Silay City Water Treatment Facilities
Negros Occidental, Philippines

1. Background Information

The Silay City Water District (SICIWA) is a water utility agency that supplies water to the city of Silay in Negros Occidental province. It is a government-owned and controlled corporation established on March 16, 1976 and its operation started in the same year. It is responsible for water treatment and water supply services in the city. It utilizes groundwater supply from carefully selected sites in the city. The present facilities include five deep wells with depth ranging from 89 to 166 meters. The water is pumped from the ground through a submersible pump with a capacity that range from 15 hp to 50 hp. The SICIWA has an elevated concrete ground reservoir and a ground tank with the storage capacity of 380 m^3 and 550 m^3, respectively. All deep wells are sealed with the cement grout to prevent the entry of surface water and other pollutants that may contaminate the wells.

The utility's area of responsibility has a total population of 78,048 people. The current service area of SICIWA has a population density of 363 persons/km^2. This plant is designed to produce treated drinking water that complies the water quality parameters prescribed by the Philippines National Standards for Drinking Water (PNSDW) and the Department of Health (DOH). The SICIWA can supply water with a daily maximum production capacity of 7,776 m^3. The peak hour demand occurs during 5:30 am to 10:30 am. Raw water from underground is subjected to an oxidizing agent, Chlorine dioxide before passing through a modular filtration system. The filter media is composed of filter Ag-plus, crystalline silica, abrasive sand approved by NSF/ANSI (National Sanitation Foundation/American National Standards Institute), and graded pebbles. The final stage of the treatment is the disinfection process using Sodium hypochlorite solution. The chemicals are transferred from chemical tanks up to the injection points by dosing pumps. **Figure 1** shows the Silay City Water District office and **Table 1** presents the overall information of SICIWA.

Figure 1 Office of Silay City Water Distirct

Table 1 Overall Information of SICIWA

Year of commissioning	2006
Type of source	Ground water
Per capita consumption (L/ d)	110.19
Topography	Plain/tropical
Design capacity (m^3/d)	7,344
Maximum capacity (m^3/d)	7,776
Average daily production (m^3)	7,637
No of domestic connections	6237
No of non-domestic connection	232
Total employees	29
Automation	Yes
Date of access of the source information	March 2016
Reference	Silay City Water District

2. Water treatment process flow

The main processes in the SICIWA are as follows:

Groundwater → ClO_2 (oxidizing agent) dosing → Filtration system → Chlorination (disinfection) → Storage tank → Distribution pipelines

The backwash water generated from the filtration system is directly discharged to the sewer system.

The water treatment process at SICIWA is illustrated in **Figure 2**. These system are run in five different places in the Silay City: Bautista, Burgos, Fortuna, NJL and SFVR and has a common storage and distribution unit.

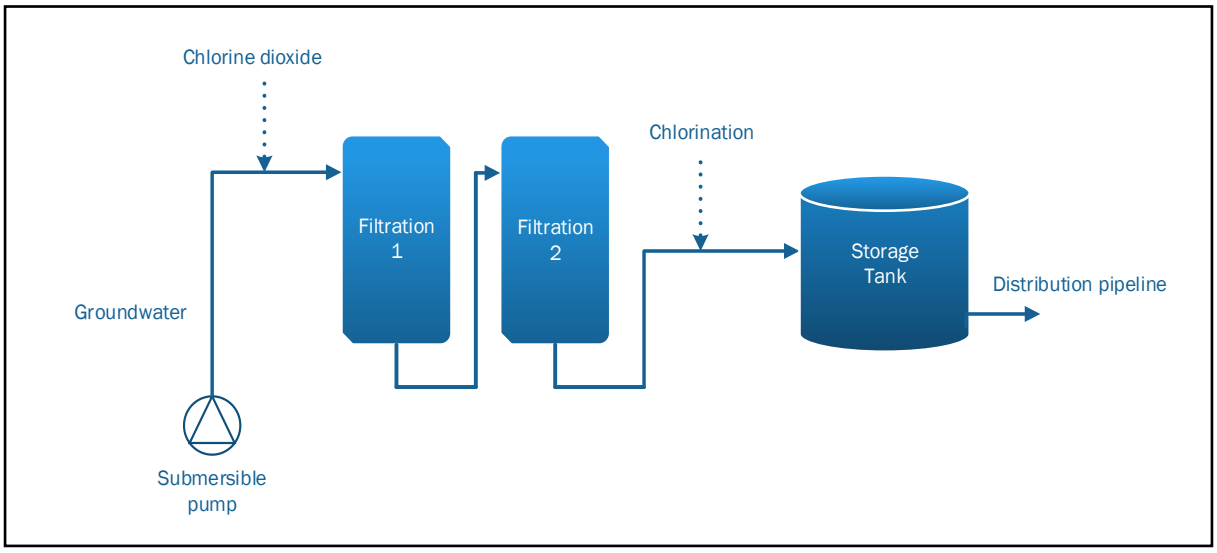

Figure 2 Schematic Diagram of Water Treatment Process

2.1 Water intake

The current facilities include five deep wells, equipped with pumping equipment (submersible pumps) ranging from 15-20 hp, an elevated concrete reservoir and ground tanks with the storage capacity of 380 m^3 and 550 m^3, respectively. **Table 2** presents the details of five pumping stations operated by SICIWA. The SFVR (St. Francis Villa Rosario) pumping station is the recent pumping

station established in the year 2012. It has a vertical depth of 166 m and the pumping water level of 18.6 mbgl (meter below ground level). It means that the groundwater is pumped 18.6 m below the ground level. The concentration of Iron and Manganese in raw water is 1.8 ppm and 0.06 ppm, respectively, while the arsenic concentration is negligible. **Figures 3 to 7** show the pictures of these pumping stations.

Table 2 Five pumping stations of SICIWA and its parameters

Parameters	Name of Pumping Stations				
	Bautista	**Burgos**	**Fortuna**	**NJL**	**SFVR**
Location	Brgy. Guinhalaran	Brgy. Mambulac	Brgy. V	Brgy. Lantad	Panaogao Road
Depth (m)	126	126	166	89	122
Casing diameter (m)	200 x 150	250	200	200 x 150	200
Static water level (mbgl)	3.5	2.7	4.1	2.7	5.7
Pumping water level (mbgl)	12	18.4	18.6	15	18
Present discharge (L/s)	25	20	10	20	20
Rating (KW)	22.4	18.62	7.5	18.62	14.92
Year completed	2001	2003	1977	2005	2012

Figure 3 Burgos Pumping Station

Figure 4 Fortuna Pumping Station

Figure 5 Bautista Pumping Station

Figure 6 NJL Pumping Station

Figure 7 SFVR Pumping Station

2.2. Oxidation

The groundwater extracted by submersible pump is subjected to an oxidizing agent through injection ports using an automatic dosing pump. The oxidizing agent, Chlorine dioxide (ClO_2) is generated on site by the reaction of Hydrochloric acid and Sodium chlorite at the ClO_2 generation system as shown in **Figure 8**. Chlorine dioxide is used because it is more effective as a sanitizer in water of variable quality. It has a strong disinfecting power in wide pH range. It oxidizes soluble forms of iron and manganese present in groundwater. In addition, it controls the taste and odor of the groundwater.

The United States Environmental Protection Agency (U.S. EPA) established secondary maximum contaminant levels (SMCLs) for iron at 0.3 mg/L and for manganese at 0.05 mg/L. These guidelines correspond to approximate concentrations at which iron and manganese will not cause aesthetic problems, such as colored water, turbidity, staining, and bad taste that would impact public acceptance. The ClO_2 is dozed at 0.23 mg/L targeting the residual chlorine of 0.8 mg/L.

Figure 8 Chlorine dioxide Generation System

2.4 Filtration

The SICIWA employs a modular filtration system. The cylindrical filtration tank has a diameter of 1.5 m and a height of 1.2 m. The oxidized water enters into the two units of filtration system to improve the water quality. The filtration system consists of layers of filter media for drinking water treatment components classified by Underwriters Laboratories Inc. in accordance with standard ANSI/NSF. The filter media is composed of Clack Filter Ag-Plus enhanced performance filtration media; Clack Filter Ag-Plus general purpose filtration media; abrasive sand; and graded pebbles to provide bed support. **Figures 9-13** show the actual package of the filter media used.

Figure 9 A bag of Clack Filter Ag-Plus (enhanced performance filtration media)

Figure 10 A bag of Filter Ag (general purpose filtration media)

Figure 11 A sack of abrasive sand

The Clack Filter-Ag Plus used are light tan to near white in color with the effective size of 0.5 mm and uniform coefficient of 1.8. The filtration rate of filters located at individual pumping stations are shown in **Table 3.**

Table 3 Filtration Rate of the Modular Filtration System at Different Pumping Stations

Name of pumping station	Filtration rate (LPS)
Bautista	25
Burgos	20
Fortuna	10
NJL	20
SFVR	20

Clack Filter-Ag Plus is a clinoptilolite natural media with a large surface area of over 100 times greater than silica sand and with microporous structure, which can be used as a highly efficient filter media for the reduction of suspended matter. It has many outstanding advantages over common granular filter sands and multimedia. Its operational advantages include deep bed filtration, high sediment removal capacity, and high service flow rates. The suggested operating conditions are presented in **Tables 4.**

Table 4 Suggested Operating Conditions of Clack Filter Ag-Plus

Parameters	**Enhanced performance filtration media**	**General purpose filtration media**
Maximum temperature (°C)	60	60
Bed depth (cm)	61-91	61-91
Backwash flow rate ($m^3/m^2.h$)	36.7-49 $m^3/m^2.h$	19.6-24.5
Backwash bed expansion (% of the bed)	30-40	30-50
Service flow rate ($m^3/m^2.h$)	12.25	12.25

Cleaning of filter media is performed by backwashing every eight hours of operation. The backwashing procedure lasts for 15-30 minutes. There is no existing wastewater treatment facility to manage the backwash water. However, the SICIWA plans to build a facility on backwash water treatment and recycling after enough funding is available. At present, the backwash water is discharged directly in sewers.

2.8 Disinfection process

The filtered water then passes through another injection port using an automatic dosing pump where Sodium hypochlorite is used for disinfection (**Figure 12**). Sodium hypochlorite is used because it is effective when water is free of other chemicals and contaminants. As water quality declines, then so does the effectiveness of Sodium hypochlorite. Sodium hypochlorite is effective when water is free of contaminants and it is relatively cheap and cost effective. The concentration of Sodium hypochlorite is 2 mg/L. The dosage is determined based on the volumetric flow rate and water quality. The company which supplies Sodium hypochlorite determines the dose and the dosing rate. So far, the dose and dosing rate are not affected by the changes in season. In every pumping station, there is one chlorinator for disinfection which makes use of Sodium hypochlorite. The chlorine contact time is about 15 minutes.

a) Injection Port for Disinfection at Fortuna Pumping Station

b) Injection Port for Disinfection at NJL Pumping Station **c) Sodium Hypochlorite**

Figure 12 Disinfection Ports

2.9 Storage Tank

The treated water is stored in reservoirs (elevated and ground tanks). The first water reservoir located at Burgos pumping station was constructed in 1932. It had been rehabilitated and is still in use. The storage capacity of the Burgos reservoir is 380 m^3. **Figure 13** shows the elevated storage tank at Burgos Pumping Station. Moreover, the SICIWA has newly acquired a ground reservoir located at SFVR pumping station (**Figure 14**) which has a storage capacity of 550 m^3.

Figure 13 Water Reservoir at Burgos Pumping Station

Figure 14 Water Reservoir at SFVR Pumping Station

2.10 Sludge disposal

Currently, there SICIWA lacks sludge disposal unit. The backwash water generated after cleaning of filter media is discharge into the sewer. SICIWA has a planned for a program to build a facility on backwash water treatment and recycling. This will be implemented as soon as enough funding is available.

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

The current trend of increasing population density in Silay City incurs an increasing demand for water supply especially during peak hours. The SICIWA projected an annual water storage

requirement as depicted in **Table 3**. It shows that the existing water storage capacity of 930 m^3 which is no longer enough to cater the increasing population to be served in the coming years. From these data, the proposed additional storage capacity will relieve the peak hour demand needs to some extent.

Table 3. Projected Annual Water Storage Requirement

Year	Served Population	Total Required Storage Capacity (m^3)			Existing Storage Capacity (m^3)			Proposed Storage Capacity (m^3)	Total Capacity (m^3)
		Operational	Emergency	Total	Elevated Tank	Ground Tank	Total		
2017	44,277	1187	148	1335	380	550	930	360	1290
2018	47,002	1249	156	1405	380	550	930	360	1290
2019	49,326	1329	166	1495	380	550	930	360	1290
2020	51,726	1346	168	1514	380	550	930	360	1290

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

SICIWA accounts 48% of Non-Revenue Water. Out the total 2,612,589 produced water only 1,348,764 m^3 of the water was billed by SICIWA in 2014. This fraction of water losses is accounted due to: leakage from old distribution pipelines, old valves and fittings; water used for filter backwashing; and commercial losses because of defective water flow meters and illegal connections.

Lack of backwash water treatment and sludge disposal facility is also posing difficulty in the service management.

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

- SICIWA has recently constructed an additional storage facility of 360 m^3 concrete ground reservoir for the adequate storage of the treated water at Bautista pumping station.
- Operation of Boostering Facilities with the capacities ranging from 10-20 LPS from 5:30 to 10:30 am to improve the system pressure from 5 psi to 25 psi downstream. This measures targets to increase the water sales by 10.5%.
- To cope up with the problem on Non-Revenue Water, SICIWA has planned program for the total rehabilitation and replacement of old distribution pipelines, valves and fittings. This work will be funded by the Development Bank of the Philippines to be implemented by year 2017-2027.
- The SICIWA has a plan for a program to build a facility on backwash water treatment and recycling. However, its implementation is highly dependent upon the availability of funds. The current priority project of the SICIWA that needs an urgent solution is the rehabilitation of old distribution pipelines, valves, and fittings.

6. Recent investment made for the plant's improvement

- Extension of distribution network at Bangga Sawmill, Brgy Mambulac and Sitio Dap-dap, Brgy. Lantad.
- Extension of transmission pipeline from Tresfuentes Bridge up to the proposed pumping station at Hacienda Maquina, Brgy. Lantad.
- Replacement of production meters from mechanical type to electro-magnetic flowmeters to improve accuracy of flowmeters.
- Replacement of concessionaires' water meters from multi-jet/vane wheel type water meter to volumetric type water meter.

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

The SICIWA administration prepared a program of work for the proposed improvement for the Silay City water supply system. The following are the proposed work:

- Construction of 360 m^3 concrete ground reservoir;
- Extension of 1,620 m transmission pipelines with a diameter of 200 mm to be laid from Tresfuentes bridge up to the proposed well site locate at Hacienda Maquina, Brgy. Rizal;
- Supply and installation of boostering facilities;
- Waterline extension project located at Bungol, Brgy. Balaring.
- Construction of additional four pumping stations; two of which will be situated at the relocation sites (Yolanda and Bon-Bon), while the other two will be located at residential areas (Bagtic and Maquina).

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

Generally, in terms of water quality, there was no reported or recorded consumer complaint. There is a *suggestion box* provided by the SICIWA office to allow and encourage the consumer to express freely their opinion and feedback without any hesitation regarding the service and water quality provided by the SICIWA.

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

The five pumping stations have Variable Frequency Drive (VFD) installed for the controller and Programmable Logic Control (PLC) and the installation of electromagnetic flowmeters.

10. Other Highlights

Currently, the SICIWA has a plan for a program of future expansion to cater the projected 7,500 additional consumers by year 2020.

Depletion of groundwater supply has never been a problem encountered by the SICIWA even during the dry season as the SICIWA has its own watershed maintained and protected at Barangay (Brgy.) Patag in Silay City. This watershed is part of the Negros Island Region forest reserve (**Figure 14**).

Figure 14 SICIWA Watershed Located at Sitio Baliguan, Brgy. Patag, Silay City

11. Water quality data

Water analysis is conducted twice a week for each pumping station. Bacteriological analysis are done in accredited water laboratory at W.J. Villanueva, Inc., Bacolod City, Negros Occidental. The results of bacteriological water analysis from the five pumping stations, sampled on February 24, 2016 are presented in **Table 4**. The test results show that the water bacteriological quality complied to the requirement set by the Philippines National Standards for Drinking Water (PNSDW) and the Department of Health (2007). The standard value of total and fecal coliforms is < 1.1 MPN/100 mL and < 500 CFU/mL for the heterotrophic plate count.

Table 4 Results of Bacteriological Water Examination (2016)

Sample Source (Pumping station)	Total Coliforms (MPN/100 mL)	Fecal Coliforms (MPN/100 mL)	Heterotrophic Plate Count (CFU/mL)
Bautista	< 1.1	< 1.1	0
Burgos	< 1.1	< 1.1	0
Fortuna	< 1.1	< 1.1	0
NJL	< 1.1	< 1.1	0
SFVR	< 1.1	< 1.1	0

Table 5 presents the results of physico-chemical test on treated water samples analyzed on November 11, 2015. It complies with the 'Philippine National Standards for Drinking Water (2007)'.

Table 5 Results of Physico-Chemical Test on Treated Water Samples

Parameter	Unit	Bautista	Burgos	Fortuna	NJL	SFVR	Philippine National Standards for Drinking Water (2007)
Turbidity	NTU	1.19	4.11	1.95	3.19	4.88	*5*
pH		7.1	7.13	7.15	6.9	6.93	*6.5-8.5*
Total Dissolved Solid	mg/L	206	172.2	204	182.3	184.9	*500*
Arsenic	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	*0.05*
Chlorine	mg/L	10	12.5	11.2	5	7.5	*250*
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	*0.003*
Iron	mg/L	0.257	0.94	0.856	0.78	0.917	*1*
Lead	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	*0.01*
Manganese	mg/L	0.0137	0.1052	0.0694	0.061	0.0755	*0.4*
Nitrate	mg/L	3.54	8.41	2.66	3.54	3.1	*50*
Sulfate	mg/L	1.09	1.9	1.09	1.39	1.04	*250*

12. References

Asian Development Bank and Southeast Asian Water Utilities Network. (2007). Data Book of Southeast Asian Water Utilities 2005. Retrieved from http://www.adb.org/sites/default/files/publication/28928/seawun-data-book.pdf.

Official Website of Silay City Water District. Retrieved from http://silaycitywd.gov.ph/

Philippine National Standards for Drinking Water. (2007). Department of Health, Administrative Order no. 2007-0012. Retrieved from http://www.lwua.gov.ph/downloads_14/Philippine%20National%20Standards%20for%20Drinking%20Water%202007.pdf.

Stein, B. (2014). Chlorine Dioxide Versus Chlorine: What's the Difference?. The Poultry Site. Retrived from http://www.thepoultrysite.com/articles/3114/chlorine-dioxide-versus-chlorine-whats-the-difference/. Accessed in May 10, 2016.

SICIWA Annual Report (2015). Retrieved from http://silaycitywd.gov.ph/wp-content/uploads/2015/05/General.pdf. Accessed in 28 April 2016.

SICIWA Plans and Programs (2015). Retrieved from http://silaycitywd.gov.ph/wp-content/uploads/2015/05/plansandprograms.pdf. Accessed in 10 May 2016.

Prepared by:

Rodney L. Nabalona
Operations Division Manager
Silay City Water District (SICIWA)
Silay City, Negros Occidental, Philippines
Email: silaywd@yahoo.com.ph

Jeanger Juanga-Labayen
Science Research Specialist II
Technological University of the Philippines Visayas
Capt. Sabi St., Talisay City, Negros Occidental, Philippines
Email: jeanger.labayen@gmail.com

Ildefonso V. Labayen
Instructor
Technological University of the Philippines Visayas
Capt. Sabi St., Talisay City, Negros Occidental, Philippines
Email: ivlabayen@yahoo.com

Date: 28 April, 2016

URL: http://www.jwrc-net.or.jp/aswin/en/newtap

Email: newtap@jwrc-net.or.jp