AUSTRALIAN Pork™

AUSTRALIAN PORK LIMITED

SEPS: Sedimentation and Evaporation Pond Systems

2015

"We find our SEPS a great system, we separate liquid effluent & solids at next to no cost. We get a dry stackable solid out of the SEP's each year with only a loader."

Producer NSW

PROJECT TITLE:

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INTRODUCTION

The Sedimentation and Evaporation Pond System (SEPS) is a low cost system that uses settling of solids, anaerobic and facultative digestion, and evaporation of liquid to treat and manage effluent. The SEPS concept was developed to overcome the difficulties associated with sludge removal from large, deep piggery effluent ponds and to allow solids to be recovered for use in farming and pasture production. Kruger et al. (2000), Martin et al. (2001) and Watts et al. (2002) describe the concept.

SEPS consist of two or three separate sedimentation and evaporation ponds. These are long, narrow, shallow and trafficable earthen channels, generally built in parallel. At any time, only one channel is active. Piggery effluent is directed into one end of this channel. The manure solids settle and break down while liquid is continuously removed from the other end, generally directed into an effluent holding pond. At the end of the active period, usually six or twelve months, the active channel is taken off-line and the effluent from the piggery is directed to the next channel. Liquid is drained or siphoned from the decommissioned channel(s), leaving wet sludge. This dries by evaporation over time. It can then be removed using earthmoving equipment before being stockpiled ahead of composting, on-farm reuse or sale. Photograph 1 is a SEPS aerial view.

Another potential use for SEPS channels is for drying sludge removed from an anaerobic pond. In this case the SEPS would not have an outlet, it would simply collect, store and dry sludge pumped into it.

Overall Layout

The layout of the SEPS depends on the site constraints and slope. A summary of overall layout considerations follows.

» Effluent may enter the SEPS via channels or pipes directly from the sheds. It may also be pumped from a sump with an agitator if gravity flow is not possible

» The SEPS generally consists of two or three separate channels, one of which is in active use while the other/s are drying or being cleaned. At large piggeries, the required channel length is very long and a two channel SEPS may not be practical. Consequently most existing SEPS include three channels

Photograph 1 Aerial view of contour SEPS. (Photo courtesy of Google Earth)

» On a sloping site, the SEPS channels run along the land contour, with separate channels arranged in parallel down the contour (Photographs 1 and 2)

» On a flat site, the SEPS consists of two or three straight channels arranged parallel to one another (Photographs 3 and 4)

» Providing 30-40 m space between channels offers a contained area for storing the dried solids that will be periodically removed from the SEPS. A gentle slope on this area directs stormwater runoff into the next channel

» Overflow effluent from the SEPS will need to be syphoned to an accompanying sump or holding pond until it can be irrigated, recycled or evaporated. Photograph 5 shows a simple syphon arrangement.

Photograph 2 Contour SEPS channels (photo courtesy of Ian Kruger)

Design and Construction

Channel design and construction needs to consider functional capacity, practical management, environmental protection and safety. Specific requirements follow.

» Provide sufficient capacity to manage the expected solids load. As a guide, each SEPS should be able to store 12 months wet solids, or about 0.5 m^3/standard pig unit (SPU)/yr.

In a two channel system, using a 12 month rotation interval, each channel must be able to store 12 months solids. The drying channel will need to be emptied prior to the end of the 12 month active cycle in the other channel.

If the layout incorporates three separate channels operating on a six monthly rotation interval, each channel should provide volume of 0.25 m^3/SPU/yr (i.e. two channels provide 12 months storage of wet solids). Figure 1 shows a typical configuration for a channel able to store six months solids (three channel SEPS).

» Choose channel dimensions that promote drying and allow for practical solids removal. Providing evaporation rates exceed rainfall during the drying period, evaporation losses are greater if the channel is shallow with a large surface area. The base width of the channel should allow easy operation of the machinery that will remove the dried solids. A channel storage depth of 0.8 m and base width of 6 m works well.

The volatile solids (VS) loading rate to an active channel is about 1000 g VS/m^3/d.

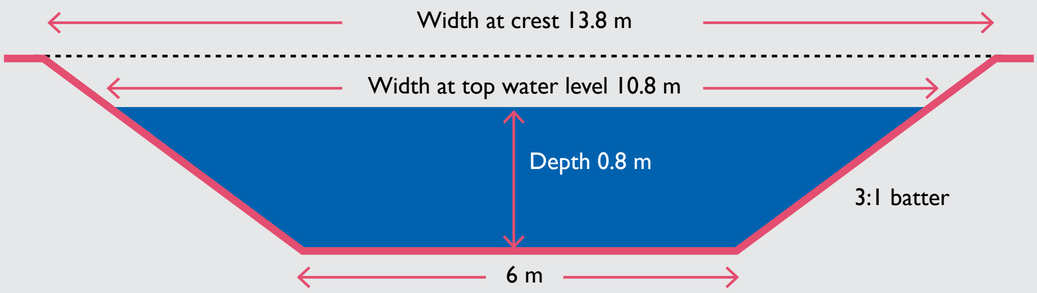
Hydraulic retention times (HRT) vary but are generally 10-25 days depending on flushing volumes.

Photograph 3 Aerial view of SEPS on flat site (photo courtesy of Google Earth)

Photograph 4 SEPS channel on flat site (photo courtesy of Alan Skerman)

Photograph 5 Raised syphon pipe on simple winch at exit end of SEPS channel

FIGURE 1 Typical channel configuration in a three channel SEPS



Loading rate	0.25 m^3 / SPU
Effluent volume per 1000 SPU	250 m^3
Cross sectional area to Top water level (TWL)	6.72 m^2
Top water level (TWL) length per 1000 SPU*	39.4 m
Top water level (TWL) surface area per 1000 SPU*	410 m^2

Table 1 shows example channel volumes and lengths for a three channel-SEPS for five different sized piggeries. Figure 1 shows the typical channel configuration in a three-channel SEPS.

TABLE 1 Channel Volumes and Lengths for a Three Channel SEPS for Different Sized Piggeries

No. SPU	Volume at outlet (ML)	Length at base (m)	Length at top water level (m)	Length at inside crest (m)
1000	0.25	34.6	39.4	42.4
2500	0.63	90	95	98
5000	1.25	183	188	191
7500	1.88	276	281	284
10,000	2.50	369	374	377

In all cases:

» calculations include batter on ends of SEPs

» base width is 6 m

» TWL depth is 0.8 m

» freeboard is 0.5 m

» internal batters are 3 horizontal:1 vertical

» width at TWL is 10.8 m

» width at crest is 13.8 m

» Design for solids settling and drainage of surplus liquid. To encourage settling use a level base along most of the channel length. Provide a gradient of 0.4% at the exit end of the channel to promote drainage.

Provide:

» 25-30 m of slope length for channels 50-100 m long

» 30-50 m of slope length for channels 100-200 m long

» 100 m of slope length for longer channels.

To achieve 0.4% slope, the depth at the exit end of the channel needs to be 0.2 m deeper than at the entry end for a slope length of 50 m, and 0.4 m deeper than at the entry end for a slope length of 100 m.

» Install an overflow syphon pipe with a minimum diameter of 75 mm at top water level at the end of each SEPS channel. The overflow pipes should direct flow to a sump or effluent holding pond. Pipes can be installed permanently through the channel bank. However, a syphon pipe with adjustable height provides greater flexibility. Raising the pipe inlet can provide temporary extra effluent storage. Lowering the pipe inlet allows excess effluent to be drawn down to facilitate solids drying. A simple system is shown in Photograph 5

» Banks and walls must provide for safe access by the machinery that will be used to remove solids. They must be structurally stable with suitable slopes. Bank crests should be at least 4 m wide. Batters of at least 4 horizontal to 1 vertical on external walls, and 3 horizontal to 1 vertical on the internal walls of the channels, are recommended. Earthen ramps, with gradients of 10 horizontal to 1 vertical, on the ends of the channels are recommended (Skerman 2013)

» Protect surface waters. The effluent holding pond/s following the SEPS must be sized and managed to overtop (spill) no more often than once every 10 years, on average.

Provide freeboard of at least 0.5 m on the channels to avoid overtopping due to imperfections in crest height, earthworks settlement and wave action.

Runoff from removed solids stored between the SEPS channels also needs to be contained, most easily by ensuring runoff is directed into the channel below.

If the area between channels will not be used for storing removed solids, providing cross-slopes of 2.5% on the external banks of channels will encourage drainage of stormwater runoff away from adjacent channels (Skerman 2013).

» Protect groundwater by ensuring that the permeability of the SEPS base and walls does not exceed a design standard of 1×10^{-9} m/s. Department of Agriculture, Fisheries and Forestry (2009) provides guidance on how this may be achieved. The base of the SEPS, and any accompanying effluent holding pond, must always be at least 2 m above the highest seasonal groundwater table.

"The SEP's allows us to access & utilise the fertiliser easily & annually. There is no struggling to empty a dam full of solids."

Producer NSW

Key channel design recommendations:	
bed width	6 m or more
internal batters	3 horizontal : 1 vertical
external bank batter	4 horizontal : 1 vertical
storage depth	0.8 m on flat section, ~1-1.2 m at exit end
freeboard	0.5 m
channel length	Varies depending on site constraints
bed gradient	0% for most of length 0.4% for last 50-100 m

Based on Skerman (2013)

Construction

A smaller SEPS can be constructed using a medium sized bulldozer. A scraper will be much more efficient for a larger SEPS, especially if laying down material to compact. A sheep's foot roller, vibromatic compactor or similar equipment will need to be used to ensure adequate compaction (Photograph 6).

The walls and base of the channels and the base of the solids storage area must be lined with suitable clay material that can be compacted to a design permeability of 1×10^{-9} m/s.

Sometimes, the in situ soil will be suitable for compacting to the required standard. Soil testing will confirm whether this is the case. If the in-situ material is suitable, the required permeability standard may be achieved by:

» scarifying or ripping to a depth of 150 mm

» watering (if required) to produce the correct moisture content (in the range from 2% wet to 2% dry of optimum)

» compacting to 95% of standard maximum laboratory dry density.

Photograph 6 Vibrating pad foot roller compacting the base of a SEPS channel (photo courtesy of Alan Skerman)

If the in-situ soil is not suitable, over-excavation and clay lining to a depth of 300 mm may be necessary. See Department of Agriculture, Fisheries and Forestry (2009) for more information on meeting these criteria.

Soil testing can confirm that the lining material is suitable and that the design permeability has been achieved. The integrity of the lining material should be regularly checked and maintained as needed.

Operation

SEPS are simple to manage and require minimal supervision and maintenance. A SEPS operates as follows:

» Effluent flushed from the sheds is drained or pumped directly into one end of the active channel. Liquid continuously drains or is syphoned off the exit end to an effluent holding pond or sump. If an overflow pipe is used, it needs to be regularly inspected for blockages

» Solids settle along the length of the channel although there is a greater accumulation near the entry end. For this reason, there is greater anaerobic activity near the entry graduating to facultative activity towards the exit end where solids accumulation is light. The volatile solids (VS) loading rates to SEPS channels are about 1000 g VS/m^3/d. This is considerably higher than the recommended maximum loading rates for anaerobic ponds of 450 g VS/m^3/d in a cool climate to 750 g VS/m^3/d in a warm climate

Photograph 7 Full SEPS channel with crust formed over solids

» A crust forms over the accumulating solids, gradually covering the length of the channel as it fills (Photograph 7). This appears to reduce the odour emissions

» Each channel in a two channel SEPS provides for 12 months solids storage and is in active use for a year (typically from the start of the dry season). In a three channel system, each channel stores six months solids and is in active use for six months. In both systems, when the active channel is full, it is taken off-line. The channel is drained by pumping or siphoning out all excess liquid to a holding pond and the solids are allowed to dry over the next 6-12 months through evaporation

» The crust that forms over the drying solids inhibits evaporation rates. Hence, it needs to be broken up periodically. Chaining several old tractor tyres together and dragging them across the channel in both directions is effective. A tractor of at least 90 horsepower is needed. The tyres fill with wet sludge and their movement creates a wave that mixes the dry surface material with the wetter solids beneath. Some drier solids are also pushed up the side of the bank

» Wet solids are easily removed with a front end loader or excavator. This is a relatively quick process, taking about one day for a 600 m long channel. If the solids are too wet for removal with heavy machinery, the channel contents can be agitated within the channel then removed using a vacuum tanker that can also spread the removed material onto nearby land (Skerman 2013). If the solids are allowed to fully dry in the channel they can be efficiently removed using a front-end loader.

Maintenance

Properly constructed and compacted SEPS require minimal maintenance. They should be regularly monitored to check for blocked pipework, excess solids deposition and excess crust formation, all of which may inhibit function.

The banks should be periodically inspected and any required repairs undertaken to maintain freeboard height. In the unlikely event of a bank breach, repairs must occur as soon as practical.

Performance

Payne et al. (2008) investigated the performance of SEPS at Young, NSW and Mingenew, WA. The SEPS provided good primary treatment of the liquid effluent, reducing:

» total solids (TS) by 77%

» VS by 82%

» total Kjeldahl nitrogen (TKN) by 36%

» phosphorus (P) by 89%.

Table 2 shows the full chemical composition results for the SEPS influent and effluent and the composition of removed solids. It also includes data collected by Skerman (2013) who measured similar performance by a Queensland SEPS, with removal rates of 62% for TS, 83% for VS, 46% for N and 88% for P.

The VS removal by the SEPS compares well with that of anaerobic ponds (Tucker et al. 2010 and Skerman et al. 2008).

SEPS provide good primary treatment achieving VS reductions that exceed those realised by conventional anaerobic ponds.

The dried solids removed from the SEPS contain valuable nutrients. Table 2 provides data collected by Payne et al. (2008) in their research into the performance of NSW and WA SEPS. The values reported are the mean of composite samples taken from each quarter length of the SEPS channel.

Samples from both systems were taken in summer, after the solids had been stacked on the bank of the NSW SEPS and in situ from the WA SEPS. Consequently, the moisture content of the WA solids was 30% higher than that of the NSW solids.

The nutrient concentration data for solids presented in Table 2 are on a dry matter basis (i.e. the concentration in the solids only). The concentration in the wet solids can be calculated using the following formula:

Concentration in wet solids(g/kg) = DM concentration (g/kg) X TS content (%)

Hence, the nutrient concentrations of the wet solids are 10.9 g N/kg, 9.2g P/kg and 2.2 g K/kg (at a TS content of 68%).

TABLE 3 Chemical composition of SEPS influent, effluent and removed solids

Analysis	Average of all influent and effluent samples from SEPS in NSW & WA (mg/L except as stated) (Payne et al. 2008)			Average of Qld influent and effluent samples (mg/L except as stated) (Skerman 2013)			Average of solids samples from SEPS in NSW & WA (mg/kg except as stated) (Payne et al. 2008)		
	Influent	Effluent	% Reduction	Influent	Effluent	% Reduction	NSW	WA	Average
Total Solids	34425	7843	77%	12563	4800	62%	42	22	32
Total Dissolved Solids	6562	5982	9%						
Volatile Solids	18,705	3313	82%	10,000	170	83%			
Total Carbon							232,500	357,500	295,000
pH units	7	8	-9%				6.7	6.3	6.5
Conductivity (uS/cm)	17,592	17,675	0%				10,948	11,615	11,281
Ammonia-N	1811	1491	18%				1795	3250	2523
Nitrate-N	14	17	-21%				328	590	459
Total Kjeldahl Nitrogen	3113	1997	36%	1100	580	46%			
Total Nitrogen							29,825	38,525	34,175
Total Phosphorus	495	55	89%	300	30	88%	38,250	19,275	28,762
Potassium (acid extractable)	1093	1049	4%	300	450	-	9368	4533	6950
Copper (extractable)	5	1	90%				240	494	367
Manganese (extractable)	11	1	92%				757	465	611
Sulfur	172	45	74%				4585	8730	6658
Zinc (extractable)	20	2	90%				1112	743	927

It is possible to put a worth on the N, P and K of these solids using the value of these nutrients in inorganic fertilisers. Commercial, bulk, delivered fertiliser prices were obtained for common N, P and K fertilisers. These were $550/t for urea, $800/t for triple superphosphate and $800/t for muriate of potash.

» Since urea is 46% N and costs $550/t, N can be valued at $1.20/kg (i.e. ($550/t / 0.46)/1000)
» Triple superphosphate contains 20% P and costs $800/t. The P in triple superphosphate is worth about $4/kg (i.e. ($800/t / 0.2)/1000)
» The K in muriate of potash is worth about $1.60/kg (i.e. ($800/t / 0.5)/1000).

On this basis, SEPS solids have a NPK fertiliser value of about $53/t (excluding GST), assuming the receiving crop/soil system needs all of the nitrogen, phosphorus and potassium contained in the material. If not, the value drops. For example, if the soil is deficient in nitrogen and phosphorus but has enough potassium the value declines to about $50/t.

Using data for the number, volume and weight of solids removed from the SEPS, the dry density of this material is estimated at 800 kg/m^3. Hence, the NPK fertiliser value on a volumetric basis is around $43/m^3.

These values do not consider the availability or release rates of nutrients, the value of trace nutrients or the soil conditioning effects of carbon (29.5%) which may increase crop yields. Nor do they consider that transport, handling and spreading costs are considerably higher compared with inorganic fertilisers (say $35/t). Hence the real NPK value of SEPS solids may be more like $8/t.

Capital and Operating Costs

Watts et al. (2002) presented indicative data on the capital and operating costs of SEPS. These are presented, with updated costing, in Table 3. In addition, an effluent holding pond would need to be built. Economically, the SEPS compare well with other solids removal and effluent treatment technologies. Earthworks costs vary between sites and quotes should be obtained from at least two contractors.

Environmental Considerations

The main environmental considerations for effluent treatment systems are odour minimisation and protection of surface water and groundwater quality.

» Odour levels have been measured on SEPS in QLD, NSW and WA. Skerman (2013) measured odour emissions from a Queensland SEPS. The maximum emission rates recorded were within the range measured for conventional anaerobic ponds (Hudson 2004) and for a highly loaded anaerobic pond in southern Queensland (Skerman et al. 2008).

Hayes et al. (2007) measured odour levels from the same NSW and WA SEPS investigated by Payne et al. (2008). Odour emissions were relatively high in the short section close to the inlet of the active channel, with consistent low levels along the remainder of the channel. Progressively lower odour emission rates were recorded for the channel during the first six months of drying, the stockpiled solids removed from the SEPS and the channel during the last six months of drying.

Considering the lower surface area of the SEPS, and the similar or lower odour emission rates, it is likely that less odour will be released from a SEPS than from an anaerobic pond for a similar sized piggery. Nevertheless, in some situations, covering the inlet section of the active SEPS channel could substantially reduce odour.

During wet weather, when effluent irrigation cannot occur, effluent flowing through the SEPS and rainfall captured within the SEPS needs to be collected in effluent holding ponds. Sufficient capacity must be designed into the effluent holding ponds so that the system has an overtopping (spill) frequency not exceeding once every 10 years, on average.

» Protect groundwater by meeting the permeability standard detailed earlier in this booklet. Ensure the base of the SEPS, solids storage areas and effluent holding pond is at least 2 m above the highest seasonal groundwater table.

TABLE 4 Capital and operation costs of SEPS (updated from Watts et al. 2002)

Item	Units	200-sow low-flush	200-sow high flush	2000-sow low-flush	2000-sow high flush
No of pigs	SPU	2134	2134	21340	21340
Flushing	L/SPU/day	5	25	5	25
Hosing	L/SPU/day	1	2	1	2
Total effluent[a]	ML/yr	9	25	85	250
Effluent flow (24 hr)	L/s	0.27	0.79	2.7	7.9
Solids in effluent	% TS	3.10%	1.20%	3.30%	1.20%
Solids	t/yr	270	290	2800	2940
Solids Removal[b]	%	60%	60%	60%	60%
	t/yr	161	175	1679	1763
Capital cost[c]	$	$4,017	$4,017	$19,510	$19,510
$/ML treated /yr		$446	$161	$230	$78
$/t solids removed /yr		$25	$23	$12	$11
Operating Cost					
Pumping	$/yr (power)	$832	$1,949	$4,182	$8,963
Agitation (Tractor)	Labour hr/yr	2	2	10	10
	$ /yr (tractor)[d]	$120	$120	$600	$600
Excavator Cleaning	Labour hr/yr	4	4	24	24
$ /yr (excavator)[e]		$480	$480	$2,880	$2,880
Stockpiling solids	$/yr[f]	$97	$105	$1,680	$1,760
Total Operating	$/yr	$1,529	$2,654	$8,802	$14,203
	$/ML treated	$170	$106	$104	$57
	$/t solids removed	$9.50	$15	$5	$8

a Total effluent includes flushing water, hosing water, manure and drinking water wastage.
b These figures are adopted as typical of solids settling without additives.
c Capital cost includes earthworks for SEPS, sump and diversion banks.
d Tractor and driver costed at $60/hr.
e Contract excavator and operator costed at $120/hr.
f Removing and stockpiling solids using truck and front end loader @ $0.60/t.

Conclusions

SEPS have relatively low capital and operating costs compared with other solids separation and effluent treatment systems. They treat the effluent as effectively as anaerobic ponds. For existing piggeries, they can be added in front of conventional effluent treatment ponds if space permits.

Odour levels from SEPS are similar to, or lower, than those of conventional anaerobic ponds. Often removed solids can be stored in the area/s between channels, with contaminated runoff directed back into the SEPS. The dried solids can be readily handled and spread. In most cases a holding pond will need to be used in conjunction with the SEPS to handle the extra rainfall generated during wet weather.

SEPS have very low capital and operating costs. They provide effective solids removal and effluent treatment.

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Disclaimer:

“The SEP system means we don’t waste money and effort freighting liquid.”

Producer NSW

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