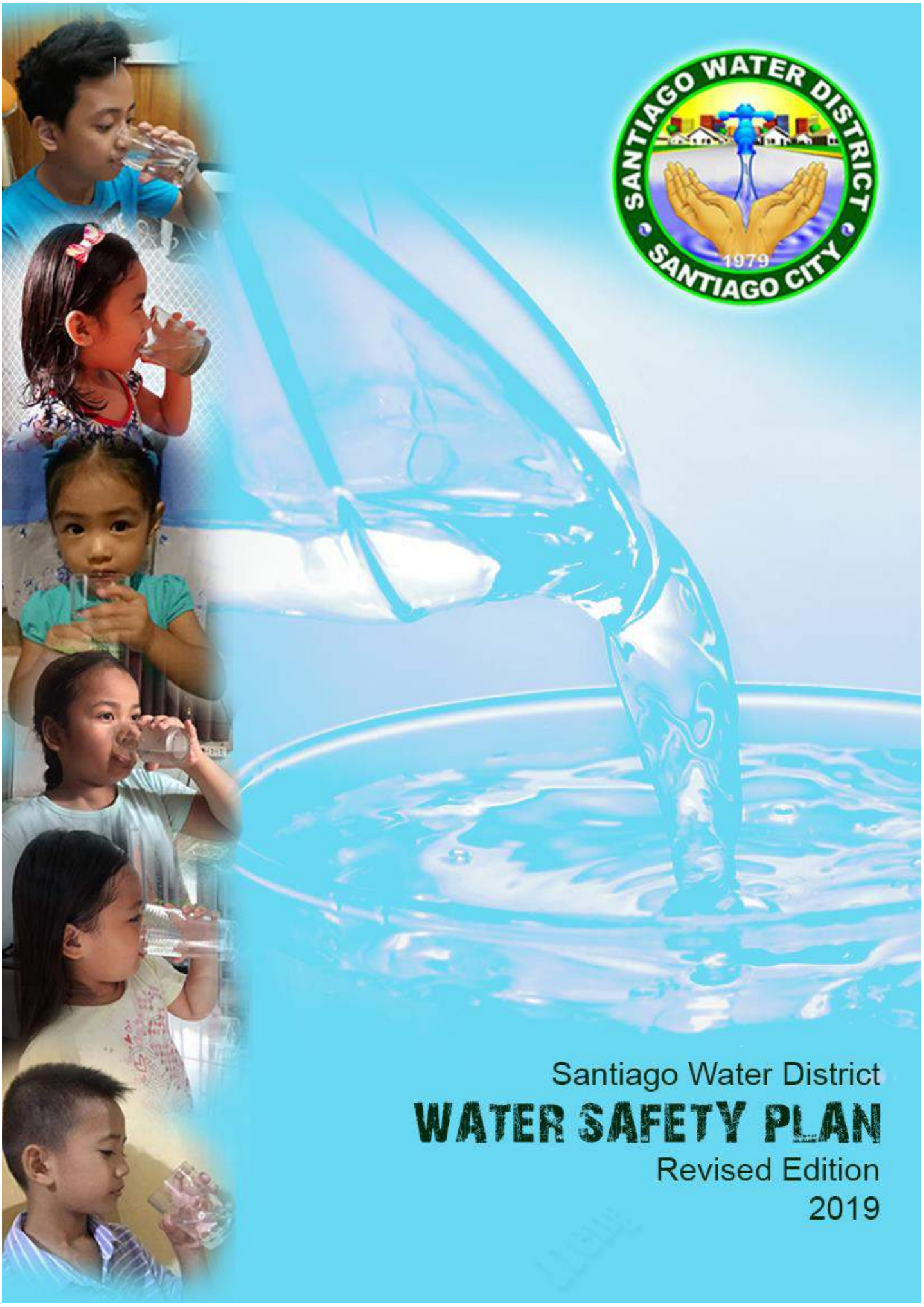

Santiago Water District

WATER SAFETY PLAN

Revised Edition

2019

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INTRODUCTION

Water is life as many say. Water is quoted as a “universal solvent” because both flora and fauna needs it. For human beings, it is needed to transport nutrients to different parts of the body. Water has been a controversial issue here in the Philippines and around the world. As the number of people increase and water resources decrease, the means on how we use our resources and keep our fellow citizens safe apparently become more important. Here in the Philippines, almost half of its population has no access to clean and potable water and the reasons may vary from poverty to lack of leadership or location and many more. Whatever the reason maybe, the responsibility of providing clean and potable water to every household has been a vital service the Government has embarked on.

With the rising demand for sufficient clean and potable water, the Santiago Water District embarked on a project that will address the pressing concerns on the provision of water as a basic service of the Government. In 2006 the Santiago Water District, a Government Owned and Controlled Corporation (GOCC), commenced the operation of its Water Treatment Plant. It is the first state of the art facility of any kind in Region 2. The Water Treatment Plant has a capacity of 625 cubic meters per hour and operates on a twenty four hour and seven days a week schedule.

Santiago City has 37 barangays, 23 are being served by SANWAD with a total of 17,346 consumers. Of which, 12,308 are residential consumers; 1,328 belong to the commercial classes; and 36 government facilities. Santiago City has the widest and most well-kept business district in Cagayan Valley. Its public market of more than 6 hectares is one of the biggest distribution centers in the Philippines. In terms of cleared checks at the clearinghouse, the volume of transactions in the city is among the top five in the country. At present, there are about 7,500 registered business establishments in the city while new business

permits have been issued to investors from as far as Singapore and other foreign countries. The city has 40 banks, and has the most-numbered universal banks in the region.[1] Putting this in consideration, SANWAD realizes the needed prerequisite for the City's progress in terms of business investments as well as its rapid increase in population density. Hence, continues to embark on projects that will expand its service area as well as projects that will augment its water supply capability.

[1] https://en.wikipedia.org/wiki/Santiago_(Philippine_city)#Demographics

Brief History

SANWAD was established in 1979 through a resolution passed by the local Municipal Council. By 1983, it has a total of 2,500 consumers. Various expansions where undertaken. An example of which is the 7 kilometers pipe laying project through a 2 Million pesos loan grant from LWUA which served an additional 1,000 consumers.

In 1991, via a Supreme Court decision, SANWAD was converted from a Quasi-Public Corporation (QPC) to a Government Owned and Controlled Corporation (GOCC). It was then classified as a Medium Water District by 1995.

A Comprehensive Water Supply Improvement and Expansion Project was initiated in 2001. The project included the following: (1) drilling of deep wells; (2) construction of a Water Treatment Plant (WTP); (3) elevated reservoirs; (4) booster pumps and a sump tank; and (5) laying of new pipelines.

In May 2006, SANWAD's organization expanded, thus, it became a Big Water District.

The Comprehensive Water Supply Improvement & Expansion Project was finally inaugurated on February 2007. Notwithstanding that project completion was on its final stage. The Water Treatment Plant (WTP) which was the centerpiece of the project became operational even prior to the inauguration.

Our Mission-Vision

We shall deliver sufficient potable water - at a profit if we can - at a loss if we must - but always sufficient and potable 24/7.

As mandated by the Department of Health's Administrative Order 2014-0027 which declares the development and implementation of Water Safety Plan (WSP) by all drinking-water service providers and as required by the Local Water Utilities Administration Memorandum Circular No. 010-14, the SANWAD management created an 18-man WSP Team which will develop a Water Safety Plan.

The WSP focuses on monitoring the safety of water from its source to SANWAD's consumer taps. This comprises the protection of water sources, water treatment plant, pumps and reservoirs from risks that will endanger the quality of water being delivered to consumers.

Specifically, this plan aims to:

a) Ensure the safe quality of supplied water from its reservoirs to the tap of every home in the City of Santiago;

b) Prevent contamination of water by identifying potential risks and addressing these risks quickly and effectively with appropriate control measures;

c) Provide policies and procedures to maintain quantity and quality of service even during adverse conditions;

d) Facilitate decision-making on critical issues in a potentially stressful environment and define responsibilities and roles during emergency situation; and

e) Provide procedures for using the lessons gained following every emergency or unforeseen event to guarantee that every hazard and issues are covered and will not recur in the future.

I. THE WATER SAFETY PLAN TEAM

The Water Safety Plan Team of the Santiago Water District is composed of the following personnel:

Team Leader	Jose Roy R. Palma
Asst. Team Leader	Dionisio M. Agonoy, Jr.
Water Source	Dionisio M. Agonoy, Jr. Ramilio Angoluan
Water Treatment	Jose Roy R. Palma Jaime S. Balido
Quality Assurance	Floremil B. Pira Irene D. Paa
Water Distribution	Leo Teriza P. Chaves Federico F. Gallardo
Water Pipelines	Romeo C. Maniago Arnel R. Mendoza
Logistics	Juan M. Baltar Maricelle V. Ines
Customer Relations	Charmaine S. Medina Tinobelle Castrosanto
Personnel Relations	Apolinar B. Santiago Vilma S. Castrosanto
Secretariat:	Miriam Christine P. Gepilano Princess Jane S. Guillermo

SANWAD WATER SAFETY PLAN TEAM

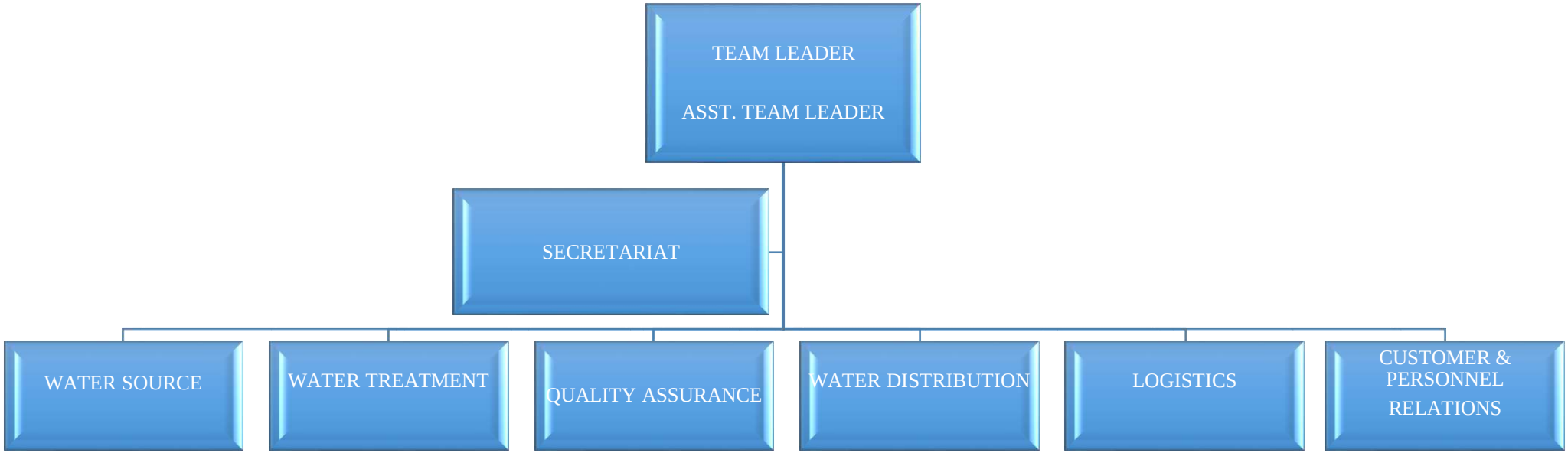


Figure 1 SANWAD WATER SAFETY PLAN

II. THE WATER SUPPLY SYSTEM

SANWAD's water are sourced out from fourteen deep wells namely, Palogan, Roque, Sefton, St. James, Camella, Rotary, Lumidao, Mabini 1, Mabini 2, Abaya, San Andres, RC Miranda, Rizal 1 and Rizal 2. The total output of the 14 pumping station is ±580 cubic meters per hour. All sourced out raw water are conveyed to the Water Treatment Plant via Transmission Lines with pipe sizes ranging from 4" to 12" in diameter.

Raw water is then collected to two Receiving Chambers. Calcium Hypochlorite or Chlorine is injected here to facilitate partial oxidation. Each receiving chamber is provided with a baffle to facilitate initial sedimentation of undissolved solids in the raw water.

Water then passes through the baffle and on to two parallel streams of Cascade Aerator. Each Aerator has three cascade falls which enables partial oxidation of dissolved iron in the raw water. Polyaluminum Chloride (PAC) which acts as a coagulant in the water treatment process is injected at the top of the Cascade Aerator. To protract the contact time of the injected PAC in the water, the Production Division innovated a means to enable the same. Concrete blocks where installed at the edge of each cascade falls in order to divert water to a smaller opening before the water drops to the next cascade. Hence, a longer contact time between the water and PAC will be achieved. A collection basin at the bottom of the cascades collects the aerated and coagulated water which will then be channeled to the next stage.

Following the Cascade Aerator streams are the Coagulation Chambers. As per design, these chambers are where the PAC chemicals are supposed to be injected. But present circumstances dictate that remodeling or the adaption of modified stages in the treatment process be implemented. Thus, the Production Division

deemed it necessary to implement its redesigned process flow in order to be attuned with the current requirements in the treatment of raw water. As such, the Coagulation Chambers were modified to act as the Flocculation Chambers where Anionic Polymer is injected. The water has a detention time of 16 minutes in order to aid complete reaction of chemicals (e.g. PAC and Polymer) resulting to a full build-up of flocs.

Following the now Flocculation Chambers are the previous ones. It operates now as a Clumping Chamber to further increase floc mass build-up for improved filtration on the succeeding stage. Like the Receiving Chamber, it also functions as a sedimentation chamber because of the integrated baffle where water passes through prior to filtration.

Chemically reacted water is immediately fed by gravity to 12 units of Dynasand Filter. As the name implies, water filtration is its lone function. It filters out the mass of flocs in the water together with iron and other particulate precipitates. Each train has 6 units which is supplied individually with 4 bars of compressed air to effect continuous cleaning of the filter media. The filter media in each filter tank is 7.3 cubic meters of graded river sand which is replenished every year for maximum filtration. As the influent flows upward, solids are trapped in the sand bed. The filtrate exits over an effluent weir at the top of the filter. Simultaneously, the sand bed, along with the accumulated solids is drawn downward into the airlift pipe which is located in the center of the filter. A small volume of compressed air is introduced at the bottom of the airlift. The air rises, draws the sand into the airlift and scours the sand of trapped particles and excess biomass.[2] Wash water from each Dynasand filters goes directly to a flash mixing tank where Anionic Polymer is again injected for sedimentation purposes on its integrated Clarifier.

[2] Evaluation of the Performance of Dynamic Sand Filtration Under Real Working Conditions

A lamella clarifier works when a solid/liquid stream that has been flocculated, enters a tank, and flows upward between a pack of inclined plates. The solids fall to the plate surface, where they slide by gravity down to a sludge collection hopper. The clarified effluent flows through orifice holes and exits the top of the settler.[3]

After undergoing filtration, water again flows by gravity to two Treated Water Tanks with a capacity of 725 cubic meters each. Further injection of Chlorine is made here for disinfection purposes, which completes the treatment process of the water to be distributed to all consumers. Baffles are integrated at both treated water tanks to facilitate appropriate contact time for the chlorine.

Distribution pumps[4] are used to boost the treated water to its consumers. There are two main distribution lines. The line with the biggest coverage is the Calaocan Reservoir line. Said Reservoir functions as a "fill and draw" reservoir and is operating by gravity distribution. It covers the greater Business District of the City. The second is the Rizal/Divisoria Line which has two "floating-on-the-line" reservoirs and operates through direct pumping.

The Calaocan Reservoir line has two overhead reservoirs with a capacity of 550 cubic meters each. The Floating-on-the-line Reservoir at the Rizal line has a capacity of 500 cubic meters and 350 cubic meters for the Divisoria reservoir. A retrofitted concrete reservoir at the Poblacion area is undergoing commissioning works as of the moment and will serve the higher areas of the same.

Part of SANWAD's innovation on the existing design of the Water Treatment Plant is the incorporation of a "Waste Water Recycling System." It utilizes the sludge lagoon as a clarifying facility wherein waste water undergoes clarifying procedures before being recycled and pumped back to the receiving chamber.

[3] https://www.parkson.com/products/lamella-ecoflow
[4] Centrifugal Pumps with a rating of 60Hp(x2), 40Hp(x1), 25Hp (3) and 15Hp (x2)

The waste water undergoes three clarifying stages wherein sludge and any other undissolved solids are separated.

The whole process from the raw water source and up to the storage reservoirs are monitored and controlled through a Supervisory Control and Data Acquisition (SCADA) system. A SCADA system is a human-machine-interface with a graphic display on the computer monitor which represents the different components of the treatment process. It is the link between the on-duty Water Utilities Development Officer and the machine. It provides real time status and control of the different components of the water generation section, water treatment process and the reservoir status.

Water quality is closely monitored by on-duty Quality Control and Assurance personnel on a 24 hour cycle. Prior to distribution, water quality is regularly tested at the distribution header as well as on all stages of the treatment process to ensure compliance to the requirements of the Philippine National Standards for Drinking Water (PNSDW). Parameters for monitoring water quality include pH, conductivity, turbidity, color, residual chlorine, iron, residual alumina, microbiological test, TDS, manganese, sulfate and chloride.

SANWAD's quality monitoring doesn't stop at the Water Treatment Plant. Laboratory personnel conduct daily monitoring of water quality right at the tap of every consumer. Again, this is to ensure excellent quality of potable water in every household.

The Laboratory Section of SANWAD likewise performs random tests in different areas for microbial organisms in the water coming from the tap of every household, thus preventing the occurrence of possible illnesses at a certain time.

All raw water and treated water distribution lines are monitored and managed by the Engineering Division. Improvements, expansions, extensions and

maintenance falls under their function. The Engineering Division is responsible in the planning, design and construction of the District's facilities and preparation of as-built plans of completed works and projects. It is also responsible in the operation, maintenance and improvements of all transmission and distribution mains including all its installed appurtenances and accessories in order to ensure delivery of sufficient potable water 24/7 to the customers through the highest level of professionalism and efficiency. It is likewise responsible in the proper identification, selection and utilization of materials and equipment in accordance to technical standards set by competent authorities in terms of quality and proper size.

CLASSIFICATION	**Diameter (Inches)**	***Material Type***	**PIPE LENGTH (meter)**
DISTRIBUTION LINES			
	12"Ø	uPVC	1,700.50
	10"Ø	uPVC	4,458.00
	8"Ø	uPVC	5,577.00
	6"Ø	HDPE/uPVC	21,421.50
	4"Ø	HDPE/uPVC	50,466.00
	3"Ø	HDPE/uPVC	26,610.00
	2 1/2"Ø	HDPE	1,080.00
	2"Ø	HDPE/uPVC	40,932.50
	1 1/2"Ø	uPVC	2,233.00
SUB TOTAL			**154,478.50**
TRANSMISSION LINES			
	18"Ø	STEEL	2,325.00
	16"Ø	STEEL	1,707.00
	14"Ø	STEEL	882.00
	12"Ø	PVC	5,327.00
	8"Ø	PVC	656.00
	6"Ø	PVC	2,693.00
	4"Ø	PVC	1,254.00
SUB TOTAL			**14,844.00**
TOTAL PIPELINE INSTALLED (VINHAR)			**169,322.50**

Figure 2 Summary of Transmission and Distribution Lines

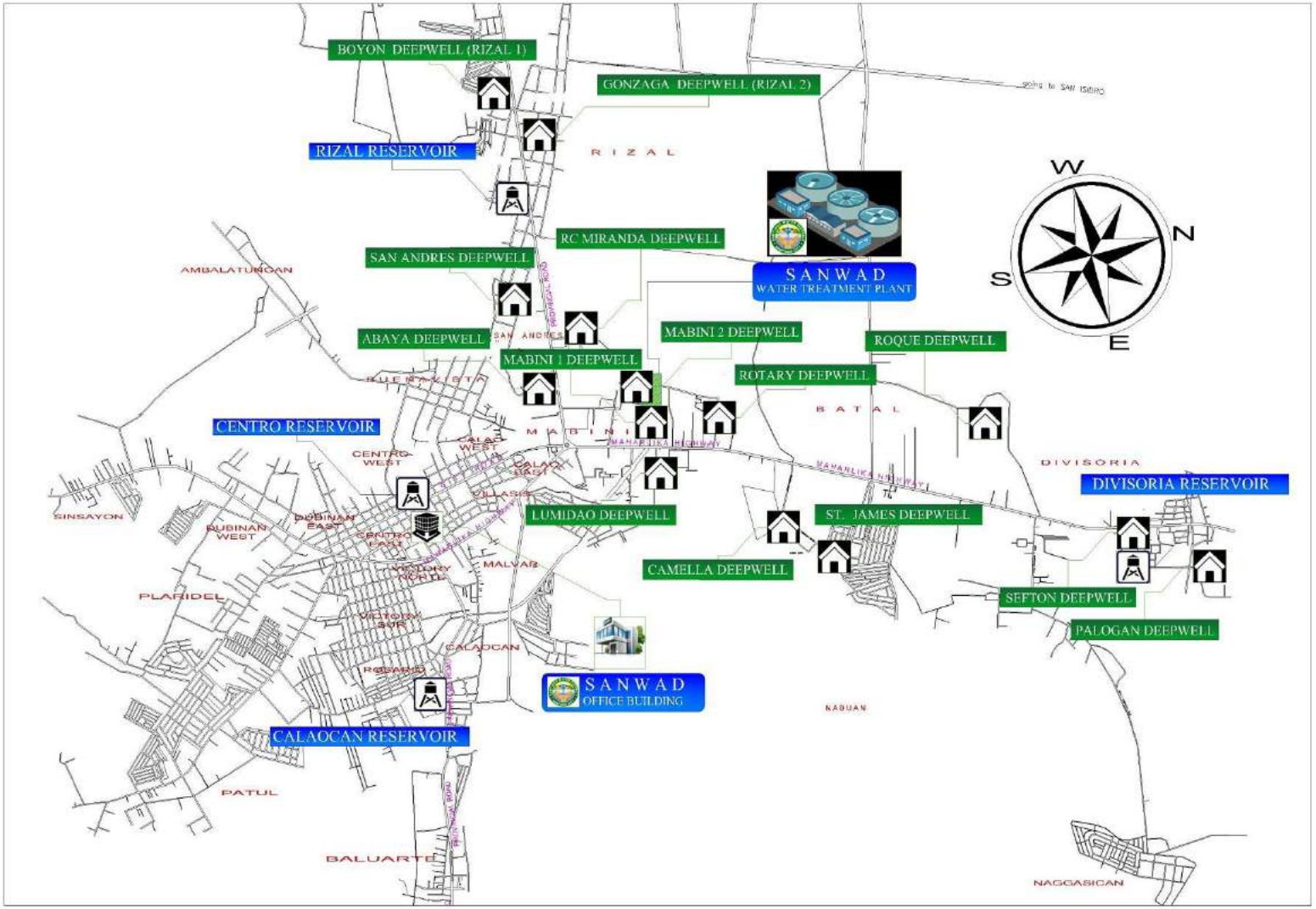


Figure 3 Location Map of SANWAD Facilities

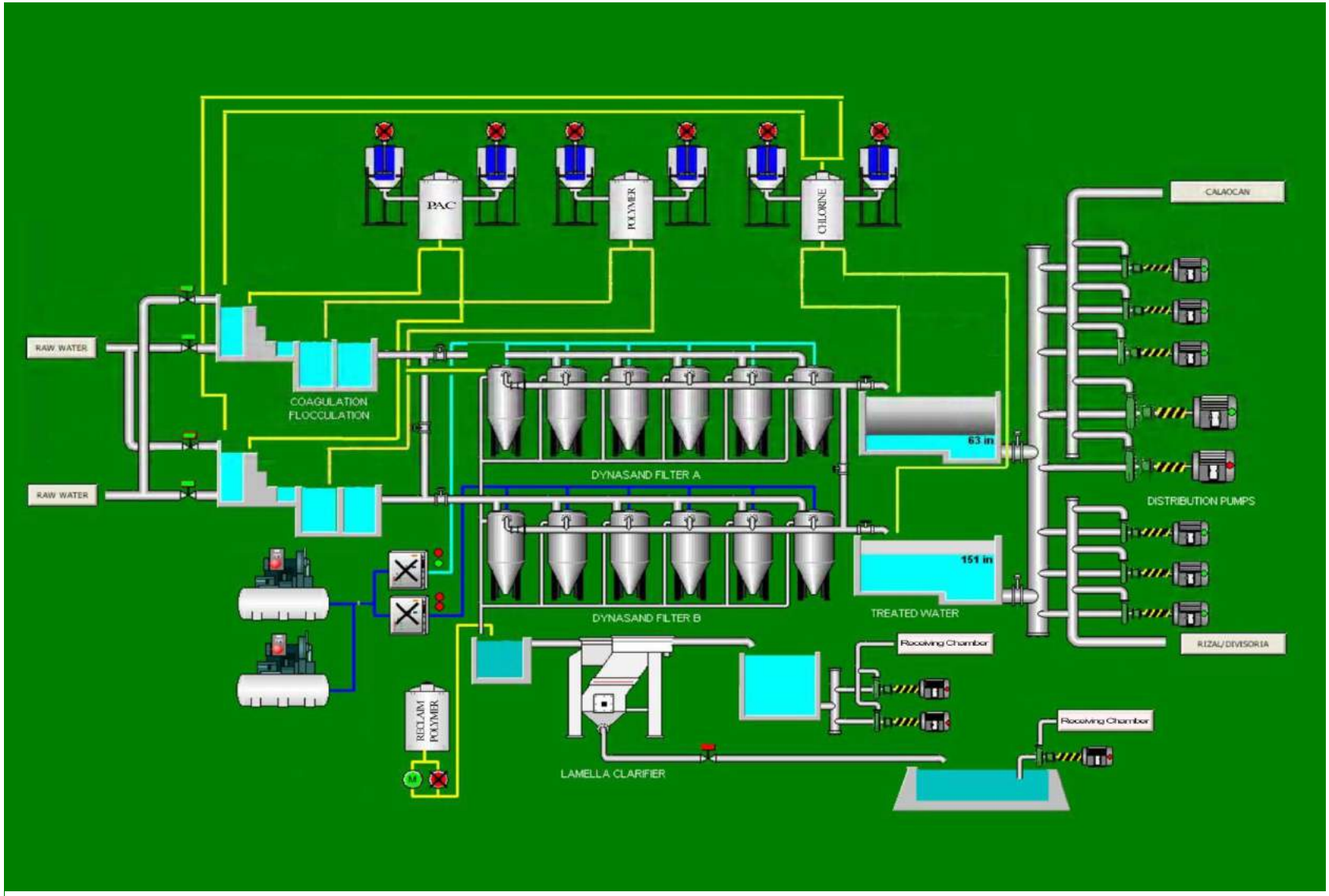
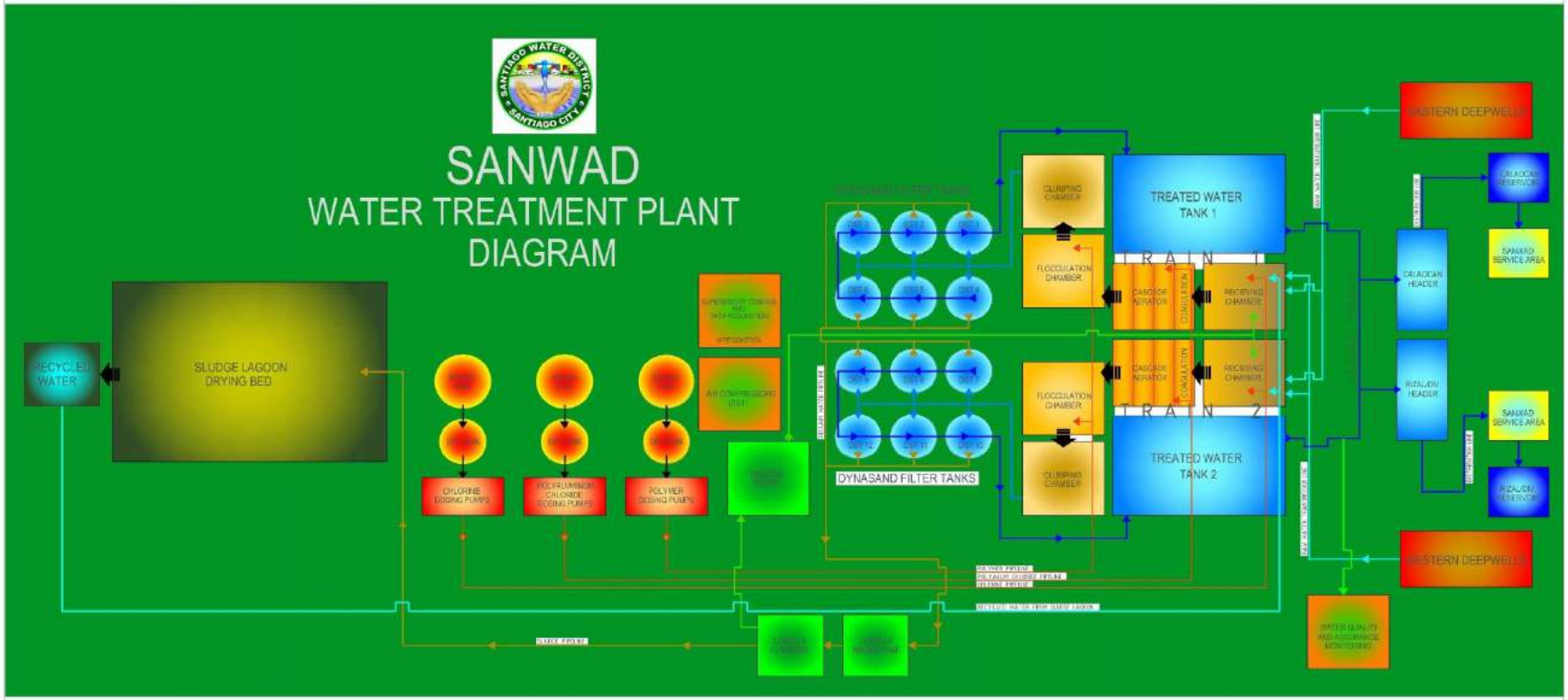


Figure 4 SANWAD Water Treatment Process



WATER TREATMENT DIAGRAM

Figure 5 Water Treatment Plant Diagram

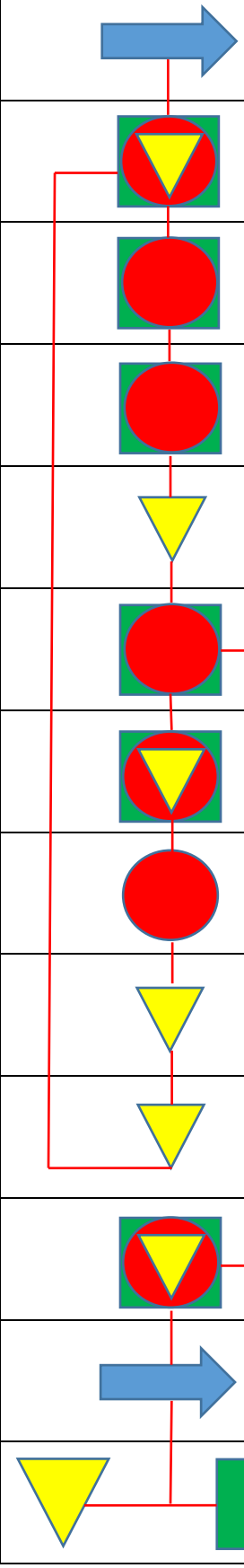
DESCRIPTION	STEP	RESPONSIBILITY
Raw Water Supply from 14 deepwells		WRFO
Receiving Chamber Pre-Chlorination Sedimentation		WUDO QC/A
Cascade Aerator Coagulation		WUDO QC/A
Flocculation		WUDO QC/A
Clumping Chamber Further increase contact and build-up of flocs		WUDO QC/A
Filtration		WUDO QC/A
Waste Water Flash Mixing Tank Flocculation		WUDO QC/A
Clarifier		WUDO
Clarified Water Sump		WUDO
Sludge Lagoon		WUDO
Treated Water Tank Disinfection		WUDO QC/A
Transport to Reservoir and Distributiion Consumers		Engineering
Reservoirs and Consumers		WUDO QC/A Engineering

Figure 6 SANWAD Process Flow

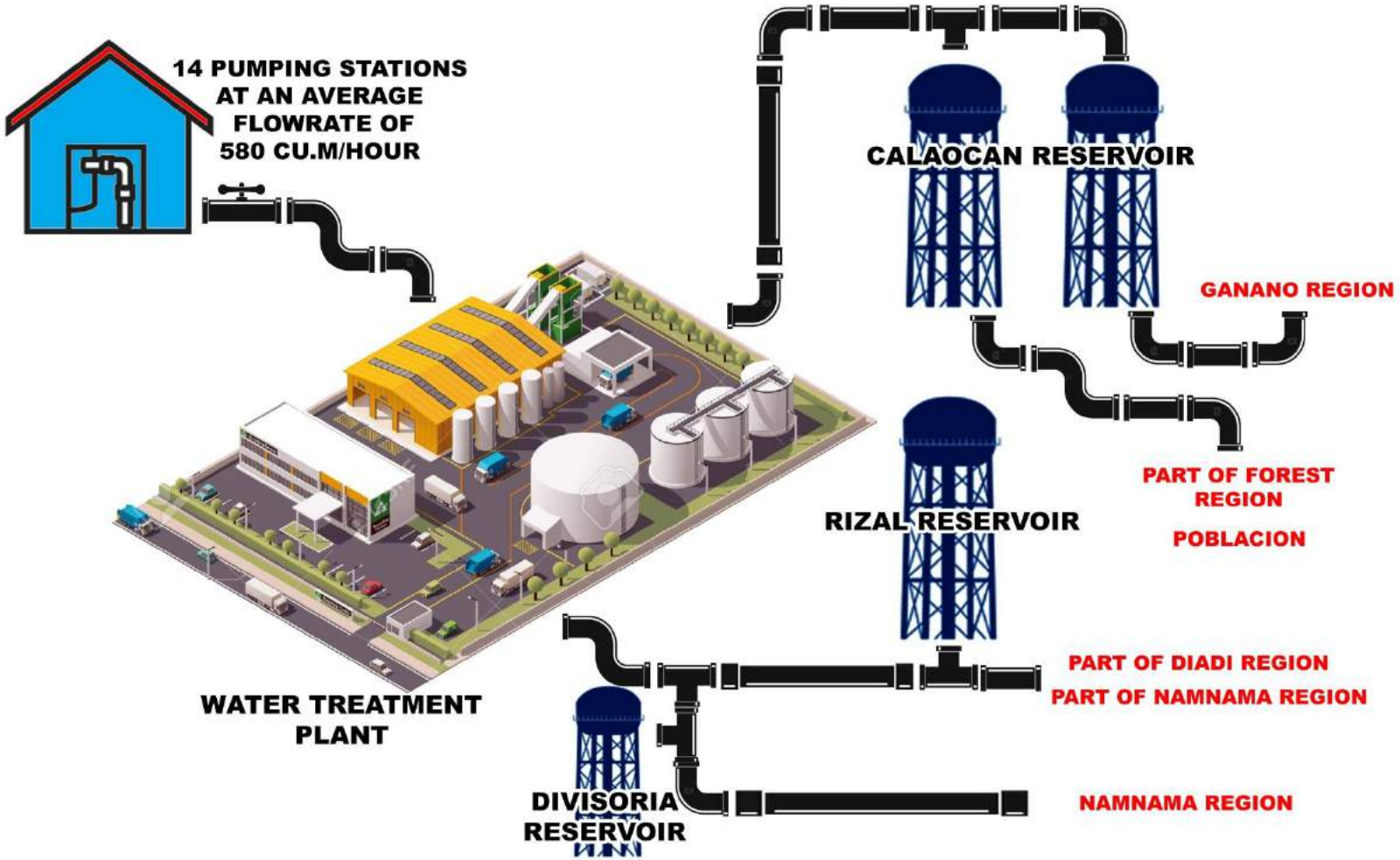


Figure 7 Water Supply System

III. HAZARD IDENTIFICATION AND RISK ASSESSMENT

Hazard identification and risk assessment were undertaken to provide control measures whenever untoward incidents arise. Careful study on every step of the water supply system has been carried out meticulously. Once the Hazards and risks were identified, prioritization of the items where considered based on the level of importance needed to prevent or control such urgencies whenever necessary.

Hazardous events that may affect the quality of drinking water which may be in the form of biological, physical or chemical incidence are identified in every step of the water supply system and provided with control measures.

Ranking of the hazards and risks were undertaken to determine urgencies. The risk and hazard assessment process involves the use of a quantitative or semi-quantitative approach (estimation of Consequence/Likelihood and Frequency/Severity) or a simple team decision to rule hazardous events in or out[5].

The likelihood and severity were based on operational history, personnel first hand experiences and technical expertise. The factors involved in the determination of priorities are: assessment of hazards that may happen in each step of the process; identify if the events are controllable; and documentation of the events that need attention.

For the purpose of determining the level of risks involved in every step, the Semi-Quantitative Risk Matrix (from Deere et. Al. 2001) is used.

[5] Training workbook on Water Safety Plans for Urban Systems (WHO)

SEMI-QUANTITATIVE RISK MATRIX

(From Deere et. al. 2001)

Risk Factor Matrix		Severity or Consequence				
		Insignificant No Impact/ Not Detectable Rating 1	**Minor** Compliance Impact Rating 2	**Moderate** Aesthetic Impact Rating 3	**Major** Regulatory Impact Rating 4	**Catastrophic** Public Health Rating 5
Likelihood or Frequency	**Almost Certain** Once a day Rating 5	**5**	**10**	**15**	**20**	**25**
	Likely Once a week Rating 4	**4**	**8**	**12**	**16**	**20**
	Moderate Once a month Rating 3	**3**	**6**	**9**	**12**	**15**
	Unlikely Once a year Rating 2	**2**	**4**	**6**	**8**	**10**
	Rare Once every 5 years Rating 1	**1**	**2**	**3**	**4**	**5**

Risk Score	**<6**	**6-9**	**10-15**	**>15**
Risk Rating	**Low**	**Medium**	**High**	**Very High**

Figure 8 Semi-Quantitative Risk Matrix

Ranking	Likelihood / Consequence	Severity / Consequence
5	**Almost Certain** - Once per day	**Catastrophic** - Potentially lethal to a large population, likely to have also very significant morbidity
4	**Most Likely** - Once per week	**Major** - Potentially lethal to a small population, likely to have also significant morbidity
3	**Likely** - Once per month	**Moderate** - Potentially harmful to a large population but no mortality
2	**Unlikely** - Once per year	**Minor** - Potencially harmful to a small population but no mortality
1	**Rare** - Once every five years	**Insignificant** - Negligible impact in terms of severity of disease or numbers of people affected

Figure 9 Ranking

HAZARD IDENTIFICATION AND RISK ASSESSMENT FOR WATER TREATMENT PLANT

Process Step	Hazardous Event	Hazard	Likelihood	Severity	Score	Rating
Deep Well Source	Seepage of leachate from septic tanks of nearby houses within the vicinity of well sources.	Physical	5	2	10	High
		Microbial	5	5	25	Very High
Transmission Line	Intrusion of contaminants due to pipeline breakage	Physical	5	2	10	High
		Microbial	5	5	25	Very High
Receiving Chamber Pre-Chlorination Sedimentation	Failure of disinfection and partial oxidation due to clogged chemical lines.	Microbial	5	5	25	Very High
	Failure of disinfection and partial oxidation due to metering pump malfunction.	Microbial	5	5	25	Very High
	Failure of disinfection and partial oxidation due to inadequate supply of Calcium Hypochlorite	Microbial	5	5	25	Very High`
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	4	3	12	High
		Chemical	4	5	20	Very High
		Microbial	4	5	20	Very High

Cascade Aerator and Coagulation	Failure of coagulation due to clogged chemical lines	Physical	5	3	15	High
	Failure of coagulation due to metering pump malfunction	Physical	5	3	15	High
	Failure of coagulation due to inadequate supply of Polyaluminum Chloride	Physical	5	3	15	High
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	4	3	12	High
		Chemical	4	5	20	Very High
		Microbial	4	5	20	Very High
Flocculation	Failure of floc build up due to inadequate supply of Anionic Polymer	Physical	5	3	15	High
	Failure of flocculation due to metering pump malfunction	Physical	5	3	15	High
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	4	3	12	High
		Chemical	4	5	20	Very High
		Microbial	4	5	20	Very High
	Failure of flocculation due to clogged chemical lines	Physical	5	3	15	High
Clumping Chamber	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	4	3	12	High
		Chemical	4	5	20	Very High
		Microbial	4	5	20	Very High

Filtration	High turbidity of filtered water due to clogged compressed air hoses	Physical	5	3	15	High
	High turbidity of filtered water due to air compressor unit malfunction or breakdown	Physical	5	3	15	High
	High turbidity of filtered water due to inadequate filter media	Physical	4	5	20	Very High
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	3	5	15	High
Waste Water Flash Mixing Tank Flocculation	Failure of floc build up due to inadequate supply of Anionic Polymer	Physical	5	3	15	High
	Failure of flocculation due to metering pump malfunction	Physical	5	3	15	High
Clarifier	High turbidity of clarified water due to pneumatic valve defect	Physical	3	3	9	Medium
Clarified Water Sump	High turbidity of clarified water due to Clarifier malfunction	Physical	4	3	12	High
Sludge Lagoon	High turbidity of water to be recycled due to heavy sludge	Physical	4	3	12	High
Treated Water Tank Disinfection	Failure of disinfection due to clogged chemical lines.	Microbial	5	5	25	Very High
	Failure of disinfection due to metering pump malfunction.	Microbial	5	5	25	Very High

	Failure of disinfection due to inadequate supply of Calcium Hypochlorite	Microbial	5	5	25	Very High`
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc. caused by open top covers.	Physical	4	3	12	High
		Chemical	4	5	20	Very High
		Microbial	4	5	20	Very High
Transport to Reservoir and Consumers	Intrusion of contaminants due to distribution and transmission pipeline breakage and pilferage.	Physical	5	2	10	High
		Microbial	5	5	25	Very High
		Chemical	4	5	20	Very High

HAZARD IDENTIFICATION AND RISK ASSESSMENT FOR DISTRIBUTION LINE

Process Step	Hazardous Event	Hazard	Likelihood	Severity	Score	Risk Rating
Storage	Intrusion of contaminants into storage tanks/reservoirs due to sabotage, unsecured vent cover	Physical Chemical Microbial	2	5	10	High
	Facility damage caused by natural calamity like earthquake, typhoon etc.	Physical Chemical Microbial	2	5	10	High
	Unprotected service reservoir access	Physical Chemical Microbial	2	5	10	High
	Turbid water due to pressure fluctuations and intermittent supply	Physical	5	2	10	High
Distribution	Any hazard not controlled/mitigated within the water treatment	Physical Chemical Microbial	2	5	10	High

	Intrusion of contaminants through leaking/deteriorated pipes during low water pressure	Physical Chemical Microbial	2	5	10	High
	Intrusion of contaminants due to sub-standard materials and improper installation of service connection	Physical Chemical Microbial	2	5	10	High
	Intrusion of contaminants due to pressure fluctuation	Physical Chemical Microbial	1	5	5	Low
	Intrusion of contaminants due to busted pipes that are accidentally damaged by other utilities	Physical Chemical Microbial	3	5	15	High
	Intrusion of contaminants due to illegal connection	Physical Chemical Microbial	2	5	10	High
Consumer Premises	Any hazard not controlled/mitigated within the distribution system	Physical Chemical Microbial	2	5	10	High

	Contamination by backflow due to unauthorized/illegal connection and intermittent water supply	Physical Chemical Microbial	2	5	10	High
	Intrusion of contaminants due to substandard materials, improper installation and unsafe practice at consumer premises	Physical Chemical Microbial	4	5	20	Very High

IV. DETERMINE AND VALIDATE CONTROL MEASURES, REASSESS AND PRIORITIZE THE RISKS

Identification of risks and hazards involved in the treatment and delivery of potable water to SANWAD consumers leads to the formulation of control measures. Said control measures must address and mitigate the possible risks and hazards identified in the preceding table. Control measures indicated herein were based on operational history, data from different points of interests and actual evaluation of the current operation of the SANWAD water supply system.

Each control measure from the raw water source down to the taps of each household were implemented meticulously and validated thoroughly. Each stage in the process indicated a decrease in the risk rating when the said control measures were implemented, hence signifying its efficacy.

IDENTIFICATION OF HAZARDS AND RISK ASSESSMENTS AND DETERMINATION OF CONTROL MEASURES FOR THE WATER TREATMENT PLAN

Process Step	Hazardous Event	Hazard	Score	Implemented Control Measures	Likelihood	Severity	Rating
Deep Well Source	Seepage of leachate from septic tanks of nearby houses within the vicinity of well sources.	Physical	10	Blank casings are installed on all wells	1	2	Low
		Microbial	25		1	2	Low
Transmission Line	Intrusion of contaminants due to pipeline breakage	Physical	10	Regular leak detection	2	3	Medium
		Microbial	25		2	3	Medium
Receiving Chamber Pre-Chlorination Sedimentation	Failure of disinfection and partial oxidation due to clogged chemical lines.	Microbial	25	Regular flushing of chemical pipelines and purchase of spare pipes	2	3	Medium
	Failure of disinfection and partial oxidation due to metering pump malfunction.	Microbial	25	Regular preventive maintenance of chemical dosing pumps and purchase of spare	2	3	Medium

	Failure of disinfection and partial oxidation due to lack of supply of Calcium Hypochlorite	Microbial	25	Immediate requisitions are implemented and a 2 month buffer supply is being implemented	1	2	Low
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	12	Installation of screen/net to deter entry of dusts, animal and insects	1	2	Low
		Chemical	20		1	2	Low
		Microbial	20		1	2	Low
Cascade Aerator and Coagulation	Failure of coagulation due to clogged chemical lines	Physical	15	Regular flushing of chemical pipelines and purchase of spare pipes	2	3	Medium
	Failure of coagulation due to metering pump malfunction	Physical	15	Regular preventive maintenance of chemical dosing pump and purchase of spare	2	3	Medium
	Failure of Coagulation due to lack of supply of Polyaluminum Chloride	Microbial	25	Immediate requisitions are implemented and a 2 month buffer supply is being implemented	1	2	Low
	Contamination due to dust, sabotage, bird	Physical	12		1	2	Low
		Chemical	20		1	2	Low

	droppings, insect accumulation, etc.	Microbial	20	Installation of screen/net to deter entry of dusts, animal and insects	1	2	Low
Flocculation	Failure of floc build up due to lack of supply of Anionic Polymer	Physical	15	Immediate requisitions are implemented and a 2 month buffer supply is being implemented	1	2	Low
	Failure of flocculation due to metering pump malfunction	Physical	15	Regular preventive maintenance of chemical dosing pump and purchase of spare	2	3	Medium
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	12	Installation of screen/net to deter entry of dusts, animal and insects	1	2	Low
		Chemical	20		1	2	Low
		Microbial	20		1	2	Low
	Failure of flocculation due to clogged chemical lines	Physical	15	Regular flushing of chemical pipelines and purchase of spare pipes	1	2	Low
Clumping Chamber	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	12	Installation of screen/net to deter entry of dusts, animal and insects	1	2	Low
		Chemical	20		1	2	Low
		Microbial	20		1	2	Low

Filtration	High turbidity of filtered water due to clogged compressed air hoses	Physical	15	Regular preventive maintenance on all Dynasand Tanks and purchase of spare hoses	2	3	Medium
	High turbidity of filtered water due to air compressor unit malfunction or breakdown	Physical	15	Regular preventive maintenance of ACU and purchase of spare	1	3	Low
	High turbidity of filtered water due to inadequate filter media	Physical	20	Readily available and stocked graded river sand	1	2	Low
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc.	Physical	15	Installed closures for each Dynasand Tanks	1	2	Low
		Chemical	20		1	2	Low
		Microbial	20		1	2	Low
Waste Water Flash Mixing Tank Flocculation	Failure of floc build up due to inadequate supply of Anionic Polymer	Microbial	20	Immediate requisitions are implemented and a 2 month buffer supply is being implemented	1	2	Low

	Failure of flocculation due to metering pump malfunction	Physical	15	Regular preventive maintenance of chemical dosing pump and purchase of spare	1	2	Low
Clarifier	High turbidity of clarified water due to pneumatic valve defect	Physical	9	Regular preventive maintenance of pneumatic valve and purchase of spare	1	2	Low
Clarified Water Sump	High turbidity of clarified water due to Clarifier malfunction	Physical	12	Regular preventive maintenance of Clarifier assembly, adjustment of pneumatic valve settings	1	2	Low
Sludge Lagoon	High turbidity of water to be recycled due to heavy sludge	Physical	12	Weekly removal of sludge or as the need arise.	1	2	Low
Treated Water Tank Disinfection	Failure of disinfection due to clogged chemical lines.	Microbial	25	Regular flushing of chemical pipelines and purchase of spare pipes	2	3	Medium
	Failure of disinfection due to metering pump malfunction.	Microbial	25	Regular preventive maintenance of chemical dosing pump and purchase of spare	1	2	Low

	Failure of disinfection due to inadequate supply of Calcium Hypochlorite	Microbial	25	Immediate requisitions are implemented and a 2 month buffer supply is being implemented	1	2	Low
	Contamination due to dust, sabotage, bird droppings, insect accumulation, etc. caused by open top covers.	Physical	12	Access points are securely closed with heavy duty top covers.	1	2	Low
		Chemical	20		1	2	Low
		Microbial	20		1	2	Low
Transport to Reservoir and Consumers	Intrusion of contaminants due to distribution and transmission pipeline breakage and pilferage.	Physical	10	Pipelines are regularly checked for leakage	1	2	Low
		Microbial	25		1	2	Low
		Chemical	20		1	2	Low

IDENTIFICATION OF HAZARDS AND RISK ASSESSMENTS AND DETERMINATION OF CONTROL MEASURES FOR THE DISTRIBUTION LINE

Process Step	Hazardous Event / Cause of Contamination	Hazard	Score	Implemented Control Measures	Likelihood	Severity	Rating
Storage	Intrusion of contaminants into storage tanks/reservoirs due to sabotage, unsecured vent cover	Physical Chemical Microbial	10	Proper and secured covers on all reservoir openings; Storage facilities have barbed & cyclone wire and CHB fence	1	2	Low
	Facility damage caused by natural calamity like earthquake, typhoon etc.	Physical Chemical Microbial	10	Ensure proper design of facility; continuing reassessment of facility integrity	1	2	Low
	Unprotected service reservoir access	Physical Chemical Microbial	10	Fencing and security personnel deployment	2	3	Medium

	Turbid water due to pressure fluctuations and intermittent supply	Physical	10	Develop additional source of water; regulate water pressure	2	5	High
Distribution	Any hazard not controlled/mitigated within the water treatment	Physical Chemical Microbial	10	Regular water quality monitoring; on-line chlorination as the need arises	2	3	Medium
	Intrusion of contaminants through leaking/deteriorated pipes during low water pressure	Physical Chemical Microbial	10	Regular leak detection and water quality monitoring; maintain adequate water pressure 24/7	3	4	High
	Intrusion of contaminants due to sub-standard materials and improper installation of service connection	Physical Chemical Microbial	10	Verification & inspection of materials to ensure compliance to WD standards; Material specification acceptance criteria	2	3	Medium
	Intrusion of contaminants due to pressure fluctuation	Physical Chemical Microbial	5	Maintain adequate water pressure 24/7	3	4	High

	Intrusion of contaminants due to busted pipes that are accidentally damaged by other utilities	Physical Chemical Microbial	15	Close coordination with other agencies	1	3	Low
	Intrusion of contaminants due to illegal connection	Physical Chemical Microbial	10	Regular leak detection & monitoring	1	3	Low
Consumer Premises	Any hazard not controlled/mitigated within the distribution system	Physical Chemical Microbial	10	Information and education campaign on standard in-house connection installation and safe water storage and handling practice	2	4	Medium
	Contamination by backflow due to unauthorized/illegal connection and intermittent water supply	Physical Chemical Microbial	10	Information and education campaign; regular leak detection	1	3	Low
	Intrusion of contaminants due to substandard materials, improper installation and unsafe practice at consumer premises	Physical Chemical Microbial	20	Information and education campaign on standard in-house connection installation and safe water storage and handling practice	3	4	High

V. IMPROVEMENT / UPGRADE PLAN

Further investigation and a reassessment of risks and hazards indicated that a significant attention be applied to reduce all risks and hazards to a tolerable level. Even with the in-placed control measures, programs on improvement or upgrade are still necessary to provide optimum service to the Consumers of SANWAD.

Upgrades and improvements on the current SANWAD water system are to be considered based on economic, environmental and social level aspect. This is to ascertain appropriate technologies and innovations for different circumstances, particularly if capital works are identified and to produce stable results for the public.

The necessary budget allocations will then be allocated by the Santiago Water District.

IMPROVEMENT AND UPGRADE PLAN FOR THE WATER TREATMENT PLANT

Action	Arising From	Identified Specific Improvement Plan	Accountabilities	Due	Status
Implement measures to control risks arising from sabotage and introduction of unwanted particles coming from air	Risk assessment process has indicated a high possibility of sabotage due to low perimeter fence and security personnel. Likewise, the adjacent surrounding has thick vegetation that can hide potential saboteurs.	Raise the perimeter fence and upgrade the defense properties of the same by adding cyclone wires at the top. Likewise, additional security personnel are necessary to cover the wide area of the WTP. To augment the security features of the WTP, CCTV monitoring is recommended.	Division Manager (Production)	Last Quarter of 2019	Planning Stage
Implement measures to control risks of contamination due to bird droppings	Risk assessment process indicates high microbial risks due to bird droppings	Continued maintenance of the net enclosing the process building.	Division Manager (Production)	Implemented all year round	For requisition

Implement measures to control risks of contamination due to insect habitation	Risk assessment process indicates high microbial risks due to insects thriving on the surface of the water.	Continued maintenance of the net enclosing the process building and installation of insect repellant. Coordinate with the LGU for regular fumigation operation at the facility.	Division Manager (Production)	Implemented all year round	For requisition
Implement measures to control risks arising from dosing pump (DP) breakdown	Risk assessment process has indicated high microbial risks due to DP malfunction	Purchase spare Chlorine DP's and its components or parts.	Division Manager (Production)	Last Quarter of 2019	For Requisition
Implement measures to control risks arising from failure of disinfection due to insufficient Chlorine	Risk assessment process has indicated high microbial risks due to inadequate Chlorine supply	A buffer supply good for 2 months consumption is applied	Division Manager (Production)	Implemented all year round	For requisition

Implement measures to control risks arising from failure of coagulation due to insufficient Polyaluminum Chloride (PAC)	Risk assessment process has indicated high turbidity risks due to inadequate PAC supply	A buffer supply good for 2 months consumption is applied	Division Manager (Production)	Implemented all year round	For requisition
Implement measures to control risks arising from failure of flocculation due to insufficient Polymer	Risk assessment process has indicated high turbidity risks due to inadequate Polymer supply	A buffer supply good for 2 months consumption is applied	Division Manager (Production)	Implemented all year round	For requisition
Implement measures to control risks arising from high turbidity of filtered water due to flocs passing through the Dynasand Filters.	Risk assessment process has indicated possible high turbidity due to insufficient filter media.	Regular replenishment of graded river sand as filter media for every Dynasand Filters.	Division Manager (Production)	Implemented all year round	For requisition

IMPROVEMENT AND UPGRADE PLAN FOR DISTRIBUTION LINE

Action	Arising From	Identified Specific Improvement Plan	Accountabilities	Due	Status
Perimeter fencing of storage facilities	Risk assessment indicates the possibility of compromise of our reservoirs and pump stations	Improvement of existing perimeter fences; stationing of watchmen to ensure safety & security of premises.	Division Managers (Production and Engineering)	Last Quarter of 2019	On-going
Develop additional source of water supply & storage facilities	Risk assessment indicates the possibility of turbidity/ contamination of water supply due to pressure fluctuations and intermittent supply.	Drilling of additional water source and utilization of Sefton & Centro reservoirs	Division Managers (Production and Engineering)	Last Quarter of 2019	On-going

Regular Leak Detection and Field Apprehension	Risk assessment indicates the intrusion of contaminants in water supply due to illegal connections	Isolation of the distribution system to identify areas with high NRW; intensify Leak Detection & Monitoring Program	Division Manager (Engineering)	Implemented all year round	On-going
Installation of pressure gauges/valves for pressure management	Turbidity of supply after repair due to pipeline breakage	Installation of Air Release Valve and blow-offs at various locations to release air & dirt during low pressure incidence	Division Manager (Engineering)	Last Quarter of 2019	On-going
Provision for post-chlorination in the distribution system to ensure required residual chlorine in compliance with PNSDW	None/decreased residual chlorine content of water supplied at far areas of the distribution system	Provision for on-line chlorination in the distribution system	Division Manager (Production)	Last Quarter of 2019	Planning Stage

VI. MONITORING OF THE CONTROL MEASURES (OPERATIONAL MONITORING)

Operational Monitoring is a systematic procedure of observation or measurements on the different steps of the water supply system. This is to evaluate if the implemented control measures are effective.

In Operational Monitoring, target and action levels are utilized. The target levels are based on the Philippine National Standard for Drinking Water. Action levels are the means where the corrective measures are operated.

Monitoring of control measures in the water supply system is highly significant to support risk and hazard administration. Each control measure are closely inspected and evaluated so that any variation in its implementation can be readily addressed to deter health-based objectives to be compromised.

MONITORING OF CONTROL MEASURES FOR THE WATER TREATMENT PLANT

PROCESS STEP / CONTROL MEASURE	OPERATIONAL UNIT	MONITORING					
		WHAT	WHERE	WHEN	HOW	WHO	CORRECTIVE ACTION
Regular preventive maintenance of chemical Dosing Pumps	Provision of at least 1 spare unit	Chlorine Dosing Pump	Chemical Room	Weekly	Inventory	Section Chief (Process Control)	Provision of spare Chlorine Dosing Pump
Buffer supply of Chlorine, PAC and Polymer	2 months stock	Chlorine drums	Chemical storage room	Weekly	Inventory	Section Chief (Water Quality / Assurance)	Request for delivery of Chlorine
Regular Flushing of chemical pipe lines	Provision of pressurized water points for flushing	Pipe lines	Chemical room	Weekly	Visual inspection	Section Chief (Process Control)	Provision of spare pipe lines and injection points.
Regular preventive maintenance on all chemical storage tanks and provision of spare	Cleaning and flushing of residues at the bottom of the day tank	Day tanks	Chemical room	Weekly	Visual inspection	Section Chief (Process Control)	Provision of spare day tank and drain facility.
Installation of vent covers and screens	Signs of screen deterioration and damage on covers due to rust	Condition of screen or covers	All tanks and process building	Monthly	Visual inspection	Section Chief (Process Control)	Repair of vent covers and screen

MONITORING OF CONTROL MEASURES FOR DISTRIBUTION LINE

CONTROL MEASURE	CRITICAL LIMIT	WHAT	WHERE	WHEN	HOW	WHO	CORRECTIVE ACTION
Perimeter fencing of storage facilities	Signs of deformation on barbed wire fence; missing padlocks on gates; reported incidents of unauthorized entry from concerned citizens	Condition of perimeter fences & padlocks	All storage/ reservoir facilities	Monthly/ As needed	Visual Inspection	Production Division	Reinforcement and improvement of existing perimeter fences; assigned watchmen or roving personnel for regular inspection of premises
Any hazard not controlled/mitigated within the distribution system	Regular water quality monitoring	Passed the PNSDW limits	Pumping stations/ Distribution system	Daily Weekly	Chlorine analyser turbidimeter	Production Division	Flushing of lines/blow-offs; On-line chlorination
Contamination by backflow due to unauthorized/illegal connection and intermittent water supply	Regular leak detection within the system Regular monitoring of DMAs for NRW	Zero leak Reduced NRW	Water Distribution System	Monthly	Water Audit Visual Inspection	Engineering Division	Immediate leak repair; apprehend illegal connections; massive leak detection & monitoring
Intrusion of contaminants through leaking/deteriorated pipes during low water pressure	Pressure management initiatives on DMAs Rehabilitation of old and deteriorated pipes	Complaints regarding water quality	Water Distribution System	Daily	Collection & testing of water sample	Production Division	Flushing of lines; immediate leak repair

VII. VERIFICATION

Verification of all control measures with their corresponding corrective actions are made in order to guarantee that the SANWAD water supply system design and operation achieves its water safety goal.

As such, SANWAD imposed systematic actions to achieve the same. Water quality targets are confirmed if compliance is met. All operational actions involved in the water system are likewise assessed if compliance is also being complied with. Lastly, consumer satisfaction is checked to ensure if the water supply system is effective up to the last line.

AUDITING

Internal and external auditing was commenced as part of the quality management structure and encompassed all facets of the water supply system. However, there is a need to re-evaluate the measures and assess the records to certify that the actions are being implemented in harmony with the design, following the implementation of this Water Safety Plan.

In addition to the establishment of an effective implementation of water quality system, auditing likewise provides factual input necessary for management decisions, risk control, identification of prospects for upgrading, evaluate personnel performance, provides opportunities for training and improve interpersonal communication of personnel.

VERIFICATION OF CONTROL MEASURES FOR THE WATER TREATMENT PLANT

Verification Activity	Location of Activity	Type of Activity	Frequency of Activity	Analyst	Recipient of Analysis / Result	Action on unusual/ failing result	3rd-Party Recipient of Results
Total & Fecal Coliform	Consumer's taps randomly selected per designed sampling plan	Sampling	Weekly	SANWAD Water Laboratory (DOH Accredited Lab)	General Manager, Division Manager (Production)	For flushing of blow-off near the positive consumer's tap & resampling	LWUA, City Health Office
Heterotrophic Plate Count	Consumer's taps randomly selected per designed sampling plan	Sampling	Weekly	SANWAD Water Laboratory (DOH Accredited Lab)	General Manager, Division Manager (Production)	For flushing of blow-off near the positive consumer's tap & resampling	LWUA, City Health Office
Residual Chlorine	WTP Treated Water (Headers 1 & 2), Calaocan & Rizal Reservoirs, Consumer's tap (Near, Middle, Far Area)	Sampling	Headers – Every 2 hours, Reservoirs & Consumer's Tap- daily	In-house Laboratory	General Manager, Division Manager (Production)	For flushing of blow-off in the area of non-complying residual, adjustment of Chlorine dose	LWUA

Physical & Chemical Analysis (13 Priority Parameters)	Raw water source (Deep Wells)	Sampling	Annually	DOH Accredited Lab for Physical & Chemical Analysis	General Manager, Division Manager (Production)	For well rehabilitation, Shock chlorination, Resampling	LWUA
Physical & Chemical Analysis (13 Priority Parameters)	Treated Water (Headers), Reservoirs	Sampling	Annually	DOH Accredited Lab for Physical & Chemical Analysis	General Manager, Division Manager (Production)	For resampling adjustment of treatment chemical dosages	LWUA
Physical & Chemical Analysis (13 Priority Parameters)	Representative samples from Consumer's tap (Near, Middle, Far areas)	Sampling	Annually	DOH Accredited Lab for Physical & Chemical Analysis	General Manager, Division Manager (Production)	For flushing of blow-off in the area of non-complying tap, For resampling	LWUA

VERIFICATION OF CONTROL MEASURES FOR DISTRIBUTION LINES

Verification Activity	Location of Activity	Type of Activity	Frequency of Activity	Who will Monitor	Recipient of Analysis / Result	Action on unusual / failing result
Verification of Pipeline Management	Office Database / Distribution Network	Internal audit	Annual	Engineering Division	General Manager	Conduct investigation on status of pipeline based on the given data and make necessary recommendations for pipeline rehabilitation if necessary
Verification of field activities: Leak Detection Pipe repair Line repair	Distribution Network	Internal Audit	Daily / Monthly / As the need arises	Engineering Division	General Manager	Immediate leak repair; make necessary recommendations for pipeline rehabilitation if necessary

AUDIT OF RECORDS FOR THE WATER TREATMENT PLANT

Verification Activity	Location of Activity	Type of Activity	Frequency of Activity	Analyst	Recipient of Result	Action on Unusual / Failing Result
Verification of Chlorination & calibration	Water Treatment Plant	Internal Audit	Semi-Annual	Section Chief (Process Control)	Division Manager (Production)	SOP for corrective maintenance
Verification of deepwell history	Production Division Data Base	Internal Audit	Semi-Annual	Section Chief (Raw Water Generation)	Division Manager (Production)	Well Rehabilitation
Verification of Pipeline Management	Office Database / Distribution Network	Internal audit	Annual	Division Manager (Engineering)	General Manager	Conduct investigation on status of pipeline based on given data and make recommendations for pipeline rehabilitation if necessary
Verification of field activities: Leak Detection Pipe repair Line repair	Distribution Network	Internal Audit	Daily / Monthly / As the need arises	Division Manager (Engineering)	General Manager	Immediate leak repair; make necessary recommendations for pipeline rehabilitation if necessary

CUSTOMER SATISFACTION

Verification Activity	Location of Activity	Type of Activity	Frequency of Activity	Analyst	Recipient of Result	Action on Unusual / Failing Result
Customer Feedback	SANWAD Office Bill Collection and Frontline	Survey	Daily	Division Manager (Commercial)	General Manager	Service Requests / Investigation
	SANWAD Office Frontline	Received Complaints (walk-in, hotline, SMS)	Daily	Section Chief (Customer Service)	Division Manager (Commercial) General Manager	Follow-ups

VIII. MANAGEMENT PROCEDURES

Management Procedures are compilations of actions to be taken in every step of the Water Supply System. It defines the actions to be taken during normal and emergency operational conditions and details the steps or procedures to follow in specific incidents and situations (corrective actions) when critical limits are exceeded.[6] Management Procedures or commonly referred to as "Standard Operating Procedures" (SOPs), are documented and updated from time to time to comply with the changing trends in the water supply system of SANWAD.

The Management Procedures are prepared by experienced personnel on the different steps and critical points of the system. Such procedures are based on historical records of the Treatment and Distribution section. Developments pertaining to corrective actions were undertaken to comply with the present set-up of the water supply system. Such updates, developments or adjustments are consistently documented to form part of the SANWAD Standard Operational Procedures for Water Safety Actions.

At present, the Engineering Division has a Rapid Action Team that responds to emergencies like leak repairs or no-water complaints beyond office hours. The Production Division likewise has formulated its own crisis control scheme. Each section hastily applies its operational procedures which were all crafted from experience and historical events from years of Plant operation.

SANWAD Management Procedures require the formulation of a Crisis Management Plan (CMP). Its sole purpose is to standardize all procedural matters pertaining to emergency situations in the water supply system during disasters, whether natural or man-made. Subsequently, a CRISIS

[6] www.who.int>wsp-training-pack-mod8

MANAGEMENT TEAM (CMT) and a CRISIS RESPONSE TEAM (CRT) is to be activated to effectively and promptly respond to emergencies and counteract possible impacts on the health targets and water supply.

As part of SANWAD's non-stop quest for excellence, the effectiveness and efficiency to accomplish its mission and vision is at the heart of this Water Safety Plan. As such, it is extremely necessary to conduct regular monitoring of each process step and apply corresponding corrective actions for every deviation in the water supply system. Moreover, incident reports are to be constantly chronicled for future reference.

STANDARD OPERATING PROCEDURES DURING HAZARDOUS EVENT

The **Water Treatment and Transmission Section** of the Production Division shall implement the Standard Operating Procedure when hazardous events occur at any part of the water treatment process. Whenever necessary, the **Property Supply Office** of the Admin/Finance Division shall provide the needed materials or equipment to address major incidents.

On the other hand, the **Operation and Maintenance Section** of the Engineering Division shall be in charge of implementing Standard Operating Procedure when hazardous events occur at any point of the SANWAD distribution system. Again, the **Property Supply Office** of the Admin/Finance Division shall provide the needed materials or equipment to address hazardous event.

For both cases above, the **Customer Services Section** of the Commercial Division is tasked with the Information Dissemination program of the Santiago Water District. Advisories for low water or no water occurrences as well as quality of water shall be circulated via broadcast media.

WATER TREATMENT PLANT		
Process Step	**Hazardous Event**	**SOP**
Receiving Chamber Pre-Chlorination Sedimentation	Failure of disinfection and partial oxidation due to clogged chemical lines.	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Flush out residual chemicals in the pipe lines with pressurized water. 3. Allow spare dosing pump to run until the needed time to rotate its operation. 4. If the pipe line de-clogging procedure fails, pipe line must be replaced with a new one. Then proceed with number 3.
	Failure of disinfection and partial oxidation due to metering pump malfunction.	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Check power terminals for possible corrosion and replace if necessary. 4. Allow spare dosing pump to run until the needed time to rotate its operation.
	Failure of disinfection and partial oxidation due to inadequate supply of Calcium Hypochlorite	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Adjust dosing rate or stroke length if necessary. 4. Conduct Jar Testing of the delivered chemical. 5. Allow spare dosing pump to run until the needed time to rotate its operation.

Cascade Aerator and Coagulation	Failure of coagulation due to clogged chemical lines	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Flush out residual chemicals in the pipe lines with pressurized water. 3. Allow spare dosing pump to run until the needed time to rotate its operation. 4. If the pipe line de-clogging procedure fails, pipe line must be replaced with a new one. Then proceed with number 3.
	Failure of coagulation due to metering pump malfunction	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Check power terminals for possible corrosion and replace if necessary. 4. Allow spare dosing pump to run until the needed time to rotate its operation.
	Failure of coagulation due to inadequate supply of Polyaluminum Chloride	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Adjust dosing rate or stroke length if necessary. 4. Conduct Jar Testing of the delivered chemical. 5. Allow spare dosing pump to run until the needed time to rotate its operation.

Flocculation	Failure of floc build up due to inadequate supply of Anionic Polymer	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Adjust dosing rate or stroke length if necessary. 4. Conduct Jar Testing of the delivered chemical. 5. Allow spare dosing pump to run until the needed time to rotate its operation.
	Failure of flocculation due to metering pump malfunction	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Check power terminals for possible corrosion and replace if necessary. 4. Allow spare dosing pump to run until the needed time to rotate its operation.
	Failure of flocculation due to clogged chemical lines	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Flush out residual chemicals in the pipe lines with pressurized water. 3. Allow spare dosing pump to run until the needed time to rotate its operation. 4. If the pipe line de-clogging procedure fails, pipe line must be replaced with a new one. Then proceed with number 3.

Filtration	High turbidity of filtered water due to clogged compressed air hoses	1. Perform de-clogging procedures 2. Check for proper backwashing
	High turbidity of filtered water due to air compressor unit malfunction or breakdown	1. Operate spare ACU. 2. Check for diagnostics at the display and perform necessary troubleshooting procedures indicated in the product manual. 3. Allow spare ACU to run until the needed time to rotate its operation
	High turbidity of filtered water due to inadequate filter media	1. Add cleaned and disinfected graded river sand. 2. Check for proper backwashing
Waste Water Flash Mixing Tank Flocculation	Failure of floc build up due to inadequate supply of Anionic Polymer	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Adjust dosing rate or stroke length if necessary. 4. Conduct Jar Testing of the delivered chemical. 5. Allow spare dosing pump to run until the needed time to rotate its operation.
	Failure of flocculation due to metering pump malfunction	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Check power terminals for possible corrosion and replace if necessary. 4. Allow spare dosing pump to run until the needed time to rotate its operation.

Clarifier	High turbidity of clarified water due to pneumatic valve defect	1. Visually inspect Pneumatic Valve for possible discharge clogging 2. Check for solenoid functionality and replace if necessary. 3. Revise Pneumatic Valve setting if necessary
Clarified Water Sump	High turbidity of clarified water due to Clarifier malfunction	1. Check and revise Pneumatic Valve setting if needed. 2. Adjust Polymer dosing as the need arise.
Sludge Lagoon	High turbidity of water to be recycled due to heavy sludge	1. Perform de-sludging procedures
Treated Water Tank Disinfection	Failure of disinfection due to clogged chemical lines.	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Flush out residual chemicals in the pipe lines with pressurized water. 3. Allow spare dosing pump to run until the needed time to rotate its operation. 4. If the pipe line de-clogging procedure fails, pipe line must be replaced with a new one. Then proceed with number 3.
	Failure of disinfection due to metering pump malfunction.	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Check power terminals for possible corrosion and replace if necessary. 4. Allow spare dosing pump to run until the needed time to rotate its operation.

	Failure of disinfection due to inadequate supply of Calcium Hypochlorite	1. Operate spare dosing pump and check for chemical flow at the discharge end. 2. Check and replace diaphragm if dosing pump has no discharge. 3. Adjust dosing rate or stroke length if necessary. 4. Conduct Jar Testing of the delivered chemical. 5. Allow spare dosing pump to run until the needed time to rotate its operation.

DISTRIBUTION LINE		
Process Step	**Hazardous Event**	**SOP**
Intrusion of contaminants to leaking and broken pipes	**Transmission, Distribution and Service Line Leak**	1. Evaluate the situation for the needed tools and determine if the area needs to be isolated. 2. If there is a need for an immediate water interruption on the area, close all isolation valves or the distribution pumps at the Water Treatment Plant. 3. Coordinate with the Local Government Unit or other Government Agencies for necessary permits for concrete breaking of pavements. 4. Once the repair is accomplished, allow flushing of the repaired line through the designated blow-off point.

STANDARD OPERATING PROCEDURES DURING NORMAL OPERATION

The **Water Treatment and Transmission Section Personnel** and the Water **Quality/Assurance Section Personnel** of the Production Division shall implement the Standard Operating Procedure during normal operations at any part of the water treatment process.

In doing so, the Water Treatment and Transmission Section personnel regularly conducts preventive maintenance procedures as its Standard Operating Procedure. Regular checking and maintenance of all dosing pumps as well as periodic flushing of all chemical pipelines are conducted daily. Dosing pumps are operated alternately to mitigate motor overworking and excessive heating. All chemical mixing and day tanks are cleaned on a weekly basis. Preventive Maintenance on all its electrical components are also conducted on a semi-annual frequency.

The water treatment facility is drained, cleaned and disinfected once a year to prevent heavy build-up of sediments and sludge. The filtration facility likewise undergoes preventive maintenance through the periodic checking of both Air Compressor Units. Likewise, both Air Compressor Units are operated alternately to mitigate motor overworking and excessive heating.

The Water Quality /Assurance Section personnel also maintains a buffer supply of chemicals to ensure water quality. The amount of chemical injected in the water treatment process is monitored and tested once per shift and the residual chlorine is likewise examined four times per shift.

On the other hand, the **Maintenance Section Personnel** of the Engineering Division shall also conduct a Standard Operating Procedure even when no hazardous events occur at any point of the SANWAD distribution system. This is to ensure proper preventive maintenance of all water mains and immediately address minor incidents before it turns to a major incident.

The Standard Operating Procedure being conducted by the Engineering Division under normal operation also co-insides with the SANWAD's efforts to reduce Non-Revenue Water up to a considerable limit. Hence, the Engineering Division personnel regularly conducts leak detection procedures and control. Said Preventive Maintenance procedures or system is visually conducted during the early hours of the morning where water pressure is at its highest. Once a leak is detected, immediate repairs are conducted.

IX. SUPPORTING PROGRAMMES

The delivery of safe drinking water to the consumers of SANWAD entails the formulation of Supporting Programs. These programs are agency-wide activities that are harmonized with the existing programs of the different Divisions of SANWAD in which a single objective is to be realized, that is the 24 hour delivery of safe drinking water to all its consumers at a minimum conceivable expense.

These actions don't have direct effect on the water quality. Instead, these are intended to guarantee that the operation of the Water Treatment Plant don't incur supplementary sources of potential hazards from the operating environment, the equipment or facilities as well as the personnel themselves, including visitors and other agency employees.

Supporting Programs are comprised of different activities like calibration, preventive maintenance, sanitation as well as legal aspects such as programs for understanding the agency's compliance obligations. Trainings and seminars are also part of the Support Program. This shall ensure updated and compliant skills and capabilities required in the implementation of the WSP.

SUPPORTING PROGRAMS

PROGRAM	PURPOSE	SPECIFIC ACTIVITY	FREQUENCY OF IMPLEMENTATION
Calibration	To ensure accurate and reliable reading of different parameters being measured especially for chemical dosing pumps, analyzers and flow meters.	Calibration of dosing pumps	Quarterly
		Calibration of laboratory instruments	Semi-annually
		Calibration of flowmeters	Semi-annually
Preventive Maintenance	To ensure that different equipment are checked and maintained to avoid process and equipment malfunction. To ensure that all assets are in good working condition	Electro-mechanical equipment	Monthly
		Deepwell Stations	Monthly
		Chemical Mixing Tank	Monthly
		Chemical Day Tank	Monthly
		Process Building, Lamella Mixing Tank and Clarifier	Semi-annually
		Dynasand Filters	Semi-annually
		Treated Water Tank	Annually

Hygiene and Sanitation	To prevent incorporation of hazards by personnel or situations who are directly involved in the water treatment process	Sealing of top covers Wearing of PPE's for personnel with direct contact with the treated water	Implemented all year round Implemented all year round
Chemical Storage	Ensure that chemicals are not contaminated and leaking in their respective storages which may affect the effectiveness of the chemicals used.	Construction of Chemical Stock room	Implemented
Trainings and Seminars	To ensure personnel capability and skills on the water treatment process and its optimization for the implementation of water safety practices	WSP Training Competency Equipment and process trainings Water Resources Facilities Operators' Course Water Quality Management Water Contamination Concepts Water Supplies Materials Selection and Quality Assurance Seminar/workshop on meter reading, Basic NRW and plumbing techniques	Annually Annually Annually Annually Annually Annually Annually

X. REVIEW AND AUDIT

The only constant thing in the world is change, so they say. With the constant shift in the environment which is directly attributed to climate change, adding to that the natural calamities which have significantly intensified in the past years and are heavily destructive in nature.

The weather conditions at these times only forms half of the dilemma of every Water Industry. New cases of potentially harmful viruses and bacteria may cause contamination of the environment, subsequently the sources of water, including the delivery per se.

Although not likely in the near future, the threat of terrorism is also considered by the SANWAD WSP. This may bring water interruptions, contamination and the whole operation may be compromised.

Considering the above circumstances, the SANWAD WSP must be evaluated, amended or restructured to comply with the changes inherent at this period of the millennium. An updated edition of the SANWAD WSP is a necessity, at least once a year. New risks and hazards are to be assessed and addressed to ensure continues delivery of safe drinking water to all consumers. As a pre-requisite to these annual evaluation, continues training and seminars must be implemented for various employees and the Water Safety Plan Team.

The documentation of operations or procedures in the implementation of the Water Safety Plan is to be performed religiously. Periodic auditing by every Section involved in the water supply system should be systematically carried out. It should indicate system performance against agreed indicators. Moreso, it must consist of data and the level of conformance to the quality system as indicated in the WSP. The extent of compliance to regulatory requirements is also considered

in the audit report. All of these are for the sole purpose of facilitating proper modifications or fine-tunings which may be incorporated in the updated WSP, as a result of an intensive review and evaluation during the annual WSP Team conference.

Review and Auditing shall also entail factual inputs for management decisions. It will also determine if the SANWAD is at risk or there is a need for improvements and weigh personnel performance. It will also provide opportunities for added trainings and improve communication and motivation of personnel.

Aside from the annual updating or revision of the WSP, the Team will also be reconstituted. Changes in employee status or movements have a direct effect on the composition of the Team. Factors necessitating such actions are career movements, resignation or retirement of members, expansion of the WSP team and other matters pertaining to management prerogative.

To ensure check and balance measures in the system, the General Manager will create a Water Safety Plan Audit Team. The Auditors will have no direct involvement with the implementation of the WSP, together with the personnel. They must be technically knowledgeable with the components of the WSP as well as qualified enough to conduct assessment procedures.

Considering that the WSP Team were drafted from the Operation and Technical Services cluster and are constituted based on their water quality management expertise, the WSP will be audited by personnel from the Administration and Business Services cluster.

XI. REVISE THE WSP FOLLOWING AN INCIDENT

Revision on the WSP is done once a year. But unforeseen hazards and risks may occur on the water supply system at any given time. Hence, immediate actions may be undertaken to ensure a decline in the severity on the effects to water quality and safety. In the event that an urgently needed modification is to be implemented following an unforeseen hazard or risks, proper documentation must be undergone and prompt assessment follows. The results of the assessment or evaluations will then by integrated in the WSP even before its annual review.

Prompt revision on the actions indicated on the WSP will ensure unforeseen risks or near misses from occurring again. Further, the occurrence of these events may also lead to areas of improvement whether it is a new hazard or a revised risk. Training on the new matter at hand may be conducted in the near future.

The revisions immediately implemented and incorporated in the WSP will be automatically be part of the items to be audited.

ACKNOWLEDGMENT

This SANWAD WSP Manual was devised through the labors of the Production, Engineering, Commercial and Administrative/Finance Divisions, through the leadership and guidance of the Santiago Water District General Manager. The chronicles of each Division are indispensable in the formulation of this manual. Documented events in the water supply system beyond the normal operation are valuable for the team in identifying the hazards and risks together with the implemented activities to counter the effects leading to poor water quality and safety.

Furthermore, this manual would have not been conceived without the guidance of the Water Safety Plan Manual by the World Health Organization. Additional points and ideas were also taken from the Maynilad and San Jose Del Monte Water District WSP's which from part of SANWAD's own WSP.

Finally, SANWAD is in debt of gratitude to the personnel who unselfishly contributed their expertise, wisdom, time and effort in the creation of this manual.

LIST OF ABBREVAITIONS

SANWAD	-	Santiago Water District
WSP	-	Water Safety Plan
WTP	-	Water Treatment Plant
PAC	-	Polyaluminum Chloride
CWSSP	-	Comprehensive Water Supply System Project
SOP	-	Standard Operating Procedures
LGU	-	Local Government Unit
NRW	-	Non-revenue Water
QPC	-	Quasi-Public Corporation
GOCC	-	Government Owned and Controlled Corporation
SCADA	-	Supervisory Control And Data Acquisition
PNSDW	-	Philippine National Standard for Drinking Water
TDS	-	Total Dissolved Solids
WRFO	-	Water Resources Facilities Operator
LWUA	-	Local Water Utilities Administration

GLOSSARY OF TERMS

Backflow - flow of water in a pipe or line in a direction opposite to the normal flow; often associated with back siphonage or the flow of possibly contaminated water into a potable water system.

Backwash - the upflow or counter-current flow of water through a filter, lifting the mineral bed and flushing away to the drain the particles of foreign matter that have been filtered from the water supply during the service cycle.

Calcium Hypochlorite – a white, crystalline compound, Ca(OCl)2 , used as a disinfecting and bleaching agent.

Chlorine - a halogen element, a heavy, greenish-yellow, incombustible, water-soluble, poisonous gas that is highly irritating to the respiratory organs, obtained chiefly by electrolysis of sodium chloride brine: used for water purification, bleach making etc.

Chlorine Residual – when a sufficient dosage of chlorine is applied to water, microorganisms of sanitary significance are destroyed and there is a reaction on all oxidizable matter. After all these reactions have taken place, at the end of a specified contact time there remains a certain minute quantity of chlorine in the water.

Clarifier - is a component of the process and allows the large flocs containing much of the suspended matter to sink to the bottom of a tank or basin, while the clear water overflows and is then further treated.

Coagulant – a substance that triggers formation of a soft, semisolid mass in water, to which constituent to be removed are attracted and/or trapped by adhesion; often the constituent become heavy enough to settle out.

Coagulation – is a water treatment process that promotes aggregation of small particles into larger particles that can be subsequently removed by sedimentation and/or filtration.

Contaminant – materials not normally found in water that make the water less desirable or unfit for its intended use.

Disinfection – water treatment process designed to destroy disease-causing microorganism making water safe for humans to drink normally by adding chlorine, chlorine dioxide etc.

Fecal Coliform – subgroup of coliform bacteria that has a high positive correlation with fecal contamination associated with all warm blooded animals.

Filter - a device used to clean water by removing iron, silt, taste, odor, color, etc., before it is fed into the softener or supply lines of the consumer.

Filter Media - A media filter is a type of filter that uses a bed of sand to filter water for drinking.

Floc - a flocculent mass formed in a fluid through precipitation or aggregation of suspended particle s.

Flocculation – to form flocculent masses, as a cloud or a chemical precipitate; form aggregated or compound masses of particles. Increase the cohesion of the floc formed by coagulation.

Heterotrophic Plate Count (HPC) - is a procedure used to estimate the number of live heterotrophic bacteria that are present in a water sample. A sample of water is put on a plate that contains nutrients that the bacteria need to survive and grow.

Polymer – a general term for chemical composed of long chains of molecules of known electrical charge and electrical strength. These compounds aid water treatment by agglomerating (clumping together in bunches) very small particles so that they can settle out of water and/or become trapped in filters.

Raw Water – water as it comes from the source (well, lake, reservoir, river) or untreated water.

Septage - the waste or sewage in a septic tank.

Total Coliform – refers to any rod-shapes, non-spore-forming gram negative bacteria capable of growth in the presence of bile sales, or other surface-active agents with similar growth-inhibiting.

Turbidity – a cloudiness or haziness of water caused by individual particles that are too small to be seen without magnification.

REFERENCES

1. Philippine National Standards for Drinking Water
2. San Jose Del Monte Water District WSP
3. Maynilad WSP
4. Training Workbook on Water Safety Plans for Urban Systems by WHO
5. SANWAD Water Treatment Plant Operation Manual