Nakhon Sawan Water Treatment Plant
Nakhon Sawan, Thailand

1. Background Information

Nakhon Sawan is located about 250 km north of Bangkok and marks the point of confluence of two of major Thai rivers, the Ping and the Nan. These two rivers converge to form the Chao Phraya, which flows south to Bangkok and out into the Gulf of Thailand. Nakhon Sawan water treatment plant operates as Build-Operate-Transfer (BOT). The plant is operated by Nakonsawan Water Supply Company Limited under Universal Utilities Company Limited (UU). The Provincial Water Authority (PWA) signed the contract with the company on 7 November 2000 and the commercial operation of the water treatment plant commenced from 1 March 2003. Further background information about Nakhon Sawan WTP is shown in **Table 1.**

Table 1 Overall Information of Nakhon Sawan Water Treatment Plant

Constructed Year	2003
Water Source	Chao Phraya River
Number of connections	8,446
Population served	42,230
Peak Operating Flow (m^3/h)	352
Design capacity (m^3/h)	600
Peak/Design flow	0.59
No. of operators working at the plant	3
Date of access of the source information	2013
Reference	(Universal Utilities, 2015)

2. Water Treatment Process

The major processes are as follows:

- Raw water extraction (intake) → Pipe-line static mixing (PAC and pre-chlorination) → Flocculation (baffled channel type) → Sedimentation (rectangular, tube settler) → Rapid sand filters (fine sand) → Clear water tank (Liquid chlorine disinfection) → High Lift Pump Building (to distribution network).

- Sludge generated from sedimentation tank and filter backwash are collected and sent to sludge drying bed and sludge storage pond.

Figure 1 below shows the treatment process at Nakhon Sawan WTP.

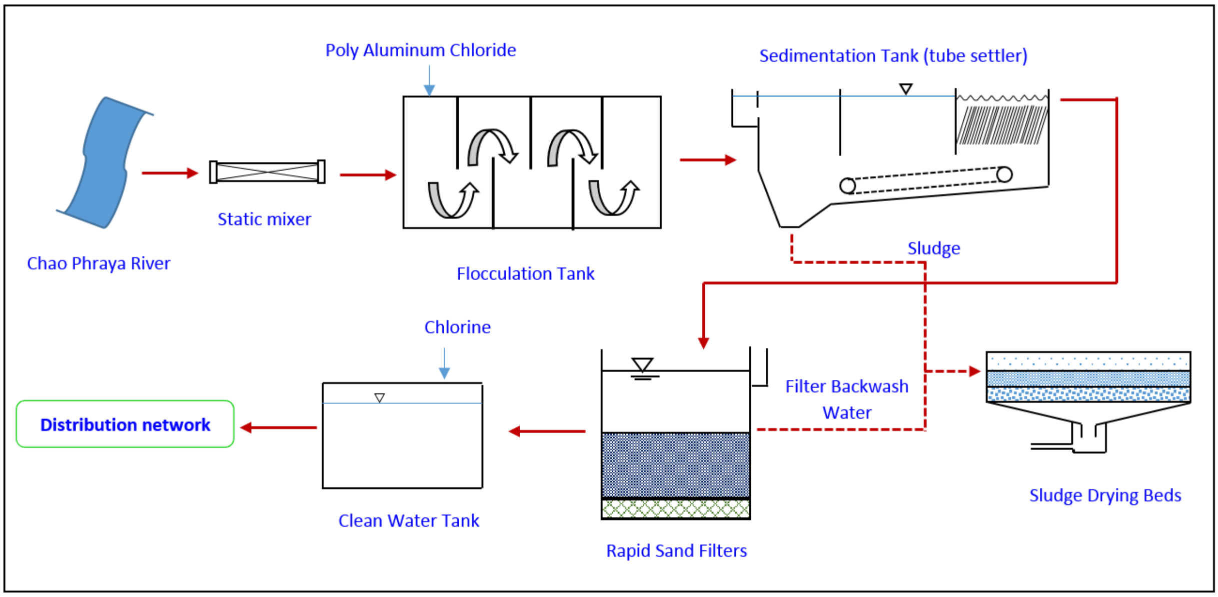

Figure 1 Water Treatment Process at Nakhon Sawan WTP

2.1 Chemical feeding and rapid mixing

Two kinds of chemicals are mainly used for water treatment, solid poly aluminum chloride (PAC) as a coagulant and liquid chlorine for pre- and post-chlorination. PAC **(Figure 2)** is added at the entrance of flocculation tank. These chemicals are injected in raw water pipeline using static mixing.

Figure 2 Solid PAC

Figure 3 Liquid Chlorine (20kg)

2.2 Flocculation

Figure 4 illustrates the flocculation basin. Nakhon Sawan WTP uses hydraulic flocculation mixing method, round-the-end baffled channel type (**Figure 5**). The overall detention time at this stage of treatment is 27 minutes. Here, with the help of PAC, the colloidal particles are flocculated. According to Kawamura (2000), the retention time of water in horizontal baffle hydraulic mixing is from 30 to 40 minutes. Shorter retention time might lead to reduce the quality of flocs (smaller size). To promote the connection, generally, the velocity gradient value is in the range from 60 to 70 s^{-1} at the first compartment. To prevent the breaking of the large flocs, the velocity gradient at the last compartment was reduced to 10-30 s^{-1}. The average velocity gradient at Nakhon Sawan WTP is 38 s^{-1} (Ratchanet, 2013).

Figure 4 Flocculation (2 basins)

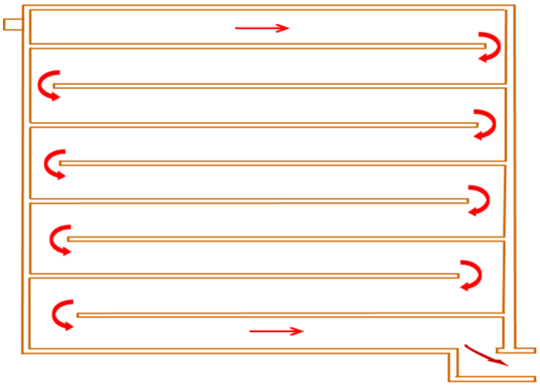

Figure 5 Round-the-end Baffled Channel Type

2.3 Sedimentation

Sedimentation basin is a rectangular type (**Figure 6**) with V-notched weir (with tube settler installed as shown in **Figure 7**). The length of sedimentation basin is very short and detention time is 1.7 h with the water mean velocity of 0.72 m/min (Ratchanet, 2013). Thus, tube settlers are installed in basin and surface loading is 5.5 $m^3/m^2\cdot h$. According to Kawamura (2000), the surface loading rate of the sedimentation tank which is covered by the tube settler system should be limited between 7.5 to 8.8 $m^3/m^2.h$. Sludge is removed by mechanical sludge collector.

Figure 6 Sedimentation (2 basins)

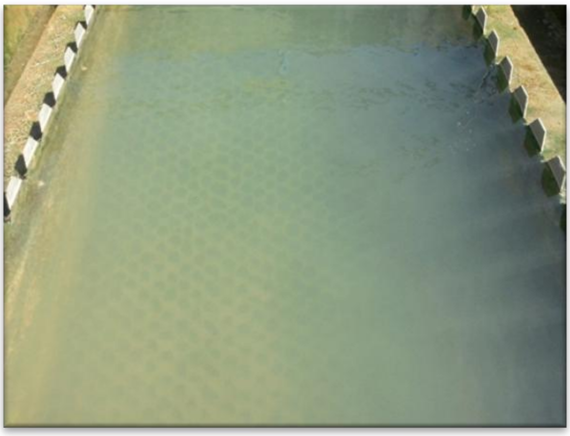

Figure 7 Tube Settler

2.4 Filtration

The media utilized in rapid filters is fine sand with 0.7 mm of effective size, uniform coefficient of 1.4 and filter depth 63 cm. The filtration bed area is 12 m^2. This filter depth satisfies the technical design requirement (70 cm, according to AWWA (1999)). In addition, the filtration rate is maintained at 6.9 m/h. The backwash method consists of water wash with air scour. The backwash rate of 0.8 m/min. The surface of filter is cleaned manually.

Figure 8 Filtration (4 basins)

Figure 9 Filter Control Panel

2.5 Sludge disposal

There are two sludge disposal methods being used at Nakhon Sawan WTP; three drying beds in the premise of WTP and a sludge basin near the Chao Phraya River (Ratchanet, 2013). **Figure 10, 11** and **12** shows the sludge disposal facilities. By using solar energy and drainage system, liquid sludge is dewatered and dried at sludge drying bed.

Figure 10 Drying Bed (3 basins)

Figure 11 Transport line of sludge from WTP to sludge basin

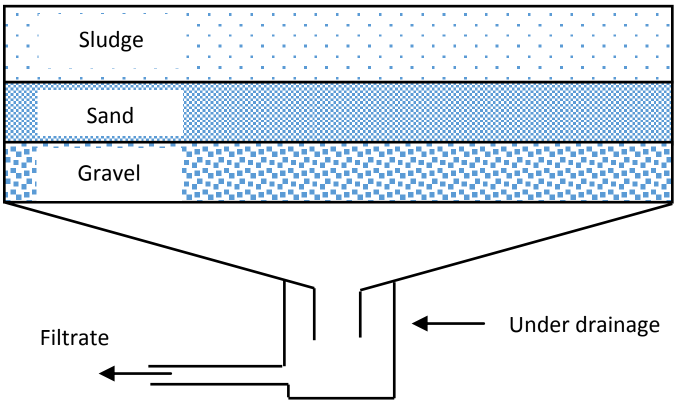

Figure 12 Conventional Sludge Drying Bed

3. Aspects of treatment processes posing most difficulty for daily operation

- The site of treatment plant should be considered for future plant expansion as well as construction cost, accessibility, site maintenance cost, and operator safety. Nakhon Sawan WTP has narrow area, especially sedimentation basin is very small sized (installed tube settler). It is expected to have some difficulties in case of operation and maintenance (O&M) and future installation of new facilities.

- Dual media and deeper bed (coarse sand) are superior to conventional filter (fine sand) in terms of head loss development and filter run time (Mayer et al., 1999). There is a need to introduce these media at Nakhon Sawan WTP when the turbidity of raw water is high during rainy season. However, there is no plan yet to upgrade this WTP.

- Residual chlorine concentration of approximately 0.3 mg/L should be maintained in treated water at all times for preventing the growth of algae on the basin walls and the growth of microorganisms in the filter bed. But, algal growth in the effluent trough and walls of settler basin at Nakhon Sawan WTP can be observed (**Figure 13**).

- There is a possibility that pre-chlorine injection is not functional. Especially in the raw water, high concentration of Fe and Mn was detected (refer **Table 2**). It is therefore suggested for a continuous pre-chlorine injection.

Figure 13 Sedimentation Basin with Algae Attached

- Color differentiation of the pipes is extremely important to avoid any mistake or confusion by the operators. Thailand has already introduced multiple colored pipeline valves system 100 years ago (**Figure 14**), however, Nakhon Sawan WTP has all of its pipelines in blue colour, as seen in **Figure 15**.

Figure 14 Thai Waterworks Museum

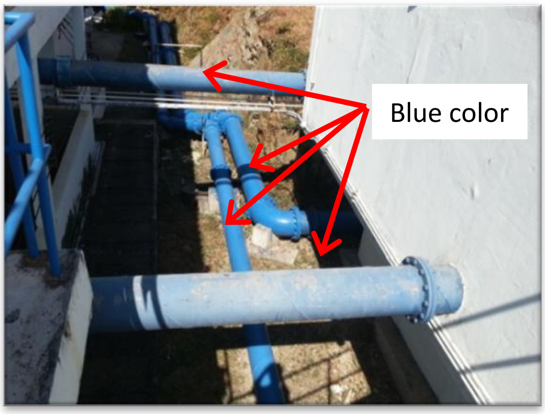

Figure 15 Pipeline Color of Nakhon Sawan WTP

- It is extremely important to continuously monitor water quality at all stages of water treatment process. Thus, monitoring equipment are required to be maintained properly for measuring exact value at all times. However, in this WTP, the online turbidity measurement equipment is not maintained properly, and often shows errors (**Figure 16**).

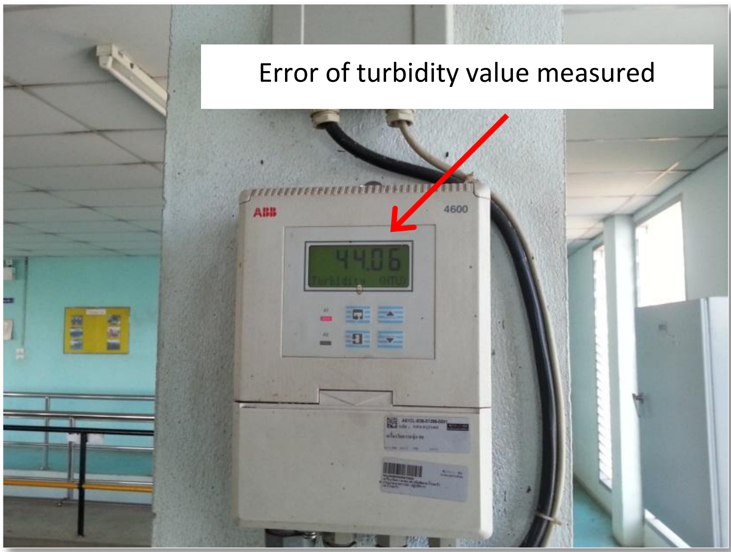

Figure 16 Turbidity Online Measurement

4. Aspects of water services management in general posing most difficulty at the moment

Water quality is degraded during distribution system by several causes, including:

- Contamination from external sources (i.e. non-authorized connection)
- Hydraulic transients: when the velocity and pressure of a flow changes rapidly at the same time. This phenomena can damage the whole system (pipeline, pumps and valves)
- Deteriorated pipeline: pipelines, especially metallic pipes are corroded easily since it is exposed directly to the soil and/or atmospheric.
- Improperly maintained storage facilities.

5. Measures are now being taken to cope with 3) and 4)

- PWA is planning to establish a water safety plan (WSP) in 2015 addressing the following five parameters: raw water system, production system, chemical feeding system, quality control system, distribution system

- This water safety plan consists of both risk assessment and risk management for whole treatment process, from water source (catchment) to distribution to its customers. It helps to ensure that the water quality is always safe to customer's usage and the water source is always available.

6. Recent investment made for the plant's improvement

Tube settlers were installed to increase the settling surface area of sedimentation tank. This modules consist of three main parts: (1) tubular channels, (2) a series of sloped, (3) a structural wave sheets. The installation footprint of sedimentation tank is reduced greatly by installing this system. The quality of effluent flow is also improved.

7. Technologies, facilities or other types of assistance needed to better cope with operational and management difficulties in 3) and 4)

- Intermittent injection of Pre-chlorination is not enough to remove Fe and Mn by oxidation, as well as to prevent the growth of algae in effluent trough and walls of settler basin. Thus, continual injection of chlorine is suggested.
- The single colored pipelines should be changed by using various colors in the pipelines to avoid confusions by the operators.

8. Customer's opinion on water quality and water services in general

- PWA has created a website for customer's complaint registration (http://en.pwa.co.th/complain/complain_view.php)

- A consumer who is unsatisfied with the service or has any suggestion can visit this website and lodge the complaints or suggestion, or can also send it to the plant by post.

- Customers expect the WTP provides a better water service with sufficient supply of water with better quality. The website shows a gradual increase in the number of complaints.

9. Advanced technology used in this water treatment plant or any points to improve the process, water quality and capacity.

- Advanced technology: none
- All sampling lines are installed in the same place thus making sampling easy for each treatment process.

10. Other Highlights

- Chemical usage: solid PAC and liquid chlorine. Alkaline chemical is not used
- Water tariff: 0.4 US$/$m^3$

11. Water quality data

The water quality data obtained from Nakhon Sawan WTP are presented in **Table 2**. All measured parameters are under the drinking water standard of Thailand.

Table 2 Raw Water and Treated Water Quality (Ratchanet, 2013)

Parameters	Unit	Raw water	Treated water	Standard (Thailand)
pH	-	7.8	7.7	6.5-8.5
Turbidity	NTU	29.5	0.59	5
Conductivity	µs/cm	197	201	-
Total hardness	mg/L	86	89	-
NO_3-N	mg/L	0.407	0.436	45
Iron	mg/L	1.39	0.06	0.5
Manganese	mg/L	0.55	0.05	0.3
Copper	mg/L	0.037	0.025	1.0
Zinc	mg/L	0.043	0.026	5.0
Chloride	mg/L	8.0	11.3	250

12. Additional information

Latitude: 15°40'57.86"N | Longitude: 100° 7'32.17"E

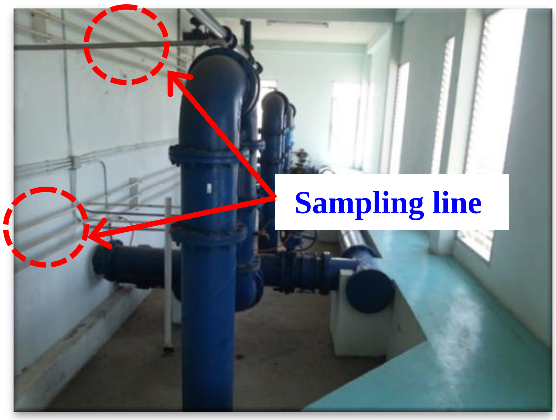

Figure 17 Sampling line

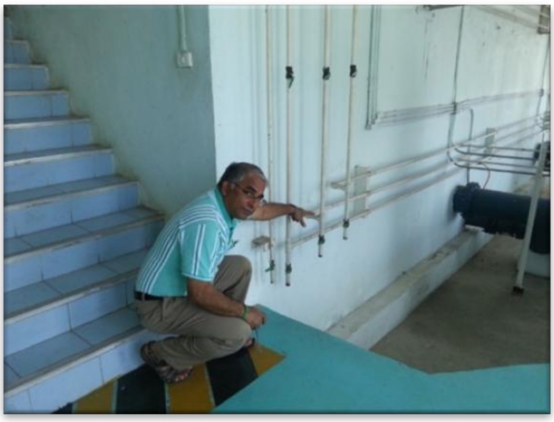

Figure 18 Sampling points

13. References

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Disclaimer:

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