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The Water Distribution System Performance in Sekar Gading Residence

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Abstract. Water distribution systems are built to meet the water needs of a city or community. The management of water distribution can be conducted by government agencies as well as independently as in Sekar Gading Residence. The aim of this study was to determine the performance of water network service managed by Sekar Gading Residence Service by analyzing the performance of network service to network ability in fulfilling minimum requirement of customer from water discharge side. The result of debit analysis from water meter showed that the reliability level was 70%. While, the system can be considered to be satisfactory if the minimum reliability level of 80% is fulfilled. Therefore, the water management system would be n failling condition about 2.94 months, and with very failure rate varying between 14.29% to 71.43% deficit. The conclusion of this study is the performance of clean water network service in Sekar Gading Housing was not up to the optimal solution.

Keywords: evaluation; performance; reliability; resiliency; vulnerability; water distribution..

I. INTRODUCTION

The infrastructure system is a major supporting factor of the social and economic system functions in the society. The infrastructure system is defined as the basic facilities or structures, equipment, installations built and required for the functioning of the social and economic system of society (Grigg, 2000). Infrastructure plays a very important role for the growth and development of a city, because infrastructure can have an impact on improving the level and quality of community life, growth patterns and prospects of economic development. Clean water is one of the important aspects and gets priority in urban planning (Catanese & Snyder, 1996; Qudus and Kusumawardani, 2016).

Water distribution system as one of the infrastructure made to meet the water needs of residents of a city or a community. Clean water source can be derived from springs, lakes, rivers or deep groundwater. Water source must meet the clean water standards issued by the Ministry of Health and then distributed to consumers. For Sekar Gading Residence, the management of clean water services conducted by a Business Water Distribution Services in the residential.

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To accelerate the fulfillment of clean water needs for the community, the government can involve the private sector and the public in the implementation of clean water services. The involvement of private and public is mandated by The Government Regulation no. 16 of 2005 on Drinking Water System. The Government Regulation no. 16 0f 2005 Article 1 clause 5 regulates that the community is allowed to participate in conducting clean water services (Government of the Republic of Indonesia, 2005). Community-based service is motivated by the inadequacy of the state and institutions to meet human needs or because of the limitations of contemporary institutions that can not adequately fulfill the basic needs of human beings (Ife & Tesoriero, 2006). One of the implementation of clean water service conducted by the community is located in Sekar Gading Residence, Semarang. When this study was conducted, the PDAM water supply network had not reached this location. Therefore, the community built and managed deep well water to meet clean water needs.

The study was conducted based on the premise that the water distribution systems at these locations did not produce the expected level of service. The less optimal water services was influenced by several factors such as the topography, the distribution of consumers, the availability of water, the operation policy, performance or the level of service expected and network development (extension).

Sekar Gading Residence in Gunungpati, Semarang is one part of the city of Semarang that did not receive clean water service from Regional Water Company of Semarang. This location met the criteria as an object of a case study or observation location considering this area is a residential area that already have a infrastructure network and managed independently by utilizing the water resources available in the environment. From the preliminary survey, the area is also experiencing water services were unsatisfactory both in terms of flow and water pressure. According to Joko (2010), an adequate drinking water supply system should aim to provide 1) safe and healthy water for the customers, individuals and communities; 2) adequate water quantity; 3) water continuously, easily and inexpensively to support the health of individual and community. The purpose of the study is to determine the performance of clean water services managed by Business Water Services in Sekar Gading Residence in Gunungpati, Semarang by analyzing the performance of the clean water network services, namely network capabilities to fulfill the minimum requirement of customers mainly water discharge. A high performance service is a service which is capable of satisfying the needs of customers or it is able to exceed the expectations of customers (Anderson, Fornel, & Lehmann, 1994).

Performance is the result of work which has strong relationship with strategic goals of the organization, consumer satisfaction and economic contribution (Amstrong & Baron, 1998).

The preliminary study of the water network services conducted by Sekar Gading Residence Clean Water Service Manager showed that the customer did not get proper attention from the manager. This was reflected in the number of customer complaints on the quality of water services as revealed from the results of preliminary survey directly in some locations of service area management. The complains included insufficientt flow discharge, less pressure, non-continuous flow or streaming hours can not be expected, and poor water quality.

The service performance could be determined from the analysis of the failure of the pipeline and its operation to meet the needs. Several performance indicators had to be able to give an indication of how intense of failures and how long a failure occurred. Therefore, network performance could be figured out. The service performance was to cover reliability, resiliency, and vulnerability (Suharyanto, 1999).

Analysis of the performance parameters of pipelines operation was usually conducted by evaluating the network based on the mean and variance of these parameters. The pipeline network reliability is emphasized on the long-term average percentage of the ability of the pipeline to meet the needs. In fact, variations in the discharge, changes in network configuration, and the policy of network operation cause variations in performance operation parameters. Therefore, these three factors were considered to be investigated for its effect on the sevice performance of the operation of clean water pipelines.

Service performance presented in this study was some of the performance indicators which could provide an indications of how intense the failures and how long the failure occured. The service performance covered the reliability, resiliency and vulnerability.

The reliability of a network would indicate or measure the ability of the pipeline to fulfill its function is to meet the needs of clean water. As a consequence, a failure was interpreted if the debit pipeline services was smaller than the water demand in the period, in addition, to mean of the total amount of time in which the pipeline is able to meet its needs in the long term.

In the event of a failure, the performance of resiliency could be defined as the ability of a pipeline to return to a normal state or to a state of "satisfactory" from the state of "failing". The faster pipeline back into a state of satisfactory, the consequences of such failures would be smaller. Therefore, the time when pipelines was in transition from a state of "failing" into the state of "satisfactory" or vice versa, from state "satisfactory" to the state of "failing".

The average period of pipelines in a state of "failing" continuously can be determined from the total number of time that pipeline suffered from "failing" state divided by the average frequency of occurrence of transition. If a failure occured, the performance of vulnerability was measured from how prone a failure occured. To measure the level of vulnerability, the deficiency variable was used.

The quantity of clean water is one of the requirements in water supply. It is based on the amount of clean water available. This means that the clean water can be used to meet the needs of the region and and the number of residents to be served. Quantity requirement can also be reviewed from the standard water discharge to the consumers according the demand of water. The needs of water of the community varied depending on geographical location, culture, economic level, and urban scale of residence. The amount of water consumption based on city category can be seen in the following table.

Table – I: Guidelines for Water Consumption.

Town categories	Total population (people)	Water demand (liters / person / day)
Metropolitan	> 1.000.000	210
Big	500.000 – 1.000.000	170
Moderete	100.000 – 500.000	150
Small	20.000 – 100.000	90

The clean water standard for Semarang can be determined based on the city category. The standard minimal clean water consumption is 170 litres per person per day and the average amount of residents per family is four peoples. Therefore, the minimum water discharge is 21 m³ per family per month.

II. METHODS

This study required data from the recording and data storage from the Service Manager of Sekar Gading Residence in Semarang in the form of a monthly water meter measured on each household which was used as samples in this study (residents of Sekar Gading Residence) for at least 1 year (m³/month). The data obtained was the volume of water usage data from December 2014 until November 2015.

Table – II: Volume Use of Water at Level Customer

Customer Code	Year												Average (m³/month)
	'14	2015											
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
F-1	27	26	22	6	28	29	19	20	15	10	10	19	19,25
F-2	27	10	29	30	22	21	16	33	11	21	24	14	21,50
F-3	20	20	22	21	15	15	12	20	21	22	20	21	19,08
F-4	13	35	26	21	34	30	27	31	29	25	29	32	27,67
F-5	31	29	27	22	29	39	35	32	11	15	15	15	25,00
F-6	31	24	18	20	35	28	31	16	21	15	11	12	21,83
F-7	10	12	10	18	12	12	22	20	10	12	12	10	13,33
F-8	20	20	20	20	20	20	27	28	20	23	20	26	22,00
F-10	20	20	20	20	20	20	20	20	20	31	24	19	21,17
G-1	22	22	22	25	32	22	18	30	21	20	6	21	21,75
G-2	15	15	15	15	15	15	15	15	15	15	15	20	15,42
G-3	30	21	20	6	21	22	22	22	25	32	19	23	21,92
G-4	41	44	33	18	20	31	33	38	24	56	21	20	31,58
H-1	17	27	19	15	28	29	25	25	22	25	19	16	22,25
H-2	18	14	35	31	40	31	35	26	23	29	24	21	27,25
H-3	13	26	25	30	24	31	29	30	26	27	26	30	26,42
H-4	11	21	13	15	17	18	10	10	21	22	12	9	14,92
H-5	27	10	29	30	22	21	16	33	11	21	24	14	21,50
H-6	50	20	34	33	43	51	22	20	22	38	30	30	32,75
H-7	12	43	15	10	16	11	11	11	25	18	20	19	17,58
H-8	30	19	21	20	29	33	18	20	31	33	30	30	26,17
H-9	16	23	15	28	23	21	22	20	34	23	25	20	22,50
H-10	21	16	33	18	21	24	14	15	21	23	16	17	19,92
H-11	22	28	27	20	27	24	12	15	11	23	24	22	21,25
I-1	17	16	14	16	18	14	15	17	15	20	20	25	17,25
I-2	23	21	26	22	20	29	22	28	27	20	27	24	24,08

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Customer Code	Year												Average (m³/month)
	'14	2015											
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
I-3	20	20	20	20	20	20	20	20	20	31	49	12	22,67
I-4	22	15	17	21	30	26	16	16	22	24	19	35	21,92
I-5	27	29	24	27	26	29	29	30	20	26	32	27	27,17
I-6	14	18	20	19	17	15	17	17	19	20	24	24	18,67
I-7	20	36	30	35	37	36	34	37	38	43	38	36	35,00
I-8	5	6	5	6	9	8	8	6	7	6	7	6	6,58
I-9	27	29	20	27	29	31	22	31	23	28	28	33	27,33
J-1	26	18	22	30	28	30	26	25	26	28	35	26	26,67
J-2	24	8	3	35	18	21	21	21	6	13	18	15	16,92
J-3	32	15	25	27	28	28	26	22	20	27	29	27	25,50
J-4	30	22	24	24	28	29	21	20	21	26	28	27	25,00
J-5	24	25	27	19	30	28	13	13	29	29	13	34	23,67
J-6	11	6	19	11	17	24	17	17	23	15	12	10	15,17
J-7	27	19	18	28	28	27	29	27	26	27	22	35	26,08

Data analysis was conducted after the required data had been already completed. The conditions and limitations experienced at the time of measurement / survey in the field need to be considered to obtain the valid data and maximum analysis for results and describes the actual conditions. The analysis for the service of water distribution system in the Sekar Gading Residence District Gunungpati Semarang City was conducted in this following method.

This analysis was performed for the level of clean water services: (a) calculate the maximum deficit (m³/month) and the ratio (%) based on the average water discharge "less" than the minimum requirements (21 m³/month) per each customers; (b) calculating the average deficit (m³/month) and the ratio (%) based on the average water discharge "less" than the minimum requirements (21 m³/month) for each customer, and (c) counting the number of months "failing".

The analysis of failing water services was conducted by (a) classifying the incident of "failing" service, (b) calculating the period of failing service per month, (c) identifying the number of months of "failing" service, (d) counting the number of "failing" incidence group, (e) calculating the number of months of "failing" service per the number of failing group, (f) calculating the resilience that was the number of months "failing" per number of failing group.

Analysis of the water service performance was carried out by (a) calculating the percentage of "deficit" and the reliability of pipelines, (b) calculating the maximum deficit, which includes the average of deficit, minimum and maximum deficit (m³/month), as well as calculating the percentage ratio of the average shortage, shortage ratio and the ratio of minimum and maximum shortage, (c) calculating the average deficit, which includes the average deficit, minimum and maximum deficit (m³/month) and calculating the average percentage of deficit ratio, the ratio of minimum deficiency and the ratio of the maximum deficit and resilience, which included the average periode of the "failing" state continuously in months and the frequency of insidence of failure.

III. RESULTS AND DISCUSSION

In analyzing the performance of clean water services to the water discharge in Sekar Gading Residence Area of Gunungpati, Semarang, the number of customers and the water discharge usage (record meter readings of water) for 12 months from December 2014 to November 2015 were calculated. The minimum discharge used as a basis for analysis was 21 m³ per month with calculation that the needs of water (consumtive use) was 170 liters per person per day (standard of infrastructure). The analysis results can be seen in the following tables.

Table – III: Water Usage in Customer Level

Customer Code	Average (m³/month)	Occurrence lack	Customer Code	Average (m³/month)	Occurrence lack
F-1	19,25	failed	H-8	26,17	
F-2	21,50		H-9	22,50	
F-3	19,08	failed	H-10	19,92	failed
F-4	27,67		H-11	21,25	
F-5	25,00		I-1	17,25	failed
F-6	21,83		I-2	24,08	
F-7	13,33	failed	I-3	22,67	
F-8	22,00		I-4	21,92	
F-10	21,17		I-5	27,17	
G-1	21,75		I-6	18,67	failed
G-2	15,42	failed	I-7	35,00	
G-3	21,92		I-8	6,58	failed
G-4	31,58		I-9	27,33	
H-1	22,25		J-1	26,67	
H-2	27,25		J-2	16,92	failed
H-3	26,42		J-3	25,50	
H-4	14,92	failed	J-4	25,00	
H-5	21,50		J-5	23,67	
H-6	32,75		J-6	15,17	failed
H-7	17,58	failed	J-7	26,08	

The average clean water needs was obtained by dividing the total amount of recorded discharge from the water meter during the observation period (12 months) with the length of the observation period. From this analysis showed that 12 out of the 40 samples experienced deficit. Those who experienced deficit receive the water discharge les than 21 m³/month.

The level of service to customers identified based on the flow rate to the customer. So the basic assumption is that the water was recorded at the water meter for each customer reflects the ability of the network services business conducted by Water Services of Sekar Gading Residence Semarang. Results of the analysis of the level of service and water service failures that occurred in the study site is shown in the following table.

Table – IV: The failure rate of water distribution service

Customer Code	Average debit (m^3/mths)	Status	Long time of failure on events Failed To				Number of failed months	Total failed event	Older mean failure (months)	Deficit				Resiliency
										Maximum		Average		
			I	II	III	IV				m³ per mths	Ratio (%)	m³ per mths	Ratio (%)	
F-1	19,25	failed	1	6	0	0	7	2	3,50	15	71,43	6,00	28,57	0,29
F-2	21,50		2	4	1	0	7	3	2,33					0,43
F-3	19,08	failed	1	1	1	1	4	4	1,00	9	42,86	12,00	57,14	1,00
F-4	27,67		1	0	0	0	1	1	1,00					1,00
F-5	25,00		4	0	0	0	4	1	4,00					0,25
F-6	21,83		2	1	3	0	6	3	2,00					0,50
F-7	13,33	failed	6	5	0	0	11	2	5,50	11	52,38	10,00	47,62	0,18
F-8	22,00		6	1	1	0	8	3	2,67					0,38
F-10	21,17		9	1	0	0	10	2	5,00					0,20
G-1	21,75		1	2	0	0	3	2	1,50					0,67
G-2	15,42	failed	12	0	0	0	12	1	12,00	6	28,57	15,00	71,43	0,08
G-3	21,92		2	1	0	0	3	2	1,50					0,67
G-4	31,58		2	1	0	0	3	2	1,50					0,67
H-1	22,25		1	2	2	0	5	3	1,67					0,60
H-2	27,25		2	0	0	0	2	1	2,00					0,50
H-3	26,42		1	0	0	0	1	1	1,00					1,00
H-4	14,92	failed	1	6	2	0	9	3	3,00	12	57,14	9,00	42,86	0,33
H-5	21,50		1	1	1	1	4	4	1,00					1,00
H-6	32,75		1	1	0	0	2	2	1,00					1,00
H-7	19,25	failed	1	6	3	0	10	3	3,33	11	52,38	10,00	47,62	0,30
H-8	26,17		1	1	2	0	4	3	1,33					0,75
H-9	22,50		1	1	1	1	4	4	1,00					1,00
H-10	19,92	failed	1	1	2	2	6	4	1,50	7	33,33	14,00	66,67	0,67
H-11	21,25		1	3	1	0	5	3	1,67					0,60
I-1	17,25	failed	11	0	0	0	11	1	11,00	7	33,33	14,00	66,67	0,09
I-2	24,08		1	1	0	0	2	2	1,00					1,00
I-3	22,67		9	1	0	0	10	2	5,00					0,20
I-4	21,92		2	2	1	0	5	3	1,67					0,60
I-5	27,17		1	0	0	0	1	1	1,00					1,00
I-6	18,67	failed	10	0	0	0	10	1	10,00	7	33,33	14,00	66,67	0,10
I-7	35,00		1	0	0	0	1	1	1,00					1,00
I-8	6,58	failed	12	0	0	0	12	1	12,00	16	76,19	5,00	23,81	0,08
I-9	27,33		1	0	0	0	1	1	1,00					1,00
J-1	26,67		1	0	0	0	1	1	1,00					1,00
J-2	16,92	failed	2	1	4	0	7	3	2,33	18	85,71	3,00	14,29	0,43
J-3	25,50		1	1	0	0	2	2	1,00					1,00
J-4	25,00		1	0	0	0	1	1	1,00					1,00
J-5	23,67		1	2	1	0	4	3	1,33					0,75
J-6	15,17	failed	5	2	3	0	10	3	3,33	15	71,43	6,00	28,57	0,30

Results of calculation of water service performance that occur at the location of the study are shown in the Table 5.

Table – V: Water Service Performance

No.		Parameter	Unit value	
1.	a.	"Less" occurrence	30,00	%
	b.	Reliability	70,00	%
2.		**MAXIMUM DEFICIT**		
	a.	Average deficit	11,17	m³/mths
	b.	Minimum deficit	6,00	m³/mths
	c.	Maximum deficit	18,00	m³/mths
	d.	Deficit average ratio	53,17	%
	e.	Minimum deficit ratio	28,57	%
	f.	Maximum deficit ratio	85,71	%
3.		**AVERAGE DEFICIT**		
	a.	Average deficit	9,83	m³/mths
	b.	Minimum deficit	3,00	m³/mths
	c.	Maximum deficit	15,00	m³/mths
	d.	Deficit average ratio	46,83	%
	e.	Minimum deficit ratio	14,29	%
	f.	Maximum deficit ratio	71,43	%
4.		**RESILIENCY**		
	a.	The Average of period of continuously falling state	2,94	mths
	b.	Frequency of incidence	2,15	times

The level of service to the customer was identified based on the flow of water discharge reaching the customer. Therefore, the basic assumption was that water recorded on each customer's water meter reflected the capabilities of existing water supply services. From Table 5 above, it can be identified that based on the average service of water discharge there are 30% or 12 customers from 40 customers in the location of Sekar Gading Residence which has a monthly average debit of less than 21 m³ per month (minimum requirement value of each customer).

It should be emphasized here that the use of the average monthly discharge rate is a moderate indicator. In fact, there were insidence where customers receive a water discharge rate less than 21 m³ per month which can be seen Table 4.

The vulnerability of "failing" was measured by how big the deficit. Based on the monthly average water discharge, the average value of a deficit was approximately 9.83 m³ per month (46.83% deficit), and the minimum deficit was 3.00 m³ per month (14.29% deficit) and a maximum deficit of approximately 15.00 m³ per month (71.43% deficit). Therefore, on average, there is a shortage of water by 47% of the minimum water discharge.

From the analysis of the "failing" incidence, within the period of 12 months, there were 12 customers received less amount of water discharge meaning that in each failing insidence, there were 12 months of failing insidence. It was caused by water discharge which was available during the 12-month standard did not meet the minimum requirement of 21 m³ per month. In addition, the average period of minimum deficit ratio was 1 month and 7 customers.

Similarly, when viewed in the event of "failing" of the system as a whole, the average of the period of system experiencing a shortage of water continuously was approximately 12 months. The average frequency of failing insidence was occurrence of the failure of the is 2.15 times. This may imply that during the 12 months, there were 2.15 times failure. Therefore, whenever there was a failure, then the system persisted in the failing condition for about 6 months (12 months/2.15 times failed). The index of the resilience of the system was 0.18 (2.15/12). Overall, the level of water supply network services in the area of the Sekar Gading Residence was still not satisfactory, namely the reliability value is 70%, with the length of the system was in failing state for approximately 3 months, and the failing rate varied greatly for example between 14.29% to 71.43% deficit.

IV. CONCLUSION

From the analysis of the water discharge identified by the water meter recording per month on 40 customers in the study area from December 2014 until November 2015, the overall level of water service by Water Service Providers in Sekar Gading Residence was still not satisfactory with the reliability level of 70% (the system was categorized to be satisfactory if the minimum reliability level of 80% is met). The duration of the system in a state of falling was approximately 2.94 months, and with a very varying failing rate that was between 14.29% to 71.43% deficit.

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REFERENCES

1. Amstrong, M., & Baron, A. (1998). *Performance Management: The New Realities Developing Practice*. London: Institute of Personnel and Development.
2. Anderson, E. W., Fornel, C., & Lehmann, D. R. 1994. *Consumer Satisfaction, Market Share and Profitability: Findings From Sweden*. Journal of Marketing, 58, 53-66.
3. Catanese, A. J., & Snyder, J. C. 1996. *Perencanaan Kota*. Jakarta: Erlangga.
4. Grigg, N. dan Fontane G. Darel. 2000. *Infrastructure System Management & Optimization.* International Seminar "Paradigm & Strategy Of Infrastructure Management", Civil Engineering Department Diponegoro University.
5. Ife, J. W., & Tesoriero, F. 2006. *Community Development: Community-Based Alternatives in an Age of Globalisation*. Australia: Pearson Education Australia.
6. Joko, Tri. 2010. *Unit Air Baku Dalam Sistem Penyediaan Air Minum*. Yogyakarta : Graha Ilmu.
7. Mays, L.W. and Y.K. Tung. 1992. *Hydrosistem Enggineering and Management*. McGraw Hill, Inc, New York.
8. McGhee, Terence. 1991. *Water Supply and Sewerage*. McGraw Hill, Inc, New York.
9. Menteri Dalam Negeri. 1999. *Keputusan Menteri Dalam Negeri Nomor 47/1999 Tentang Pedoman Penilaian Kinerja Perusahaan Daerah Air Minum*. Jakarta: Kementerian Dalam Negeri.
10. O'Connor, Patrick. 1995. *Practical Reliability Engineering*. John Willey and Sons, Inc, New York.
11. Peraturan Pemerintah RI Nomor 16 Tahun 2005 Tentang Pengembangan Sistem Penyediaan Air Minum.
12. Suharyanto and Pranoto S.A. 1999. *Analisa Pelayanan Jaringan Air Bersih*. Media Komunikasi Teknik Sipil, BMPTTSSI, Edisi Desember 1999.
13. Sugiyanto, Nasrullah, Sri Sangkawati. 1999. *Peningkatan Efisiensi dan Tingkat Layanan Pengoperasian Jaringan Air Bersih*. Laporan Penelitian, EEDP Batch III 1998/1999.
14. Sutrisno, C. Totok., Eni Suciastuti. 1996. *Teknologi Penyediaan Air Bersih*. PT. Rineka Cipta, Jakarta.
15. Tung, Y.K. 1985. *Evaluation of Water Distribution Network Reliability*. Proceeding of The ASCE Hydraulic Division Speciality Conference, Orlando, Florida.
16. Qudus, N and Kusumawardani, R. 2016. Mapping model of groundwater catchment area based on geological fault: Case study in Semarang City. International Journal of Engineering and Technology, Vol. 8, No. 2, pp 566 – 572