Greater Kandy Water Treatment Plant
Central Province, Sri Lanka

1. Background Information

Greater Kandy Water treatment Plant (GKWTP) (**Figure 1**) is located at Pahalakondadeniya, Katugastota in Kandy - North region of the Central province. This treatment plant is operated under the National Water Supply and Drainage Board (NWSDB) of Sri Lanka. The catchment area of this water supply system includes the highly urbanized area in Kandy city. The raw water intake of GKWTP is near the solid waste dumping site of the Kandy city at Thekkawatta, which is downstream of the intake of GKWTP.

Figure 1 Greater Kandy Water Treatment Plant

The treatment process of GKWTP consists of aeration, coagulation, flocculation, sedimentation, filtration and disinfection. GKWTP produces potable water adhering to SLS 614:1983 (Part I and II, drinking water quality standard). The distribution network of the GKWTP is about 293 km long and consists of pipes of varying diameters from 200 mm to 1200 mm. The overall information of GKWTP is presented in **Table 1.**

Table 1 Summary details of Greater Kandy Water Treatment Plant.

Constructed Year	2006-2015 (Total 3 phases, project currently on phase 1 stage II)
Water Source	Mahavali River
Population served	400,000
Current Peak Operating Flow (m^3/d)	49,000
Design capacity (m^3/d)	72,000 (Phase 1-Stage II)
Peak/Design flow (m^3/d)	115,000 (Phase 3)
No. of operators working at the plant	27
Date of access of the source information	2015
Reference	(GKWTP Water Safety Plan, 2015)

Greater Kandy Water Supply Project was proposed as a measure to solve the acute drinking water shortage in Pathadumbara, Kandy Four Gravets, Akurana, Pujapitiya and Harispattuwa Pradeshiya Saba areas. The GKWTP operation was started on 8 January, 2007. Earlier to this, water need for these areas was fulfilled by 21 small water supply schemes that were operating with minimum facilities and shallow tube wells with unsatisfactory water quality. The current GKWTP project was designed to produce 115,000 m^3/d at completion in phase 3. At present, it is capable of producing 72,000 m^3/d (Phase 1 – Stage II). The layout plan of for Phase 1 – Stage II is shown in **Figure 2**. The schematic diagram of for Phase 1 – Stage II is shown in **Figure 3**.

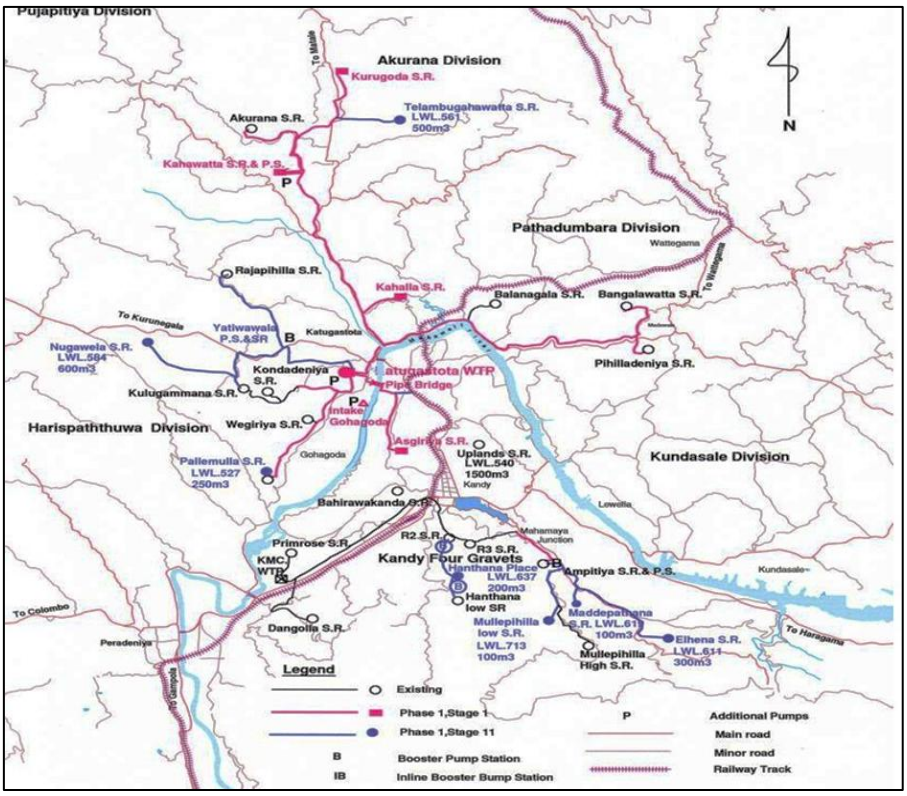

Figure 2 Layout of the Plan (phase 1-stage II)

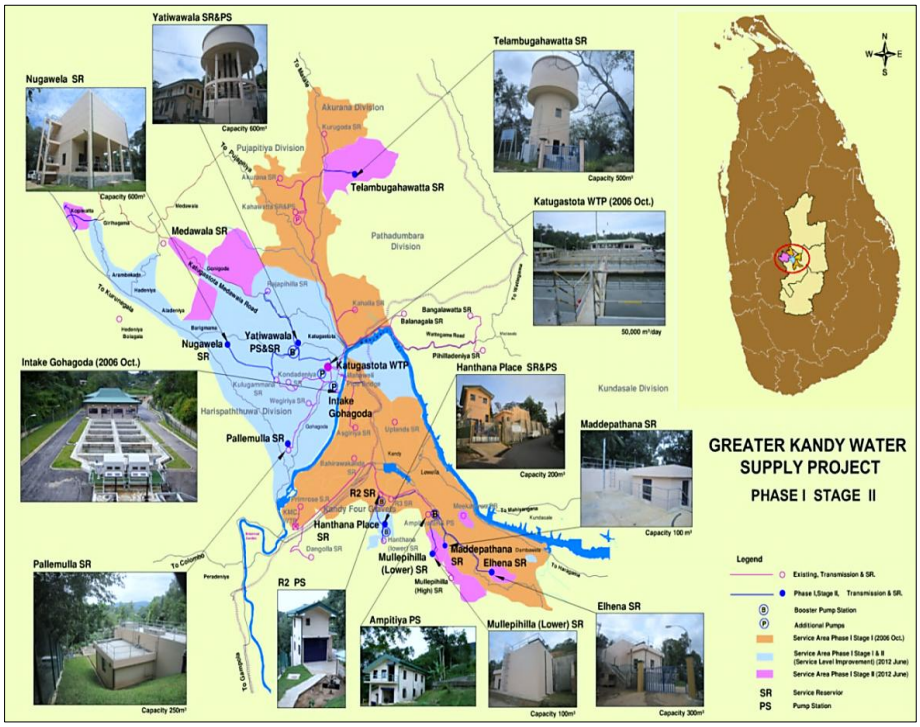

Figure 3 Schematic Diagram (phase 1-stage II)

Raw water is extracted from the Mahaweli River at an intake structure constructed in the Kahawatta, with a maximum capacity of 110,000 m^3/d. The Mahawali river catchment is not protected and flows through highly populated areas, hence affecting the quality of raw water. Raw water pumping is done in accordance with an agreement made with Mahaweli authority, Sri Lanka.This raw water is screened and grit removed at the intake and conveyed to the treatment plant at Pahala kondadeniya via 1000 mm diameter pipeline. At the treatment plant, water is treated to meet SLS 614 standard and then distributed.

On an average, 15,000 m^3/d is issued to Kandy Municipal Council and the rest is continuously pumped to Harispattuwa, Akurana, Pathadumbara and Pujapitiya areas. Population served under this water supply system is approximately 400,000. Water demand varies with the District secretariat division. **Table 2** presents the water demand in the Kandy North region, where GKWTP is distributing water.

Table 2 Summary of Water Demand

District Secretariat Division	Population served	Average water demand (m^3/day)
Harispattuwa	92,579	16,935
Akurana	57,398	8,540
Pujapitiya	43,442	7,200
Pathadumbara	65,425	11,204
GangawataKorale	78,030	19,746
Thumpane	12,352	1,654

All service reservoirs are maintained by the treatment plant staffs. The distribution system is managed under 4 Officers in-Charge to whom the customers interact regarding water supply and quality issues.

2. Water treatment process flow

The water treatment process consist of some main units as follow:

Raw water extraction (Intake) → mixing chamber (PAC and pre-chlorine) → Flocculation → Sedimentation (rectangular) → Rapid sand filters → Clear well (gas chlorine disinfection) → High Lift Pump Building,
Sludge generated from the treatment process is disposed to the sludge drying bed

Figure 4 illustrate the process flow diagram.

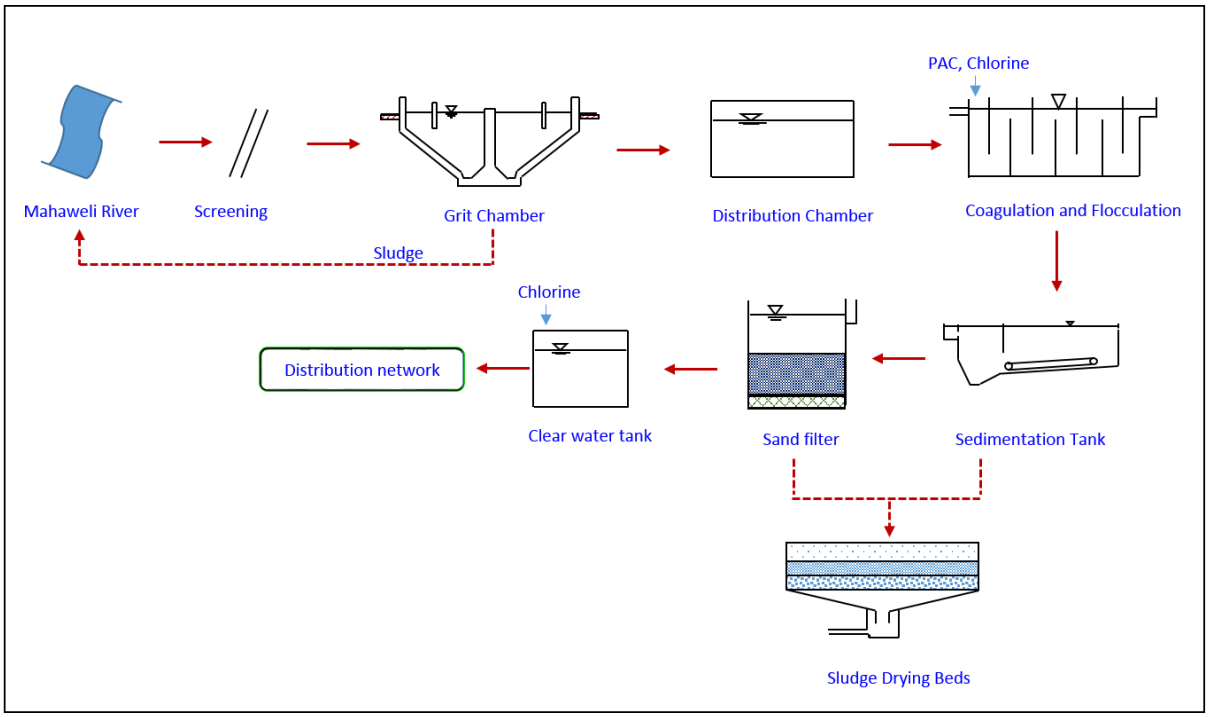

Figure 4 Treatment Process Flow Diagram in GKWTP

2.1 Chlorination

❖ Pre chlorination

Pre chlorination disinfection is carried out by using dissolved NaOCl solution (35% purity) to prevent algae growth in water treatment plant. The dissolved liquid NaOCl solution is pumped into a distribution chamber to maintain the residual chlorine levels in raw water. The raw water after mixing with choline has the chlorine concentration of 0.1-0.15 mg/L. Every month, the amount of chlorine gas requirement for pre-chlorination is about 1000 kg. Residual chlorine level in pre chlorination is monitored twice a day manually.

❖ Post chlorination

Post chlorination disinfection is carried out by gas chlorine at the clear water reservoir. The proposed chlorine feeding system is by solution feed in which the gas is metered through an orifice or rotameter under vacuum by an ejector drawing gas through the feed into the solution line. Water for preparation of chlorine solution is pumped from clear water reservoir using chlorination booster pumps or water can be diverted from a pumping main. The following residual chlorine levels shall be maintained: at the clear water tank is 0.8-1.0 mg/L; at the household is 0.2 mg/L. The minimum contact time before reaching the first household is 20 minutes. Chlorine gas requirement for post-chlorination is about 2500 kg per month. After the disinfection, water is pumped to serviced reservoirs constructed on higher elevated areas. Treated water is then distributed to the consumers by using gravity. There are 11 service reservoirs Greater Kandy water supply system.

2.2 Chemical feeding

Three kinds of chemicals are mainly used for water treatment: solid PAC as a coagulant **(Figure 5),** gas chlorine for pre-chlorination and post chlorination, **(Figure 6)** and lime for pH correction **(Figure 7).** These chemicals are injected into the raw water pipeline using piston pumps. With prior to injection of PAC, gas chlorine and lime is mixed with water to make appropriate dilutions. Quantity and frequency of chemical usage are listed in **Table 3** below:

Figure 5 Solid PAC (50 kg bags)

Figure 6 Gas Chlorine Cylinders (1700kg)

Figure 7 Solid Lime (50kg bags)

Table 3 Usage and other Information of Chemicals in GKWTP

Chemical	Unit	Dosage	Frequency of water quality measurements	Frequency
Hydrate lime	kg/m^3	$5.6x10^{-4}$	Two times per day	During low pH
Poly aluminium chloride	kg/m^3	$1.3x10^{-3}$	Jar test (Four times per day) online reading and twice a day manual reading of turbidity	Daily
Chlorine gas	kg/m^3	$1.4x10^{-3}$	Online readings Twice a day manual measurments	Daily
NaOCl for pre chlorination	kg/m^3	$5.6x10^{-4}$	Twice a day by manually	Daily

❖ **Flocculation**

Currently, GKWTP is using rapid mixing and hydraulic flocculation method. Water is pumped from the Mahaweli River to the elevated tower. Then water is transferred to the down partition inside the tower and mixing with chemicals. Water mixed with PAC, chlorine and lime flow toward the flocculation basins **(Figure 8 and 9)** under gravitational force. Flocculation basin is designed with total flow length of 840 m, average flow velocity of 0.4 m/s and the hydraulic retention time of 35 minutes.

Figure 8 Rapid Mixing Elevated Chamber

Figure 9 Flocculation Basin

Figure 10 Side View of Flocculation Basin (160 chambers)

❖ **Sedimentation**

Water from the flocculation basin comes to the large sedimentation basins **(Figure 11).** Each basins interconnection is made by using holes inside partition walls. The sedimentation tank is designed with the average surface loading rate of 1.95 $m^3/m^2.h$ (maximum surface loading rate of 2.6 $m^3/m^2.h$), hydraulic retention time of 30 minutes and the cleaning frequency of once per day.

Figure 11 Sedimentation Basins

❖ **Filtration**

There are four rapid sand filters **(Figure 12).** The media utilized in rapid filters is fine sand with the uniformity coefficients around 1.2 and the filter depth of 100 cm. The maximum filtrate velocity is 3,500 m^3/h with the surface loading rate of 10.95 m^3/m^2.h. The effluent water has a turbidity of 0.6 - 8.0 NTU. Backwash method compromised by air blowing (to expand the filter bed) followed by passing water and air mixtures (rub the filter media to remove particles) and then clear water washing. The backwash step consumes from 1 to 3 % of clean water produced. Usually, backwashing step is conducted every 24 h (when the when turbidity of effluent water reaches 8 NTU, or head loss reaches 2.5 m). The amount of sand loss due to backwash is about 500 kg/year.The backwash and air scour system design ensures all filters are air-scoured and washed equally. The difference in air or water flow shall not be greater than ± 5 % between any two filters.

Figure 12 Rapid Sand Filter

❖ **Sludge disposal**

Sludge produced from sedimentation tank and filter backwash is collected and sent to the sludge drying bed (**Figure 13** and **Figure 14**). Sludge drying bed is used for dewatering the liquid sludge and convert it to a solid form by using solar energy and drainage system. The amount of sludge produced in whole treatment process is $3.1x10^{-3}$ kg/m^3 of treated water. The sludge drying bed finishes each batch within 180 days. There are totally 4 such sludge drying beds.

Figure 13 Sludge drying bed

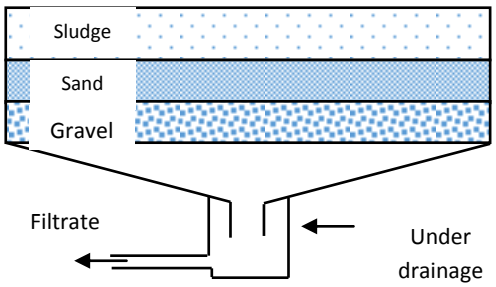

Figure 14 Conventional sludge drying bed

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

This water treatment plant is operated under water safety plan (WSP). Therefore, according to WSP module 4, all of the risks that can be encountered during daily operations of the plant are monitored and controlled.

❖ **Catchment pollution**

- Pathogenic contamination from septic tanks, hospital wastes, leachate from garbage dumping site from the Kandy city through a middle canal (Meda-Ela)
- Settling sediments on the pool due to soil erosion
- Pollution by agrochemicals during rainy season

❖ **Treatment process**

- Sometimes, plant performance reports indicate mechanical failures of the fine screen
- Pumping record book and Supervisory Control and Data Acquisition (SCADA) system indicate frequent power failures
- Manhole covers with no locks

❖ **Distribution network**

- Contamination of treated water (very high potential) due to unauthorized personnel entering the water treatment premises.

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

Percentage of non-revenue water: 25 % (mainly transmission and distribution pipe burst due to high pressure in off peak)

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

Greater Kandy Water treatment plant and its distribution is already covered with the WSP since 2013. It covers all eleven modules of WSP to catchment to end consumer. **Table 4** summarizes module 8 of WSP.

Table 4 Standard Operating Procedures for a Water Utility (WSP module 8)

Category	Sub-category	Standard Operating Procedure
Water intake point (WIP)	Raw water	• Valve operation • Screening
	Pump operation	• Switching duty pump operation • Increasing / decreasing pumping operation
Water treatment plant (WTP) operation overview	General tasks	• Hourly inspections • Site security • Record keeping • Reporting procedures • Operation Reference Manuals • Maintenance procedures • Chlorination protocols • Filter operation procedure • Alum dosing procedure • Filter inspection and replacement procedure
	Sampling and testing	• Water Quality Monitoring Program, Operational and verification • Laboratory procedures
	Emergency response protocols	• Power failure • Natural disaster (e.g. flood) • Emergency Response Protocols • Contingency Plan for Disinfection Failure
Distribution		• Tank Maintenance Program • Water mains cleaning program • Water mains replacement program • Design standards
Customer Interface		• Customer complaint protocols • Backflow prevention protocols

6. Recent investment made for the plant's improvement

- Online turbidity meter
- Increment of sampling frequency
- Newer water meters and PET pipes
- Install a variable speed drive (VSDs) to optimize the energy usage of pumps
- Stakeholder meetings
- Awareness programs to protect catchment
- Catchment protection visit
- Training programs for WSP development and implementation

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

Aeration unit is required to remove excess iron coming during higher turbidity. Laboratory facility should be improved (i.e. instruments capable for measuring heavy metals (ICP-MS)/GC-MS). Frequency of excessing Iron per year (during south west monsoon and Northeast monsoon) more than 60 times per year.

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

The 24 h call center is operating at a regional support center to monitor pipe breaks, water leakage, disrupted water supply, and water quality. Customers' opinions and suggestions are recorded and discussed by the management for implementation and improvements.

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

The whole water treatment plant is controlled by the SCADA system. Water flow, pumps, dosing system water levels, backwash all are controlled by this system. Plant operators run the plant 24h on shift basis under one operation in-charge. The staffs record water quality data in frequent intervals.

10. Other Highlights

Currently,PAC is not being used in the water treatment plant and the frequency of using lime is very less. **Table 5** presents the frequency of sampling at the distribution and water treatment plant.

Table 5 Frequency of sampling in distribution

Sampling in Distribution network		
Population served	**Maximum interval between successive samples**	**Minimum number of samples to be taken from whole distribution system each month**
Less than 20 000	1 month	1 sample per 5000 population
20 001 to 50 000	2 weeks	1 sample per 5000 population
50 001 to 100 000	4 days	1 sample per 5000 population
More than 100 000	1 day	1 sample per 10 000 population
Sampling in Water treatment Plant		
Location	**Frequency**	**Testing parameters**
Each unit process	Two times per week	Microbial(E-coli/Coli-Form) Physical (color/turbidity/Ph/odor) Chemical(Excluding heavy metals)
Treated water Residual Chlorine	Two times per week	Total chlorine Residual Chlorine
Treated water and raw water turbidity	Online testing and manual testing two times per day	Turbidity
Treated water and raw water	Once a year	Heavy metals

The sampling locations have been mapped and marked. Any water quality deviation is informed to the regional manager and is corrected as soon and as much as possible. **Figure 15** shows a diagram of the transmission system of GKWTP.

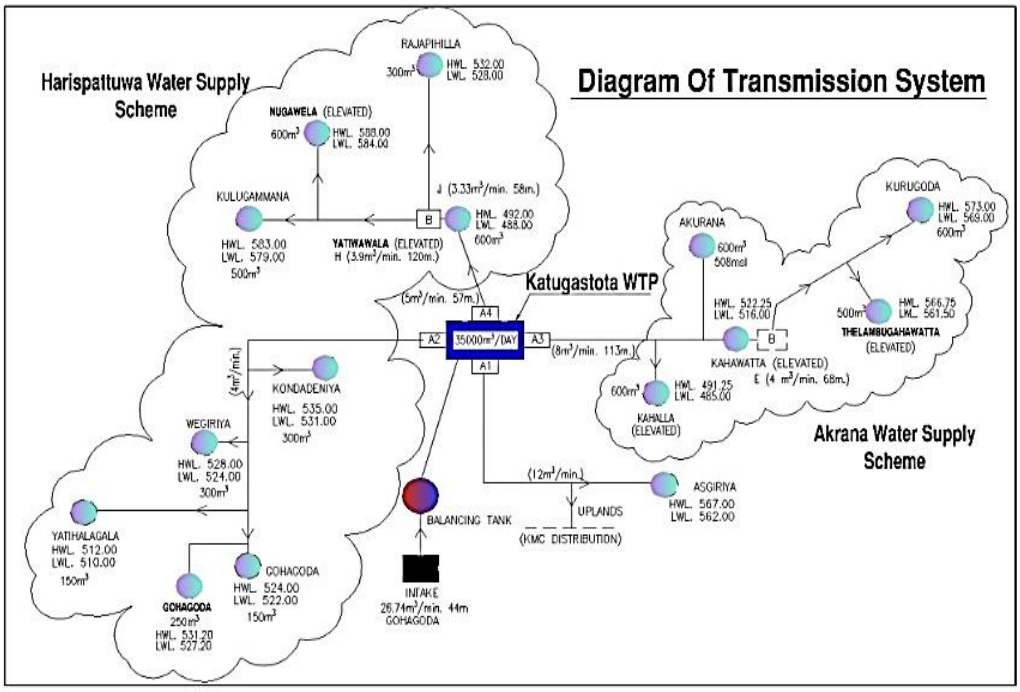

Figure 15 Transmission of GKWTP

11. Water quality data

Treated water quality at the treatment plant is analyzed and monitored daily. In the distribution, water quality is monitored according to SLS 614- 1983 (Part 2).The analyzed parameters are shown in **Table 6.**

Table 6 Raw water and treated water quality data in 2013.

Parameter	Unit	Raw water	Treated water	Desirable limit
Color	Pt-Co	92.2	1.1	< 5
Turbidity	NTU	18.4	0.3	< 2
pH		7.0	6.9	6.5-9.0
Conductivity	µs/cm	81.8	88.2	< 750
Total alkalinity	$CaCO_3$ -mg/l	25.9	21.3	< 200
Nitrate as NO_3	mg/l	0.8	4.2	< 10
Total Hardness	$CaCO_3$ -mg/l	25.2	24	< 250
Total Iron	mg/l	0.4	0.1	< 0.3
Total Coliform		9432.2	0	< 3
E. Coli		730.2	0	0

12. Other graphical information

Figure 16 shows the location of GKWTP, it is located at the central area in Sri Lanka.

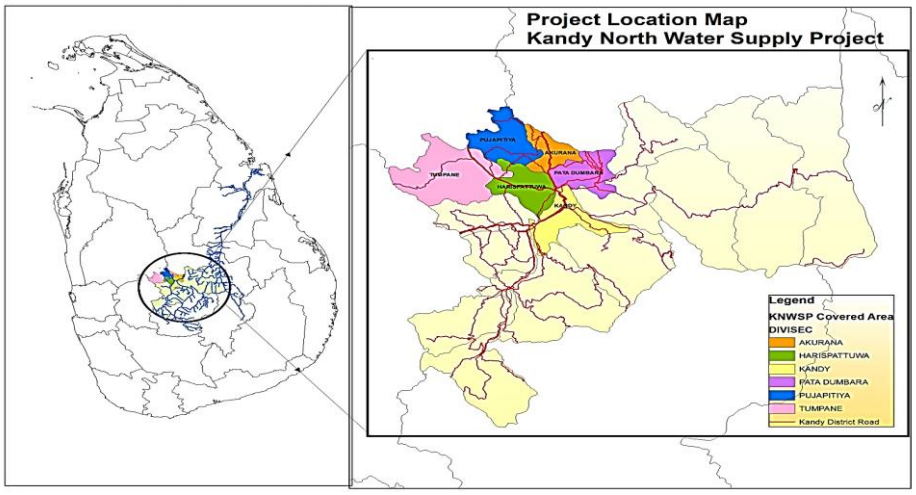

Figure 16 Location Map of GKWTP

13. References

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