

Case Study 1 - TRAFFICABLE SETTLING BASIN

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1.1 Description of the System

The effectiveness of settling devices depends on density differences between the solids and the liquid. That is, the systems are based on gravitational settling where the solid/liquid mixture is confined in a structure, and the solid component is allowed to settle to the bottom enabling the liquid component to be removed from the top of the storage.

As described in Section 7.1 (Part A report) there are various types of settling systems. These primarily include basins or tanks. Tanks may be operated in batch or continuous mode. When operated in batch mode, the effluent is poured into a tank and allowed to settle. The supernatant is discharged from the tank when settling is complete, or alternatively it is slowly drained out of the tank. A bottom scraper may transfer solids to a storage hopper. If operated in continuous mode, complex flow monitoring and chemical dosing equipment is required. Compared with batch tank systems, these systems have higher capital, operating, and maintenance costs. The operating costs depend on the degree of automation and the chemical usage (Kruger *et al.*,1995).

In basins, settling occurs when the velocity of the liquid is slowed sufficiently to allow the heavier and denser particles to be pulled to the bottom by gravity. All settling basins are designed to operate so that the velocity of the entering liquids is significantly reduced, and the liquid is then allowed to slowly drain away.

There are various types of basins. These include large earthen storages that collect up to 12 months of solids, or smaller trafficable sedimentation basins that are frequently cleaned. These basins contain relatively moist solids and are cleaned irrespective of weather conditions and basin condition.

In basins that are infrequently cleaned, partial decomposition is possible and accessing the solids can be difficult. Barker (1996) suggests earthen settling basins are built with the capacity to store 6 to 12 months of solids. The suggested dimensions of the basins include a basin top width of 30 metres or less, a length to width ratio close to 3:1, and a liquid depth of 2.5 to 3 metres (Barker, 1996). He suggests using a liquid manure spreader or slurry irrigator to mix the basin contents thoroughly prior to land spreading. This recommendation indicates that the solids in such a basin contain large amounts of water, and that the device is very likely to behave like an overloaded anaerobic pond. It is for these reasons that large, longer term settling basins are not recommended unless covered due to odour problems. Regular sludge removal is necessary to prevent the development of septic conditions and sludge re-suspension. Barker (1996) suggests that settling basins should be 0.6 to 1.0 m deep, with concrete floor and walls. The use of concrete flooring is recommended as it improves access by earth moving equipment under wet conditions.

Very few settling basins are used in comparison to mechanical screens for the removal of solids from flushing wastewater. The removal of solids and not the treatment efficiency is likely responsible for this. A settling basin design was studied in 1987 in Taiwan for treating piggery wastewater. They used four chambers, each 20 metres long, 7 metres wide and 4.5 metres deep. The flow was directed from the operation (which produces 40,000 pigs for market annually) into a single chamber on a four-day rotation. The liquids drained down the 1/150 slope and exited the basin through a

stainless steel, 5 mesh screen. On the fourth day the basin was emptied using a front-end loader on the concrete floor, and the solids were applied to the land surface. It was found that the settling basin removed 26% of the biochemical oxygen demand (BOD) and 81% of the suspended solids (SS). Data collated by Payne *et al.* (1995) confirms these percentages, whilst also showing laboratory results for nutrient removal of settling systems. The recovery of solids by settling was greater than that of mechanical screens, though Payne (1986) noted that the most efficient system for solids recovery was likely to be a combination of both mechanical screening and settling.

Lott and Skerman (1995) determined the physical and settling characteristics of feedlot manures and investigated hydraulic performance in order to design shallow settling basins for the feedlot industry. These basins have been designed for rainfall runoff events that carry manure from open pen areas. They determined that settling basins should be shallow (typically 0.3 to 1.0 metres deep), long, wide, and free draining. It is important to note that while various researchers state that a settling basin must have a detention time (eg, 10, 15, or 30 minutes) or hydraulic retention time (eg. at least 20 to 30 minutes; Mukhtar *et al.*, 1999), the design should in fact be based on depth of flow, flow velocity, and length of travel. Combined with these, the minimum solids storage capacity and head discharge characteristics of the outfall, which enables regulation of flow velocities within the settling basins, need to be considered. Based on the work of Lott *et al.*, (1994) and Payne (1984 and 1996) it appears that both feedlot and piggery settling systems should aim to reduce flow velocities to below 0.005 m/s and ideally to less than 0.003 m/s. Limiting the depth of the device reduces the time taken for a solid particle to fall to the bed of the basin and therefore good design practice focuses on limiting the depth of the facility.

The key features of a trafficable settling basin are:

- Shallow and flat
- Very low flow velocities
- Free draining with discharge flow regulation that meters outfall rates and the velocities of flows within the basin

1.2 Manufacturer/Distributor

In 1999, E.A. Systems Pty Limited used first principles from settling, density, particle size characteristics from research documents (Payne, 1984, 1986) to design a trafficable settling system for a piggery in central NSW. The specific design criteria were based on the piggery inputs and expected effluent stream from the system.

Two trafficable settling systems were designed to meet the needs of the 2,400-sow farrow-to-finish facility. The first settling system was designed on the feed consumption and hence waste generation rates of two sow modules and the resulting wastewater characteristics. The feed consumption and waste generation rates were considered to be critical design criteria for determining the required storage capacity of the settling system, as was the cleaning frequency.

The system was designed with dual basins that allowed one to be accumulating solids, while the other was being decanted and cleaned. The sediment basin was designed with an entry slope suitable for ease of front-end loader access (minimum slope ratio of 1:7). The width of the sediment bays was based on the overall width of the loading equipment to be used. The length of the sedimentation bays was based on the overall wastewater loading rate from the piggery modules. Figure 1-1 indicates the basic design plans of a trafficable settling system.

The basic feed types in use at the sow modules consisted of a coarse maintenance diet, whilst the ration provided to the growers was a high energy, more finely prepared diet. Similar flushing systems were used at both facilities. The effluent streams from both modules contained 1-3% TS. The second settling system was designed to accommodate a further two pig modules which housed grower pigs on a different feed ration with a greater intake of feed and hence an increased waste generation rate.

The initial cleaning frequency was based on cleaning each basin every 3 to 4 days. A bulk density of solids had been assumed in the design together with a solids recovery efficiency. The design allowed a front-end loader to be used in order to remove solids (refer to Photograph 1-1 and Photograph 1-2).

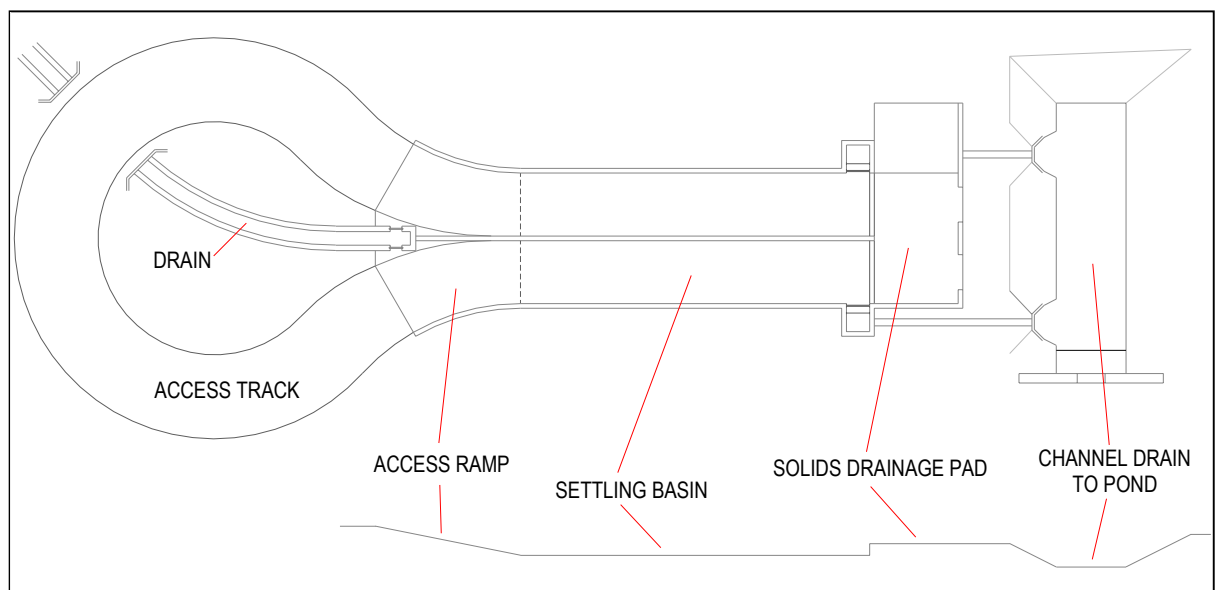


FIGURE 1-1 - TYPICAL BASIN CONFIGURATION.



PHOTOGRAPH 1-1 - TRAFFICABLE SETTLING BASINS CURRENTLY USED FOR A 2400 SOW FACILITY



PHOTOGRAPH 1-2 - REMOVAL OF SOLIDS FROM SEDIMENT BASINS

1.3 Information Sources

The information presented in this case study is derived from 2,400-sow farrow-to-finish facility.

1.4 Performance Data

Settling has the potential to remove more solids than most mechanical separation alternatives, but requires more management. There is also the potential that significant odours will be generated if settling basins are not regularly cleaned. For that reason, concreted trafficable sedimentation basins, or batch-operated sedimentation tanks, are recommended. These systems enable about 75% of the volatile solids (VS) in effluent to be settled relatively easily.

According to Kruger *et al.* (1995), about 60% of the VS in piggery effluent will settle by gravity. A detention time of 100 minutes will ensure almost complete settling. However, 50% of solids will settle within 1 minute, and 75% within 10 minutes. The remaining VS are colloidal and can only be settled through the addition of coagulants. It is suggested that over 55% of TS, 70% of VS, 20% of nitrogen (N) and 40% of phosphorus (P) can be settled without the addition of coagulants. Addition of lime may increase the settling rate to 65-70% of TS, 80% of VS, 30-35% of N and 70-90% of P (Kruger *et al.* 1995).

Oleszkiewicz (1979) suggested that aerating effluent for 30 minutes prior to settling improves the solids settling rate by 4%. He indicates that 75% of TSS is removed after 30 minutes of settling, with only a marginal improvement over longer time periods. The BOD removal rate was 35%, and the COD removal rate was 55%.

The interest in the “draining dry” settling basin is important in its application to livestock systems, because common front end tractor loaders can be utilised to empty the basin and move settled solids. Practical use of the settling systems requires them to have a concrete bottom to allow wheel tractor access to remove the settled solids. A slot or ‘v’ notch outlet will allow the basin to drain dry and still not overtop. The design of the outfall device is critical to the efficiency of the system, because it also directly affects the flow characteristics of the fluid inside the basin and therefore the settling efficiency of the system.

1.5 Running Costs and Maintenance of a Trafficable Settling Basin

The capital cost of installing a sediment basin such as that shown in Figure 1 is about \$15,000 for a 2400-sow facility. The basin in this figure was the smaller of the two sets of dual basins built for a 2400-sow farrow-to-finish operation. The estimated cost of one dual basin system would range between \$10,000 to \$20,000, depending on the site characteristics and the type of production system.

The operational time required to manage the system can be minimal if it is regularly cleaned and kept free of blockages. Nominally an hour every second day will keep the unit below a 2400-sow facility operating adequately. This time is spent keeping

drain openings and outfalls free, and the gates being opened and closed between each of the basins.

It takes between 10 to 20 minutes to completely clean a basin with a front-end loader every second day. The length of time taken is dependant upon the extent of solids dewatering. Solids from the sow operation are relatively coarse and dewater quicker than those from the grower facility. Solids from grower facilities, even when dewatered, tend to retain water in the voids between particles. Generally speaking, it takes 10 minutes to clean the basins below the sow units and 20 minutes to clean the basins below the grower facility. A further 10 minutes may be used for handling wet solids in drying areas following their delivery.

The cost of solids recovery from the basins has not been measured. It is possible to determine the cost of the operations by using an equivalent hourly rate for a front-end loader, together with the labour cost of the operator. This is considered to be \$50 to \$60 per hour in total.

Based on this information about 5 hours is required from a labourer to manage a dual basin system each week. A further 2.5 hours of front-end loader operation is also required for this basin (it is assumed that the loader is onsite and does not have to travel to the site and also that the loader is owned by the piggery).

1.6 Practical Operating Issues

Trafficable settling basins are a relatively simple system. They have very few moving parts and because they operate with gravitational flow they require no pumps or agitators. While they are a low cost alternative to systems currently used by piggeries, they do require a constant input of labour and frequent cleaning by a front-end loader.

The piggery that has installed the two basin systems has experienced good results in solids recoveries below the sow units and found that the solids can be used directly by a vermi-compost operation. The unit managers of the sow sheds has taken a particular interest in the operation of the basins and have allocated the time necessary to effectively operate the basins.

This has not been the experience with the system below the grower facility. While these basins were designed to promote settling and storage of greater amounts of solids associated with the grower units, no allowance was made for an increased requirement for dewatering time for the finer solids. The amount of solids recovered by the basins was also underestimated. This has resulted in these basins being overloaded with solids that are inherently more difficult to dewater and handle. The options for improving the effectiveness of this facility are: to increase the number of settling basins at the site to allow for greater solids storage capacity and dewatering time; or alternatively utilise a screen at the start of the basins to remove coarse solids and thus use the basins to capture the fines not otherwise captured by a screen. Because these basins are also somewhat removed from the vermi-composting operation (i.e. not within eyesight) less attention has been paid to their regular cleaning. This has resulted in basins becoming septic and solids bypassing to holding ponds.

1.7 Piggery Case Studies

Four hypothetical piggery case studies have been analysed. These are a 200-sow and a 2,000-sow unit operated under low flushing (5 L/SPU/day) and high flushing (25 L/SPU/day) regimes. Capital and operating costs were estimated using data supplied by the manufacturer. It was assumed that power costs were \$0.13/kWhr and labour costs were \$25/hr. Table 1-1 provides summarised capital and operating costs.

TABLE 1-1 - CAPITAL AND OPERATING COSTS OF TRAFFICABLE SETTLING BASIN

Item	Units	200-sow low-flush	200-sow high flush	2000-sow low-flush	2000-sow high flush
No of pigs	SPU	2,134	2,134	21,340	21,340
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 content of effluent	% TS	3.1	1.2	3.3	1.2
Solids	t/yr	270	290	2800	2940
Data - Trafficable Settling Basin					
Flowrate	L/s	0.26	0.79	2.70	7.93
	hrs/day	24	24	24	24
Operation	hrs/yr	8,760	8,760	8,760	8,760
	ML/yr	8.3	25.0	85.1	250.2
Solids Removal ^b	%(of TS)	50	50	50	50
	t/yr	135	145	1,400	1,470
Capital cost ^c	\$	8,000	8,000	30,000 ^e	35,000 ^e
	\$/ML treated /yr	964	320	353	140
	\$/t solids removed /yr	60	55	21.5	24
Operating Cost	machine time - hrs/yr	225	225	900	900
	\$/yr (\$50/hr) ^f	11,250	11,250	45,000	45,000
	Labour hr/day	0.5	0.5	1	1
	\$/yr (labour) ^d	3,250	3,250	6,500	6,500
	\$/yr	14,500	14,500	51,500	51,500
Total Operating	\$/ML treated	1,750	580	605	205
	\$/t solids removed	107	100	37	35

^a Total effluent includes flushing water, hosing water, manure and drinking water wastage.

^b While the manufacturer claims a higher solids removal percentage, this figure is adopted until better data is available.

^c Capital cost includes a shed to cover the filter and a manure collection sump with pumps and agitator.

^d Labour for monitoring and maintenance costed at \$ 25/hr

^e Two dual basin systems used on the site

^f Machine use has been added at full cost rather than a cost associated with additional use for a pre-existing onsite machine

1.8 Summary - Selection Criteria

The trafficable settling basin is a relatively low cost solids removal system. While it offers both reduced costs for the recovery of solids from wastewater and relative simplicity of operation, its use does have the potential to cause waste management problems. Poor design, and management may result in reductions in solids recovery rates, and the production of odour from septic basins. If insufficient storage space is provided for the dewatering of faecal matter derived from finely prepared diets, then the recovered solids will contain enough water that the solids will act as a slurry that will require further dewatering/drying before handling.

1.8.1 Solids removed

Few data exist on field assessments of trafficable settling systems. The only operational device in Australia has not been formally assessed for its efficiency. However, the piggery does collect data on the volume of solids that are collected from the devices and passed to a vermi-composting operation. These data show that the volume of solids collected from the systems is about twice that previously obtained from solids collections from run-down screens. Research findings show solids recoveries are about 50%. Reductions in solids recoveries have occurred when basins have not been regularly cleaned. This has been especially the case with the basin collecting solids from the grower facility.

1.8.2 Capital cost

From Table 1-1, the capital cost of installing a settling basin is comparatively low. The installation is dependant upon being able to gravity feed wastewater through the system. The minimum head differential required across the basin is about 0.7 metres. Ideally 1 metre is used for the basin to ensure that it is free draining and to promote dewatering of the solids. The ease of obtaining this head differential will influence the cost of drainage works associated with passing water into and out of the basin. The calculations of operating costs of other systems that use mechanical separation need to include ongoing maintenance and pump running costs, and also include items such as bearings for agitators at a unit cost of \$2,000 every 18 months. With the low maintenance and running costs, the overall costs are similar to or below that of other solids removal systems. The capital cost could be about \$8,000 for a 200-sow piggery and \$30,000-\$35,000 for a 2000-sow piggery.

1.8.3 Operating costs

From Table 1-1, the operating costs could range from \$35 to \$107 per tonne of solids removed. The operational costs are generally low and are based on the assumption that the piggery has a front-end loader already on site, which is likely at the 2000 sow facility, however unlikely at the 200 sow facility. These costs would be higher if a

contractor was used to recover solids from the basin. This is not considered to be a practical option for operation of a basin at the 200-sow facility.

1.8.4 Ease of operation

The settling basins are easy to operate if the flow structures into and out of the basins are kept clean. Failing to clean the basins will result in solids bypassing to holding ponds, thereby increasing the ponds solids loading rates and potential for odour generation. Odour will also be generated from the basins if they turn septic.

The fundamental requirements of basin management are:

- The need for close attention to the management of waste water entering into the basin and the rate of solids accumulation so the flow can be directed from one basin to the next when one is full
- Careful release of supernatant water covering the settled solids and thereafter water leaving the solids
- Frequently cleaning with concurrent maintenance of flow control structures.

The need for a steady input (albeit at a low level) of work time into operating the settling basin is a potential key failing of the system. Without such an input they will not operate effectively and the solids will bypass to the holding ponds and odour generation from the basin and the ponds may occur.

1.8.5 Solids management options

Experience has shown that the solids removed from sow facilities are relatively dry. These solids have been dry enough to use directly in a vermi-composting operation. The solids could also be placed directly into a compost windrow. Solids collected from a basin below grower facilities were found to retain water and remain in a slurry form. The design of this basin did promote settling as designed, but it did not allow sufficient time for dewatering of the solids. Solids in the basin remained in a slurry and those removed from the basin needed to be stored in a solids drying area before they could be easily managed.

1.9 References

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PHOTOGRAPH 1-3 - DUAL SETTLING BASINS (OVERLOADED)



PHOTOGRAPH 1-4 - OVERFLOW WEIR WITH SCUM BOARD