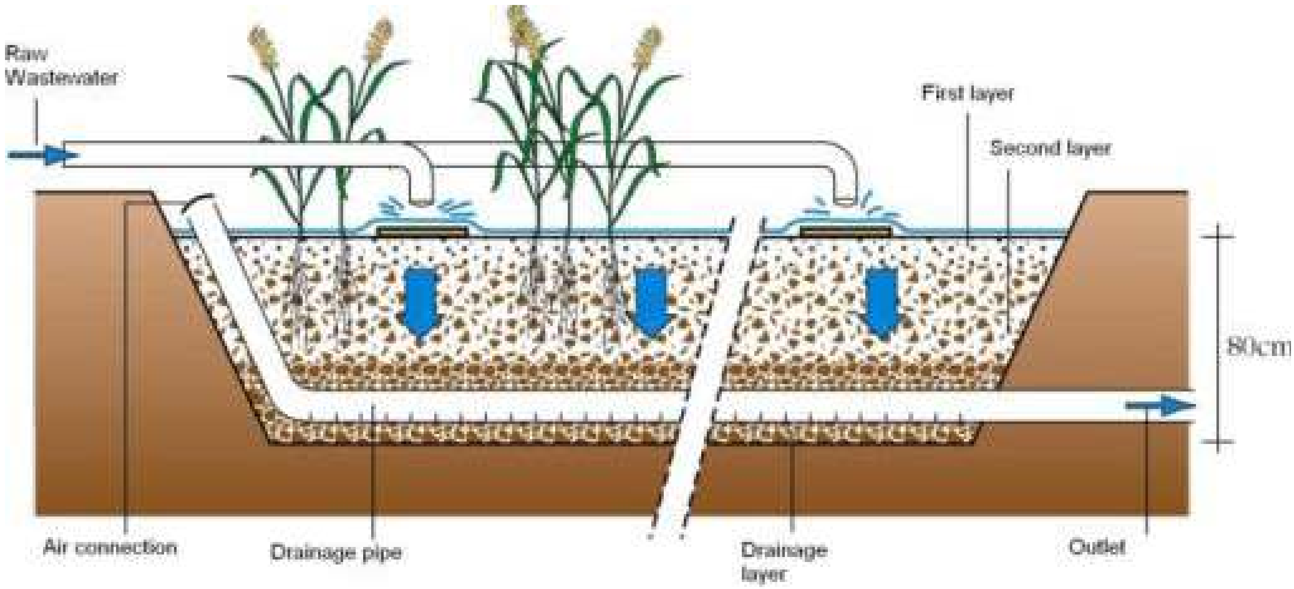
The range of application can vary from a single house up to several thousand inhabitants. The limit is only the investment cost compared to conventional treatment plants, as the costs per capita of reed beds increase nearly linear compared to conventional plants where the costs per capita decrease with the size of the plant.

This guideline is not for the treatment of industrial sewage, storm water, surplus sludge, the concept of sewage reed irrigation fields and surface flow wetlands.

2. Definition

Reed Beds according to this guideline are constructed wetlands with vertical or horizontal subsurface flow through a lined gravel/sand bed filter planted with reeds (Phragmites communis synonym australis). The sewage can be either only mechanically or biologically pre-treated or even raw. Depending on the chosen pre-treatment the reed bed system is either a single (only Stage B) or double stage system (Stage A and B).

If **raw sewage** is distributed on the reed beds a double stage system is used. The first step **(Stage A)**, is used to filter the suspended solids from the water which will accumulate on the surface of the planted filter layer and as well as a first biological step. The pre-treatment before the Stage A reed bed basins in this case is only a grinder pump station with a volume of around 1/6 of the daily flow. There is no need for buffer or septic tanks, therefore the maintenance and odour nuisance is reduced to an absolute minimum.

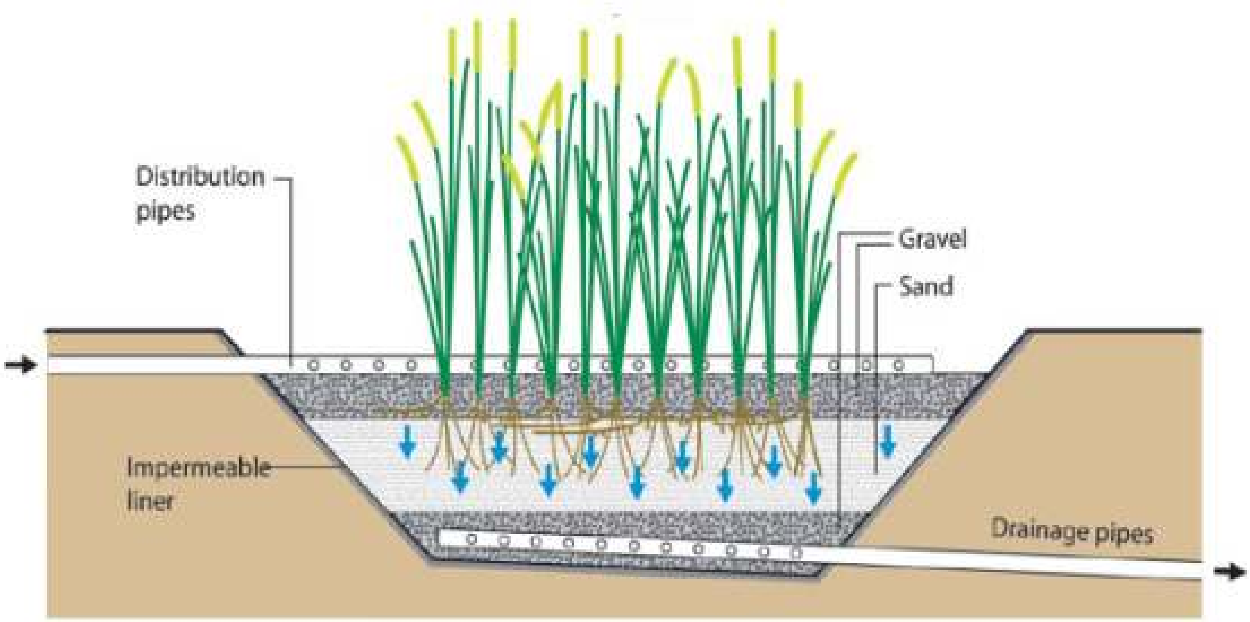


Pre-treatment of raw wastewater in the stage A (source: Molle et al., 2005). Wastewater flows out of the *end* of the distribution pipes.

The closed reed vegetation cover on the Stage A filter improves by shading and insulating the ground-level micro-climate. A continuous feed of stray wide-meshed vegetation residues mixed with the grinded solids of the sewage form on top of the sand filter layer an aboveground "spatial filter" which act as additional filter and protects the below sand filter from blocking.

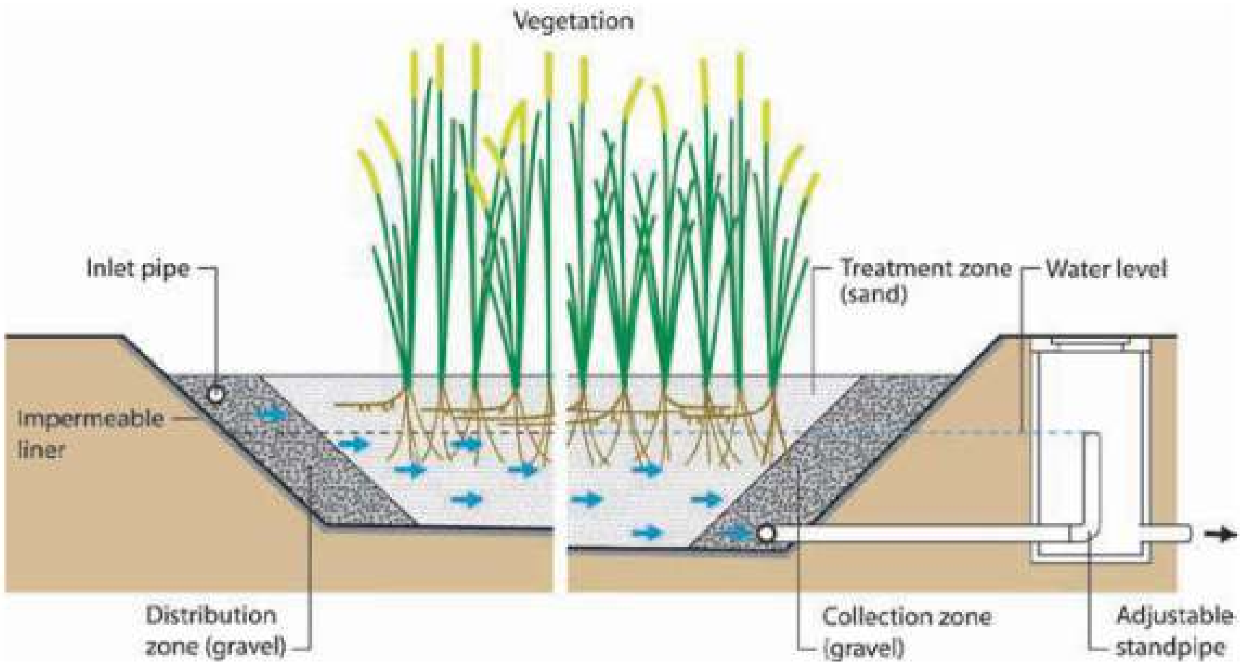
The reed plants grow through the overlying organic solids on the surface and develop numerous roots and shoots in the substrate. This leads to a forced dewatering, drying, aeration and mineralization of the organic solids. The organic solids volume declines to about 10 % of the initial volume. The filter bed and the accumulated solids are kept unblocked due to the continuous growth of rhizomes and stems from the plants, which also increase the permeability of the deeper solid layers. This sedimentation stage (Stage A) works for a period of 25 to 40 years without solids removal. During this period the solid layer increases slowly to a thickness of up to 0.5m. The resulting product of the sedimentation, dewatering and mineralization is an earthy organic material (like peat). This solid humus can be used for further composting, for fertilisation, for thermal recycling, for recultivation, gardening and landscaping.

The outflow of the sedimentation stage is then further biological treated in a second stage reed bed (Stage B). The Stage B can also be used independent from Stage A to treat the outflow of a technical pre-treatment stage like a septic tank, fine filter, SBR or UASB.



Schematic cross-section of a vertical flow reed bed (source: Morel and Diener, 2006). The middle layer of coarse sand typically has a height of 60 cm

The Stage B is the main biological treatment step of a reed bed treatment system. It is charged with pre-treated sewage. The pre-treatment are either Stage A filtration and mineralization reed basins or a conventional mechanically/biological pre-treatment, like septic tanks. The biological reed bed treatment step (Stage B) combines aerobic and anaerobic decomposition processes in a substratum layer. The polyethylene lined and refilled basins are planted with sewage adapted helophytes (Phragmites communis). The waste water percolates the filter substrate vertically or horizontally to the bottom drains. Besides the microbial and fungal decomposition of organic matter and pollutants in the rooted substrate matrix, chemical and physical precipitation, adsorption and filter processes occur. Some of the waste water nitrogen is released out of the artificial ecosystem as nitrogenous gases (denitrification).



Schematic cross-section of a HFB (source: Morel and Diener, 2006).

Through intermittent loading of the reed beds a radical change of oxygen regime is achieved. After water saturation by feeding with the distribution system a drainage network at the base collects the purified water. The pore space of the substrate is refilled with air thus enabling aerobic decomposition processes. Another part of oxygen transfer into the rhizosphere happens through a special helophyte tissue in the plant stems and roots (aerenchym) from the air.

List of Abbreviations:

A	m²	effective infiltration area
A_A	m²	effective infiltration area Stage A
A_B	m²	effective infiltration area Stage B
A_{BO}	m²	effective infiltration area Stage B under operation at once
BOD	mg/l	Biological Oxygen Demand
COD	mg/l	Chemcial Oxygen Demand
D	cm	Thickness of drain layer
d_{10}	mm	Particle size, below which 10% of the particles are located
d_{60}	mm	Particle size, below which 60% of the particles are located
PE_{BOD}	E	Population equivalent according to BOD
k_f	m/s	hydraulic conductivity
L	m	Length of horizontal reed bed
n_{BA}		Number of basins Stage A

n_{BBO}		Number of basins Stage B to be charged with waste water at the same time
N_{ges}	mg/l	Total Nitrogen
TSS	mg/l	Total suspended solids
Q	m³/h l/s	Waste water volume flow
Q_{PA}	m³/h l/s	Flow capacity pump stage A
Q_D	m³/d	Daily sewage flow
RV	%	Return Flow value
S	cm	Thickness of effective filter layer
TSS	mg/l	Total suspended solids
TDS	mg/l	Total dissolved solids
V_{PstA}	m³	Wet Volume Pump-station A
V_{PstB}	m³	Wet Volume Pump-station B
V_{ST}	m³	Volume septic tank

n_{BAO}	Number of basins Stage A to be charged with waste water at the same time
n_{BB}	Number of basins Stage B

$w_{S,d}$	l/(E*d)	specific waste water production per person
X_{Qmax}		Hourly peak flow

3. Base of design

If no measured values are available and no information given by the engineer the following characteristic of sewage can be used as base for the design:

Table 1: Capita specific waste water loads

Parameter	Raw sewage	after pre-treatment (≥ 2 h retention time)
	g/(E*d)	g/(E*d)
BOD	60	40
COD	120	80
TSS	70	25
NH_4-N	13	12
TP	3	2.7

Table 2: Design Flows (Design Guidelines ADSSC, Section 3)

Development Type	Occupancy rate E	Average Daily Flow Litres/Head $w_{S,d}$
Low Cost Residential	0 - 16	180
Medium Cost Residential	0 - 16	225
High Cost Residential	0 - 16	275
Large Villas/Palaces	0 - 50	275
High Rise	Number of flats × 5	275
Educational	Number of pupils + staff	70
Hospital [1]	Number of beds + staff	350
Commercial	Number of staff/visitors	50
Mosques	Floor area m²	100
Wet Industry	Not applicable	Varies to be advised

Dry Industry	Number of staff	50 at 8 per m2
Army Camps	Number of occupants	100
Hotels	Number of rooms	885 litres per room per day

1. Number of persons taken as twice the number of beds.

Peak flow:

The peak flow should be designed with a hourly peak flow value X_{Qmax} of 8h.

Example:

100 medium cost residential villas:

Q = 100 villas x 16 E x 225 l/(Exd) = 360,000 l/d = 360 m³/d

Peak flow= Q / X_{qmax} = 360 m³ / 8h = 45 m³/h = 12.5 l/s

4. Design

4.1. Location

For small reed beds a distance of 10 m to 15 m from the nearest neighbouring occupied building is sufficient to avoid any odour nuisance. If approved by the owner any shorter distance is possible as well, as odour only appears at pumping to Stage A during start-up of the system (no reed plant covering) and during malfunctions (anaerobic conditions through overload). For larger reed bed systems the same distance to residential areas as for any other conventional STP should be chosen.

4.2. Pre-treatment

4.2.1. General Requirements Pre-treatment

If a single Stage B reed bed system is used a well functioning pre-treatment is required. The average yearly TSS content after the pre-treatment should be not more than 100 mg TSS/l.

To maintain this pre-treatment performance the accumulated sludge in the pre-treatment must be removed whenever the sludge storage volume (50% of first chamber in a septic tank) is filled (at least every 3 years). Pre-treatment and pump station into the reed bed must be hydraulically not interacting to avoid any suction of sludge or scum into the pump station during pump operation.

If a pre-treatment is connected to a sewer network with the chance of rainwater infiltrating into the sewer network provisions to be made that during a storm water event not the complete pre-treatment volume is flushed out into the reed bed.

4.2.2. Pre-treatment Stage B, small reed beds < 10 E

For small single Stage B reed beds not exceeding 10 E the pre-treatment can be a 3 chamber septic tank with a volume of 1500 l /E, minimum volume 6 m³.

The first chamber to have 50% of the total volume.

Example:
Villa with 10 inhabitants:
$V_{ST} = 10\ E \times 1500\ l/E = 15{,}000\ l = 15\ m^3$
First Chamber 7.5 m³, 2nd chamber 3.75 m³, 3rd chamber 3.75 m³

4.2.3. Pre-treatment Stage B, reed beds 11-200 E

For single Stage B reed beds for 11-200 E the pre-treatment can be a 3 Chamber septic tank with a volume of 15 m³ + 500 l /E above 10 E.

The first chamber to have 50% of the total volume.

Example:
Compound with 50 inhabitants:
$V_{ST} = 15\ m^3 + (50\ E - 10\ E) \times 500\ l/E = 35\ m^3$
First Chamber 17.5 m³, 2nd chamber 8.75 m³, 3rd chamber 8.75 m³

4.2.4. Pre-treatment Stage B, reed beds > 200 E

For single Stage B reed beds above 200 E the pre-treatment could still be a septic tank or can either be a settling pond or an Imhoff tank where the settling area and the sludge storage area are separated.

Settling pond: 1.5 m²/ E. The discharge from sludge or water plants to the reed bed to be avoided.

Imhoff tank: Settling volume > 2 h retention time and volume ≥ 75 l/E. Sludge storage volume ≥ 70 l/E

4.2.5. Pre-treatment double Stage reed beds (Stage A & B)

Double Stage reed bed systems have Stage A reed bed basins filtering the suspended solids from the waste water and do not need a separation of solids like the single stage reed beds. A separation of solids is even counter productive as suspended solids are required to mix with the dead leaves of the reed plants and build up an organic permeable filter layer above the sand filter.

To avoid blockage of the distribution pipes of Stage A and to have a homogeneous filter layer the raw incoming sewage to be run through a cutting devise before entering the Stage A. In smaller system this cutting devices is build into the submersible sewage pumps lifting the raw sewage into the Stage A basins. In lager systems the pumps with higher flow capacities are not available with an in-build cutting device and the cutting devise must be a separate rotor rake installed after the pumps.

In large systems (> 200 m³/day) the raw sewage lift station can be equipped at the inlet with a course basket screen to protect the lifting pumps from blockage and reduce the maintenance works to a minimum.

4.3. Pump-station

4.3.1. General Requirements pump station

In areas with enough natural slope reed beds can be build without any pumps. The sewage can flow by gravity through the pre-treatment into the reed beds or directly into stage A. As the Stage A needs to be charged in batches and a batch feed is also recommended into single stage systems to increase oxygen input the sewage must be fed into the reed beds with the help of a siphon system. Special siphon system are available from specialized companies.

4.3.2. Pump station Stage A

As the sludge accumulating on Stage A needs to de-water and mineralize at least 2 Stage A basins to be build in small systems and at least 3 in larger systems.
30 – 50 % of the basins are under operation per day, the remaining are under rest to give time for the sludge to de-water and to allow air to infiltrate into the filter to avoid anaerobic conditions.
The basins under operation to be charged with at least 15 l/m^2 with each batch to insure an even distribution of the waste water over the complete surface.
Also there should be not more than 6 batches per basin per day to give time between the batches for air to infiltrate into the filter.

To determine the required volume of the pump station for Stage A the daily volume of waste water divided by the total number of Stage A basins (divided by number of basins charged at the same time) divided by 6 gives the required wet volume:

$V_{PstA} = Q_D / (n_{BA} / n_{BAO}) / 6$

Example:
Compound with 50 inhabitants:
Q_D = 50 E x 225 l/(Exd)= 11.25 m^3/d
Chosen number of Stage A basins (not less than 2 in small systems):3
Chosen number of Stage A basins charged at the same time: 1
V_{PstA} =11.25 m^3/d / (3/1) / 6 = 0.625 m^3

4.3.3. Pump station Stage B

Each Stage B basins should also be not charged with more than 6 batches per day.

To determine the required volume of the pump station for Stage B the daily volume of waste water divided by the total number of Stage B basins (divided by the number of basins charged at one time), divided by 6 batches per day gives the required wet volume:

$V_{PstB} = Q_D / (n_{BB} / n_{BBO}) / 6$

Example:

Compound with 50 inhabitants:

$Q_D = 50\ E \times 225\ l/(Exd) = 11.25\ m^3/d$

Chosen number of Stage B basins: 2

Chosen number of Stage B basins charged at one time: 2

$V_{PstB} = 11.25\ m^3/d / (2 / 2) / 6 = 1.875\ m^3$

Additional each batch should charge the reed bed basin surface under operation with not less than 10 l/m^2.

4.4. Reed Bed Basins

4.4.1. Stage A

The most important factor for the design of the reed bed basins is the surface area.
The Stage A total reed bed surface area will be calculated according to the hydraulic and organic load. The result with the higher number will be used.

The hydraulic load should be not more than 80 – 120 l / (m^2 x day)
The organic load should be not more than 50 - 100 g COD / (m^2 x day)

Example:

Compound with 50 inhabitants:

Design according to hydraulic load:

$Q_D = 50\ E \times 225\ l/(Exd) = 11250\ l/d$

$A_{Ahydraulic} = 11250\ l/d / 80\ l/(m^2 x\ d) = 140\ m^2$

Design according to organic load:

$A_{Aorganic} = 50\ E \times 120\ g\ COD\ (E \times d) / 50\ g\ COD / (m^2 \times d) = 120\ m^2$

Required surface area: 140 m²

Chosen number of basins : 3

Area of each Stage A basin: 46.7 m²

Chosen area of each Stage A basin: 50 m²

Stage A distribution points.

The raw waste water is distributed on the Stage A with elevated pipes. The discharge points must be evenly distributed on the surface with a maximum surface area for each distribution point of 60 m² and a minimum number of 2 distribution points for each basin.

Example:

Chosen area of each Stage A basin: 50 m²

Number of distribution points: 50 m²/60m² = 0.83

Chosen number of points: 2 (not less than 2)

4.4.2. Stage B vertical flow

Stage B basins after Stage A basins:

The hydraulic load should be not more than 60 - 80 l / (m² x day)

Single Stage B basins, after pre-treatment:

The hydraulic load should be not more than 60 - 80 l / (m² x day)

The organic load should be not more than 15 - 20 g COD / (m² x day)

Example:

Compound with 50 inhabitants, Stage B Reed Bed after septic tank:

Design according to hydraulic load:

Q_D *= 50 E x 225 l/(Exd)= 11250 l/d*

$A_{Bhydraulic}$ *= 11250 l/d / 60 l/(m²x d) = 187.5 m²*

Design according to organic load:

$A_{Borganic}$ *= 50 E x 80 g COD (E x d) / 15 g COD / (m² x d) = 266 m²*

Required surface area: 266 m²

Chosen number of basins : 2

Area of each Stage B basin: 133 m²

Chosen area of each Stage B basin: 135 m²

4.4.3. Stage B horizontal flow

Stage B horizontal flow basins after Stage A basins:

The hydraulic load should be not more than 40 l / (m² x day)

Single Stage B basins horizontal flow, after pre-treatment:

The hydraulic load should be not more than 40 l / (m² x day)

The organic load should be not more than 15 g COD / (m² x day)

Hydraulic calculation to be done to prove the horizontal hydraulic flow through the filter layer. kf value of filter material (m/s) to be reduced for the calculation by one power ten to the original value before installation.

Example:

Compound with 50 inhabitants, Stage B Reed Bed horizontal flow after septic tank:

Design according to hydraulic load:

Q_D = 50 E x 225 l/(Exd)= 11250 l/d

$A_{Bhydraulic}$ = 11250 l/d / 40 l/(m²x d) = 281.25 m²

Design according to organic load:

$A_{Borganic}$ = 50 E x 80 g COD (E x d) / 15 g COD / (m² x d) = 266 m²

Required surface area: 281.25 m²

Chosen number of basins : 2

Area of each Stage B basin: 140.63 m²

Chosen area of each Stage B basin: 145 m²

4.5. Mechanical Equipment

4.5.1. Stage A

The Stage A pumps should have at minimum the capacity of the peak flow.

And as well should pump the volume of the pump station within 10 – 15 min onto the reed bed basins.

The pumps to be equipped with a cutting device or in larger systems a rotor rake to be installed after the pumps.

Example:

Compound with 50 inhabitants:

Q_D *= 50 E x 225 l/(Exd)= 11.25 m³/d*

Peak flow = 11.25 m³ / 8h = 1.4 m³/h = 0.4 l/s

Flow capacity of pump

$Q_{PA} = V_{PstA}$ */ 10 min*

V_{PstA} *= 0.625 m³ (4.3.2.)*

Q_{PA} *= 0.625 m³ / 10 min = 0.0625 m³/min = 1.04 l/s*

Chosen flow of distribution pump Stage A = 1.5 l/s

4.5.2. Stage B horizontal flow

The pump should pump the volume of the pump station within 10 – 15 min onto the reed bed basins.

Example:

Compound with 50 inhabitants:

Q_D *= 50 E x 225 l/(Exd)= 11.25 m³/d*

Flow capacity of pump

$Q_{PB} = V_{PstB}$ */ 10 min*

V_{PstB} *= 1.875 m³ (4.3.3)*

Q_{PB} = 1.875 m^3 / 10 min = 0.1875 m^3/min = 3.125 l/s

Chosen flow of distribution pump Stage B = 3.2 l/s

4.5.3. Stage B vertical flow

The distribution of the waste water onto Stage B basins is done either with perforated pipes or with spray nozzles. The pump can be a submersible drainage pump, best to use a contractor pump.
The holes in the perforated pipes and also in the nozzles should have a minimum diameter of 8 mm. The area served by one hole should not be more than 5m^2.
If nozzle are used the area irrigated by one nozzle to be less than 12 m^2.
The flow of one hole or spray nozzle is about 0.2 l/s.

The flow capacity of the Stage B pumps perforated pipe distribution:

$Q_{PBV} = A_{BO}$ / 5 m^2 x 0.2 l/s.

Example:
Compound with 50 inhabitants:
Number of Stage B basins: 2
Chosen area of each Stage B basin: 145 m^2
Stage B basins under operation at once: 2
$Q_{PBV} = A_{BO}$ / 5 m^2 x 0.2 l/s = (2 x 145 m^2) / 5 m^2 x 0.2 l/s = 11.6 l/s
Chosen flow of distribution pump Stage B = 12 l/s

The flow capacity of the Stage B pumps with nozzles:

$Q_{PBV} = A_{BO}$ / 12 m^2 x 0.2 l/s.

Example:
Compound with 50 inhabitants:
Number of Stage B basins: 2
Chosen area of each Stage B basin: 145 m^2

Stage B basins under operation at once: 2

$Q_{PBV} = A_{BO} / 12\ m^2 \times 0.2\ l/s = (2 \times 145\ m^2) / 12\ m^2 \times 0.2\ l/s = 4.8\ l/s$

Chosen flow of distribution pump Stage B = 5 l/s

4.5.4. TSE discharge pumps

The drainage outflow of the Stage B basins to be pumped into an irrigation storage tank or can flow into a soak away pit.

If pumped into an irrigation tank a drainage pump can be used with the capacity to pump the daily amount within 10 hours.

$Q_{PTSE} = Q_D / 10h$

Example:

Compound with 50 inhabitants:

$Q_D = 50\ E \times 225\ l/(Exd) = 11.25\ m^3/d$

$Q_{PTSE} = Q_D / 10h$

Flow capacity of TSE pump

$Q_{PTSE} = 11.25\ m^3 / 10h = 1.125\ m^3/h = 0.3125\ l/s$

5. Construction

5.1. Excavation & dams

The most cost effective way of basin construction is the use of excavated material to build a surrounding dam for the basins. Excavation level should be above ground water table.

Other options is the use of block work walls if the soil is not compact-able or the area is limited. The Stage A basins to be build with a free board of at least 50 cm, the Stage B basins with 30cm.

5.2. Lining

The most cost effective way of basin insulation is the use of PVC or HDPE lining. Liner to be not less than 1mm. Liner to be protected by geotextile against the soil. Geotextile not less than 300 g/m².

5.3. Piping

Drainage pipes can be slotted PVC soil pipes. Distribution pipes Stage A are also PVC Pipes, as exposed to the sun these once to be Class D.

Drainage pipe distance not more than 5m. Each drainage pipe to have a vent pipe. A control manhole inside the basins ease the flushing of the drainage pipes. Water level in the basins to be adjustable from 10 cm above sand filter layer to bottom of basin.

Distribution pipes Stage B made from PVC or HDPE pipes (Irrigation pipes).

5.4. Filter layer

5.4.1. Filter layer general

In the inlet and outlet area of horizontal flow reed beds graded grain sizes to be used to separate the filter layer from the course inlet and outlet gravel filter. The inlet pipe structure and inlet gravel filter layer to have enough pore space to accommodate the complete inflow batch and distributing it over the complete width of the basin without waste water leaking to the surface.

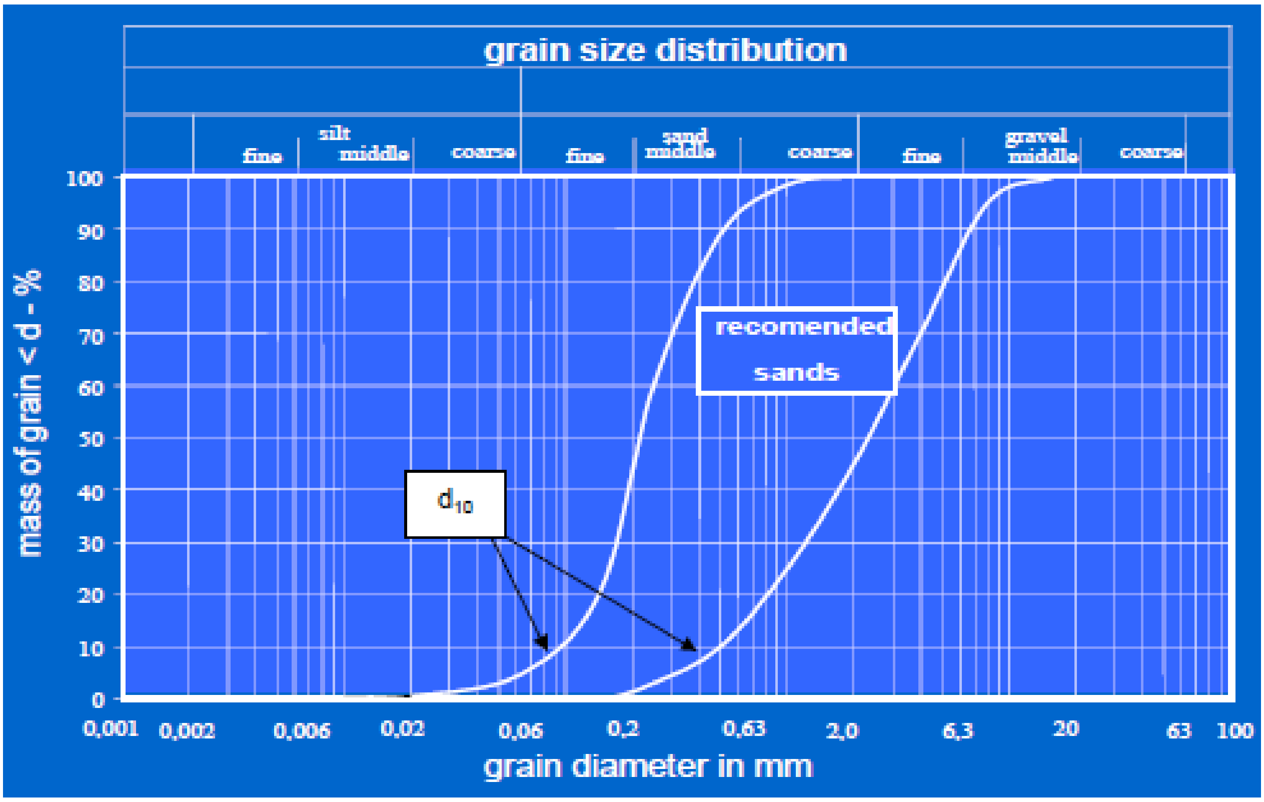
The filter layer itself to be double washed natural or crushed sand material with the following characteristics:

SOIL CHARACTERISTICS OF SAND :

kf = 10^{-4} – 10^{-3} m/s

0.1 mm ≤ d10 ≤ 0.4 mm

(Diameter at 10% passing at sieve analyse to be between 0.1mm and 0.4mm)



Recommended grain size distribution of sand in subsurface flow CWs (Platzer, 1998). The sieving curve of the sand should lie between the two curves indicated in the graph.

GRAVEL

The gravel layer to be of two different size:

First layer to cover the drainage pipes:

Approx. 15 - 30 cm layer crushed or natural gravel 9mm – 30mm size (¾ inch gravel), this layer to balance the slope of the basin and surface of this layer will be on one level.

Second layer above the first, separating first gravel and sand layer:

Approx. 10 – 15 cm layer crushed or natural gravel 2mm – 15mm size (3/8 inch gravel)

5.4.2. Filter layer

	Stage A	Stage B vertical	Stage B horizontal
Filter sand	≥ 30 cm	≥ 60 cm	≥ 60 cm
Gravel layer 2	≥ 10 cm	≥ 10 cm	
Gravel layer 1 (bottom)	≥ 15 cm	≥ 15 cm	

5.5. Plants

The most efficient plant is the reed plant (Phragmites communis). 4 – 6 pcs /m². Best is to use potted plants, which can be planted all year long.

After planting filter layer to kept wet for at least 6 month.

Fresh planted basins to be fenced against goats and camels.

5.5.1. Return flow

A return flow from the effluent back to the inflow (septic tank or Stage A pumping chamber) will support the start-up phase and the Denitrifictation. Up to 100% return flow should be adjustable by valves.

5.5.2. Disinfection

Reed beds reducing pathogens already by 1.5 – 2.5 power of ten, but if the TSE be used for unrestricted irrigation a disinfection step (Chlorination, UV) to be added.

6. Operation

6.1. General

An operational manual to be handed over by the designer/contractor to the owner and operator. Training of operator by reed bed experienced engineer.

A reed bed experienced company to supervise the operation (maintenance contract to be signed). At least once a year the system to be checked by a professional reed bed expert.

Operational works

Plant component	Work	Frequenz	Comment
Pre-treatment	Visual check	monthly	
Pre-treatment	Sludge removal	as required	1st chamber filled by 50%
Bascet screen	Cleaning	daily	
Pumps	visual check	weekly	
Chamber A	Removal of scum	monthly	
Distribution valves Stage A, manual	Operate accoring to distribution schedule	daily	larger systems equipped with automatic valves
Drainage control manholes	visual check	weekly	
Drainage pipes	flushing	yearly	
Distribution system Stage A and B	visual check, flushing	½ year	
Basins	Check water level	weekly	
Dams	Trimming reed plants	weekly	cutting plants growing out of the basins
Reed plants	Cutting and removal of reed plants	every 3rd year	
Operation manual	filling	daily / weekly / monthly / yearly	depends on size of system
In- and outflow	On site sampling: pH, TDS, t	daily / weekly / monthly / yearly	depends on size of system

In- and outflow	Laboratory: COD, BOD, TSS, NH4-N, P, Pathogens	monthly / yearly	depends on size of system
Mechanical Equipment	maintenance	according to supplier	

7. References and further resources

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