Samsen Water Treatment Plant
Bangkok, Thailand

1. Background Information

Samsen water treatment plant (SWTP) is the first treatment plant of Metropolitan Water Authority (MWA), Thailand. MWA currently owns and operates four water treatment plants in Bangkok: Bangkhen, Mahasawat, Samsen and Thonburi WTPs. SWTP was constructed back in 1914 during the regime of King Chulalongkorn. It operates with the capacity of 350,000 m^3/d and has the maximum capacity of 550,000 m^3/day. The service area of SWTP is Phayathai, Dusit, PtaNaKorn, and Rattchatevi. It is GMP/HACCP certified WTP since 2004.

SWTP expanded according to the demand of the raising population of Bangkok and currently there are four independent WTP in the premises of SWTP. This report however only focuses on the fourth water treatment plant of the SWTP (herein referred to as $SWTP^{4th}$). $SWTP^{4th}$ is the newly built water treatment plant of SWTP and operates with the capacity of 80,000 m^3/day.

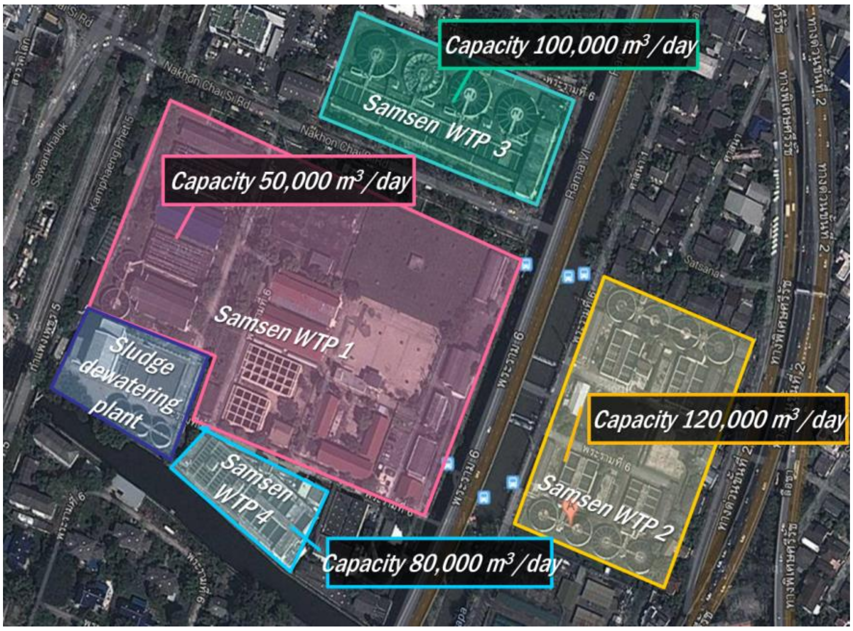


Table 1 Overall Information of $SWTP^{4th}$

Constructed Year	1994
Water Source	Chao Phraya River
Operating Capacity (m^3/d)	80,000 m^3/day
Peak capacity (m^3/d)	142,000 m^3/day
Date of access of the source information	2015
Reference	Samsen Water Treatment Plant

2. Water Treatment Process

The major processes are as follows:

- Raw water extraction (Intake) → Pipe-line static mixing (PAC, pre-chlorination and polymer) → Super Pulsator Clarifier → Rapid sand filters (fine sand) → Clear water tank (liquid chlorine disinfection) → Pumping station (to distribution network).

- Sludge (from backwash & Rapid sand filter) → Equalization tank → Sludge thickener → Thickened sludge storage tank → Filter press

- Wastewater generated from the sludge thickener is discharged back to the intake canal while the sludge cake obtained from the filter press is sent to the landfill.

Figure 1 shows the treatment process at SWTP[4th]

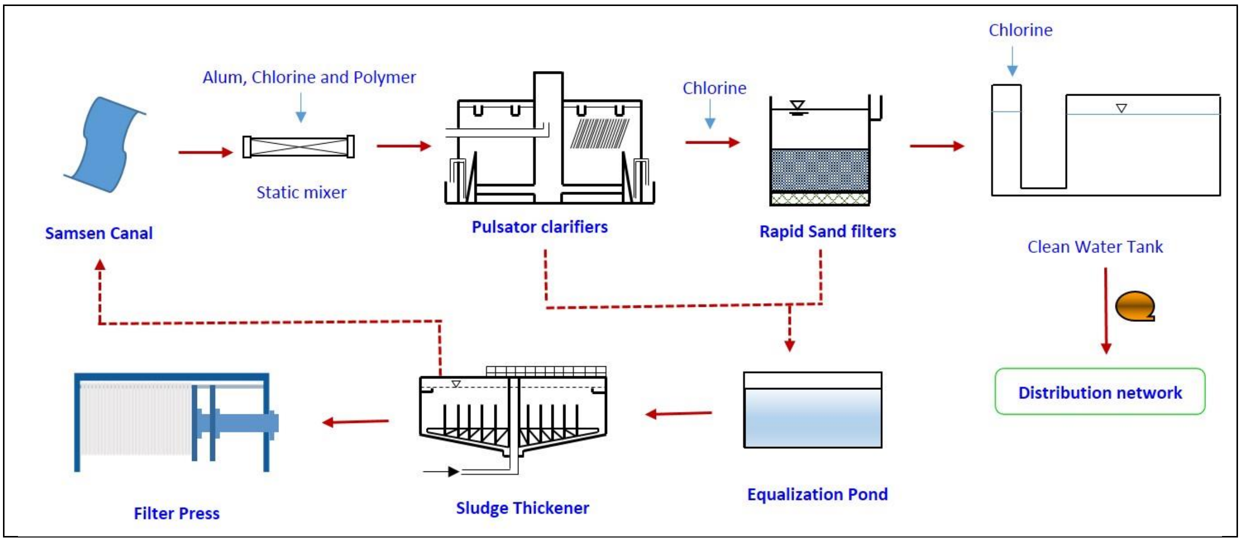


Figure 1 Water Treatment Process at SWTP[4th]

2.1 Water Intake

Samlae raw water pumping station is located in Muang district of Pathumthani, north of Bangkok. It extracts raw water from the Chao Phraya River. SWTP is about 31 km south of Samlae raw water intake station (**Figure 2**) and the raw water is conveyed to Samsen WTP by Prapa canal (**Figure 3**).

Figure 2 Samlae raw water pumping station

Figure 3 Prapa canal

2.2 Chemical feeding and rapid mixing

SWTP^{4th} mainly uses chlorine (pre chlorination, intermediate chlorination and post chlorination) and alum as coagulant. In addition, polyelectrolytes is intermittently injected as a coagulant, when the raw water turbidity is high (more than 40 NTU). Chlorine is usually injected prior the clarification (pre-chlorination) and after the filtration (post-chlorination). However, as per the operational requirement, chlorine is sometimes injected after the clarification unit (Intermediate chlorination). As presented in **Figure 4** and **Figure 5**, chemicals are injected into inflow pipe-line as an in-line static mixing type.

Figure 4 Pre-chlorination

Figure 5 Alum injection

2.3 Clarifier

SWTP^{4th} consists of Super Pulsator Clarifier (**Figure 6)** for flocculation and sedimentation in a single unit. The retention time of clarifier is 2 to 3 hours and 95% of the suspended solid gets removed in this process.

Figure 6. Super Pulsator Clarifier

2.3 Filtration

The media utilized in the rapid sand filter (**Figure 7**) is fine sand with effective size of 0.7 mm, uniform co-efficient of 1.4 and filter depth of 80 cm. The backwashing of the filter is performed every 36-48 hour and it takes about 16 minute for the backwashing process which includes water washing and air scouring (**Figure 8**).

Figure 7 Rapid sand filter (9 basins)

Figure 8 Backwashing with air scouring

2.5 Sludge disposal

Current mechanical sludge disposal facility was constructed from 2005-2008 with the total budget of around 250 million Bhat. It includes following units:

2.5.1 Equalization Tank

The backwash water generated from the filtration unit and sludge drained from the clarifier is discharged to equalization pond **(Figure 11).**

Figure 11 Equalization pond (2 basins)

Figure 12 Sludge thickener (3 basins)

2.5.2 Sludge Thickener

The wastewater from the equalization pond is then pumped to the sludge thicker (**Figure 12**) to densify the solid content. The liquid fraction is then discharged back to the intake canal.

2.5.3 Filter Press

The thickened sludge is then sent to the filter press (**Figure 13**) where the sludge is dewatered. The resulting sludge cake is then transported to the landfill site (Pathumthani province) for final disposal.

Figure 13 Filter press (2 units)

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

SWTP has three kinds of clarifiers, i.e. vertical flow clarifier (**Figure 14**), solid contact clarifier (**Figure 15**), and pulsed sludge blanket clarifier (**Figure 16**). These clarifiers have significantly different operation patterns. For examples, vertical flow clarifier has different opening dimension at each baffle for gradually decreasing the flow velocity and head loss. In case of solid contact clarifier, it is comprised of a mixing zone, flocculation (reaction) zone, sludge blanket zone, and a clarification zone. Recirculation of solids and mixing is accomplished by a radial or axial turbine. Pulsed sludge blanket clarifier has sludge blanket, the homogeneity of which is maintained by pulse cycles, applied by a vacuum chamber.

Therefore, operators are required to pay a lot of attentions to operate these different clarifiers. Especially, pulsed sludge blanket clarifier, which is operated in SWTP^{4th}, has operational difficulty during the removal of sludge as lamellar modules are located in the clean water area above the sludge blanket (**Figure 16**).

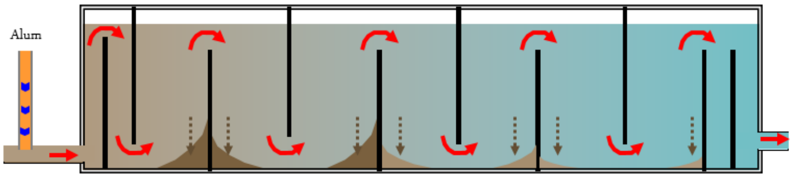
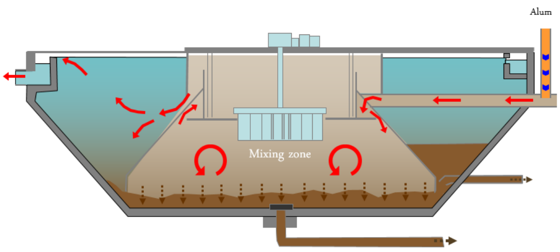


Figure 14 Vertical flow clarifier



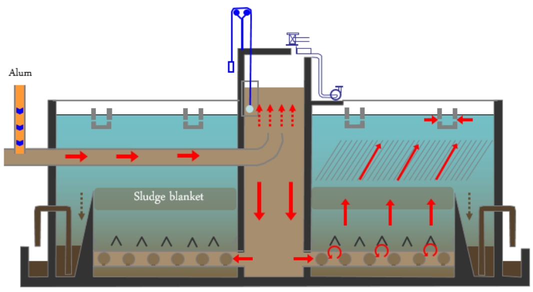


Figure 15 Solid contact clarifier **Figure 16 Pulsed sludge blanket clarifier**

In additional, excessive algae growth is visible in the clarifier as seen in the **Figure 17**. Algae causes many operational difficulties in WTP's operations including: disruption of floc settling, production of algal mats, filter clogging from algae, increased backwashing frequency, increased coagulant demand, increased chlorine demand, increased disinfection by products, pH fluctuations, tastes and odors and release of algal toxins (Kommineni et al., 2009). Algae can be controlled effectively by pre-chlorination (1 to 2 mg/L). However, the use of pre-chlorination is also the cause of THM formation due to its reaction with organic matter (Kawamura, 2000).

Figure 17 Excessive algae growth in clarifier basins

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

According to MWA, deteriorating raw water quality (Wongpat, 2012) due to high organic matter and salinity, was considered as one of the high risk factor in drinking water service as informed by water safety plan team of MWA. SWTP extracts raw water through 31 Km long Prapa canal (**Figure 18**) which is an open canal.

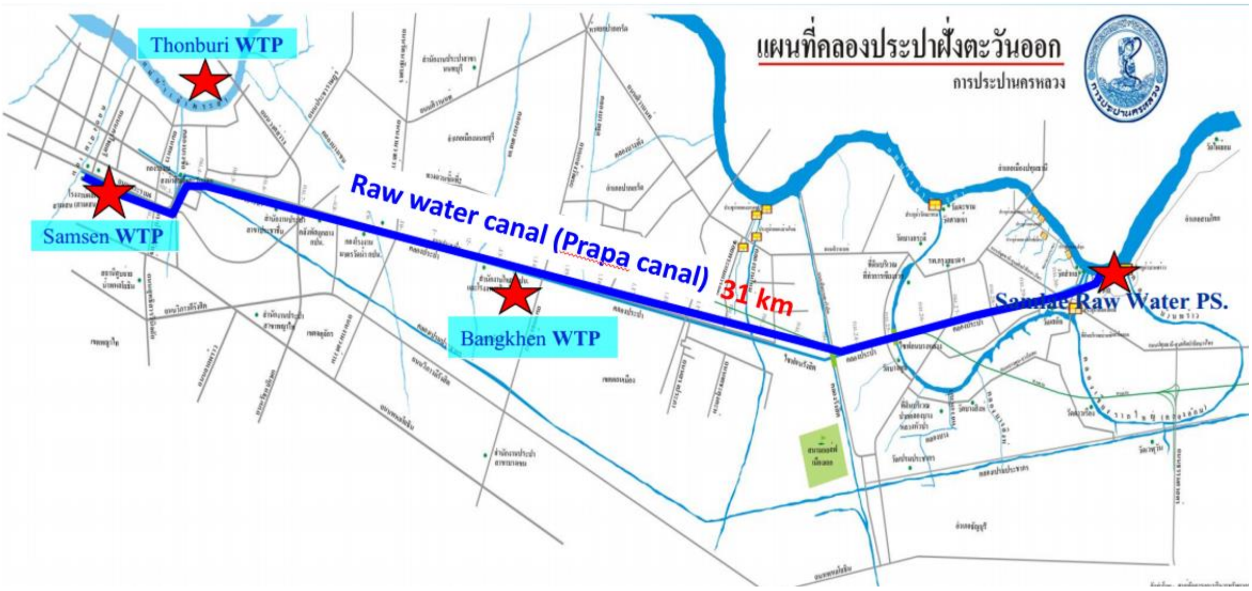


Figure 18 Raw water conveyance system in MWA

Most of the surface water is drained into Prapa raw water canal during the heavy rainfall. In addition, unpurified domestic sewage discharged into raw water canal pollutes it. The treated water quality result in 2014 shows the total organic carbon (TOC) concentration of 3.5 mg/L and trihalomethanes

(THMs), referred to as disinfection by-products, concentration of 0.26 mg/L. These high organic concentration acts as obstacles for pre-chlorination and post-chlorination.

In June 2015, MWA experienced a critical water shortage due to delayed rains during which the raw water was affected by high salinity level. The salinity level of the MWA's tap water stood at 0.2-0.3 mg/L. Sense of saltiness can be felt beyond the salinity level of 0.5 mg/L. Since May 12, MWA has reduced its production by 10 % (Bangkok post a, 2015) to avoid sea water intrusion in the Chao Phraya River.

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

- SWTP^{4th} have three injection points for chlorination, i.e., pre-chlorination, intermediate-chlorination, and post-chlorination (**Figure 19**). The injection point is selected according to organic matter concentration in raw water. For example, pre-chlorination is chosen under normal/usual raw water quality (i.e low TOC and turbidity) for preventing algal growth, but sometimes it is changed to intermediate-chlorination for reducing THM formation when TOC of raw water is high.

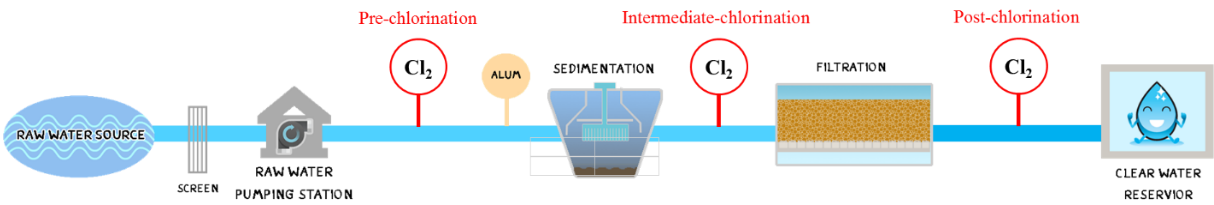


Figure 19 Water treatment flow diagram

- MWA has constructed dike along the raw water canal for preventing inflow of contamination from surface runoff. Dike prevents the runoff of domestic sewage and other pollutants (chemicals or oil scrap) from the nearby roads.

6. Recent investment made for the plant's improvement

- For continuous measurement of rapid water quality change, MWA recently introduced real-time raw water quality monitoring system. As presented in **Figure 20**, raw water canal is installed with online equipment to obtain real-time data of water quality parameter like turbidity at each stations. Therefore, SWTP can get the raw water quality data about 32 hours prior its arrival at WTP.

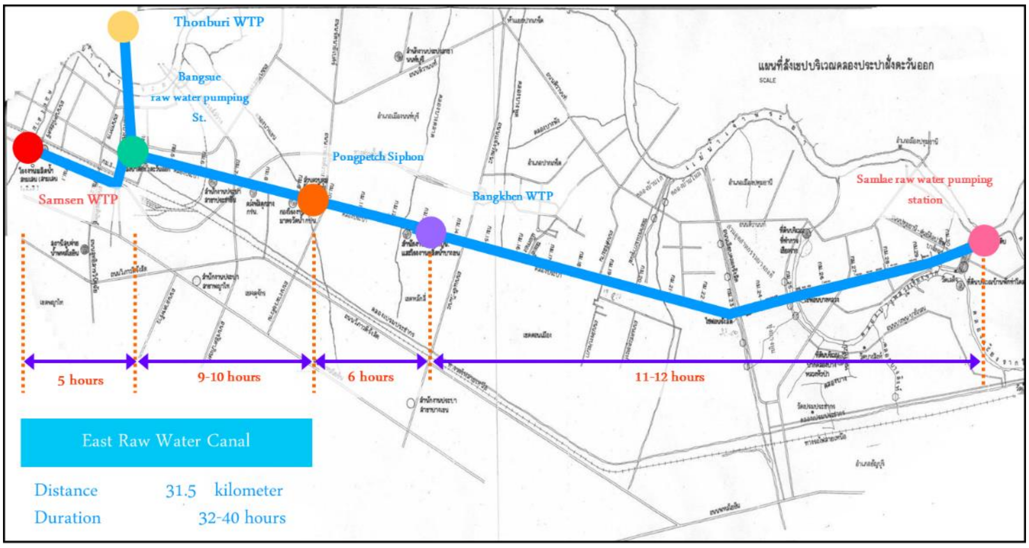


Figure 20 Raw water quality monitoring points from Samlae pumping station to Samsen WTP

- Samsen WTP has installed mini hydro turbine to generate electricity (200 kWh/d). It utilizes potential energy gathered from the elevation difference of 6 meter between sludge thickeners and turbine (**Figure 21**).

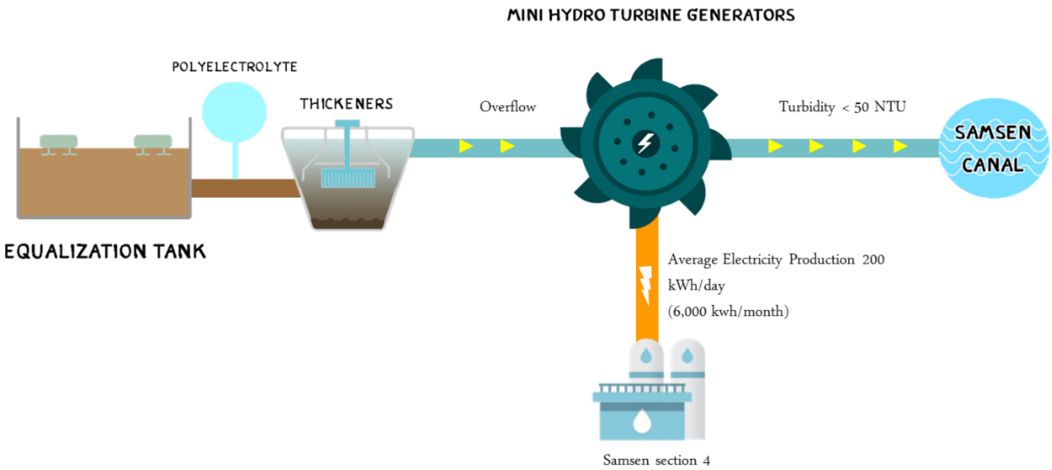


Figure 21 Flow diagram of mini hydro turbine generator

- Since 2014, MWA has operated re-chlorination at pumping station of distribution system for reducing the odor of chlorine in tap water and ensuring effective disinfection in the distribution system.

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

- To control excessive algae growth, occasional shock treatments with 2 to 3 mg/L of chlorine can be a feasible alternatives (Kawamura, 2000).

- To prevent algae growth in clarifier and filter basin, installation of the roof for blocking light can be an effective option. In addition, clarifier needs to be cleaned frequently to remove excessive algae materials and accumulated sludge on the tube settler.

- High organic matter concentration has been measured in raw water sources. Thus, on-line Total Organic Carbon (TOC) analyzer needs to be introduced for continuous measurement of it.

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

Rise of disastrous events like drought and flood has raised the public concern about sea water intrusion and stable water supply. In addition, quality of the supplied water has always been an issues as Thailand has one of the highest consumption of bottled water. According to statistics (2015), Thailand has the second highest per capita consumption of bottled water with the per capita consumption of 246 liters in 2014. It ranked after Mexico whose per capita consumption of bottled water was 264 liters. Moreover, the consumption of bottled water in 2014 increased by 2.5 times the per capita consumption of 2009 (100 liters). Thus it can be implied that most people don’t trust tap water quality for drinking water.

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

MWA recently installed real-time water quality monitoring system (pH, turbidity, conductivity, and residual chlorine devices) at various points (**Figure 22**) of water distribution system. Open access to the water quality data is available through MWA website (http://www.mwa.co.th).

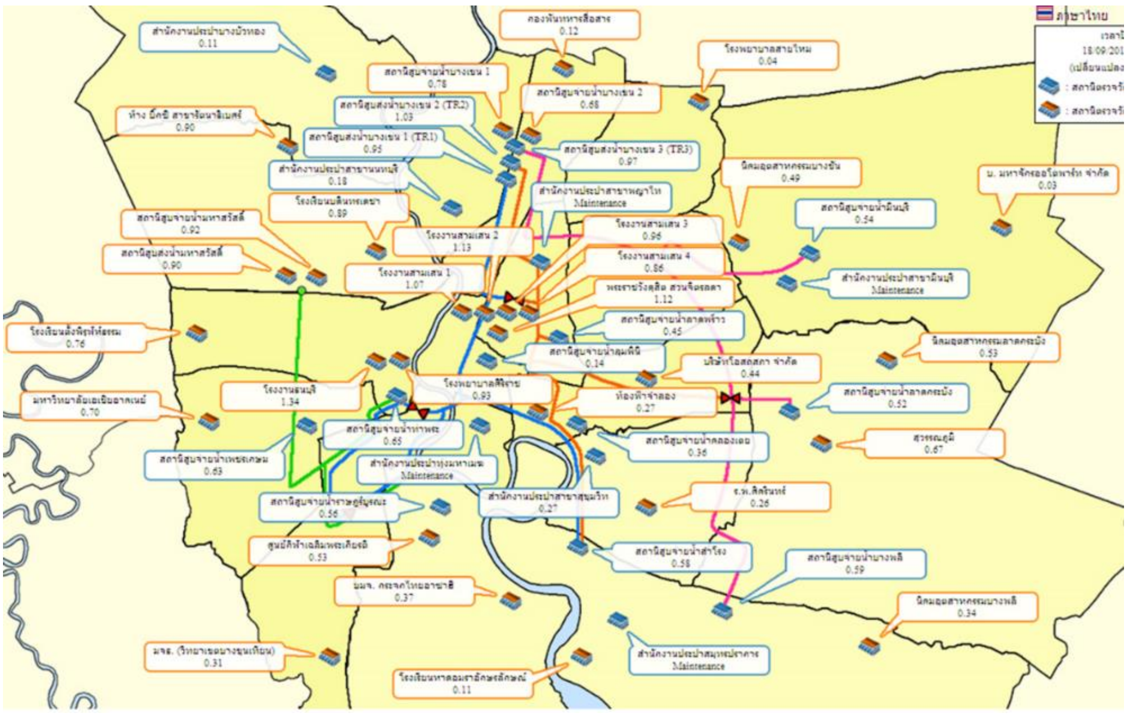


Figure 22 Real-time water quality monitoring points in distribution system (MWA website)

10. Other Highlights

The highlight of the SWTP is the Thailand's first water treatment plant which now serves as the museum. The restoration of the building containing the historical water treatment plant (**Figure 23**) was started in 2011 and was opened as 'Thai Waterworks Museum' in July, 2013.

Figure 23 Thai Waterwork Museum at Samsen WTP

11. Water quality data

The water quality data of SWTP (2014) are presented in **Table 2**.

Table 2 Water quality data

Parameters	Unit	Treated water	Standard (Thailand)
pH	-	7.3	6.5-8.5
Turbidity	NTU	0.63	5
Conductivity	µs/cm	438	-
Total hardness	mg/L	116	500
Total alkalinity	mg/L	81	-
NH_4-N	mg/L	1.85	-
NO_3-N	mg/L	2.965	45
Iron	mg/L	ND	0.5
Manganese	mg/L	0.01	0.3
Chloride	mg/L	50	250

(Source: MWA website)

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