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PLANNING OF THE MAIN DISTRIBUTION NETWORK OF GEROKGAK DISTRIBUTION RESERVOIR IN THE BURANA DRINKING WATER SUPPLY SYSTEM (SPAM), BULELENG REGENCY

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ABSTRACT

The increasing population growth rate in Bali province has led to the depletion of water sources, while the demand for providing clean drinking water continues to rise each year. To improve the water supply, the central government, provincial government, and local authorities are undertaking an effort to construct the Titab dam with an associated water supply system called the Burana drinking water supply system (spam Burana) with a flow rate of 350 liters per second. Considering this situation, a research study is needed to analyze the water demand over the next 15 years based on the projected population using Arithmetic, Geometric, and Least Square Methods in five service areas: Penyabangan Village, Musi Village, Sanggalangit Village, Gerokgak Village, and Patas Village. According to the analysis results, the Geometric Method was used for population projection, with the smallest standard deviation of 185.368 and the coefficient of correlation (r) closest to 1, with a value of 0.877. The water demand for the next 15 years was found to be 82.39 liters per second in the five service areas. To optimize the provision of clean drinking water, the analysis recommends using GIP (Galvanized Iron Pipe) with diameters of 40cm, 20cm, and 25cm, starting from the Gerokgak Reservoir to Patas Village, with a total distribution pipeline length of 15,438 meters. WaterNet, a computer program, is required for simulating water flow in the distribution network with minimal relative errors. The WaterNet analysis results showed that the criteria for flow velocity (0.3 – 1 m/s), headloss (< 10 m/km), and pressure (15 – 100 m for GIP) were all met. The required capacity of the Gerokgak Reservoir for the water supply service is 1400m3.

Introduction

Clean water is one of the most basic needs for humans because it is needed constantly in their daily activities to survive. Therefore, humans need clean water sources obtained from groundwater and surface water (Kencanawati, 2017). However, not all clean water can be used by humans to meet drinking water needs, only water that meets drinking water quality requirements can be used for drinking water. Clean water requirements in the Drinking Water Supply System include quality, quantity, continuity, and affordability (4k) where in terms of quality, physical, chemical, biological, and radiological by health regulations (Nasution, 2021). Drinking water is one of the main goals of the Sustainable Development Goals (SDGs) by 2030, namely to provide a sustainable supply of clean water to substantially prevent the amount of potable water scarcity. Therefore, solutions are needed in providing access to decent drinking water and sufficient quantities, especially for humans (Parabi, Utomo, & Fitria, 2022).

The increasing rate of population growth in Bali Province has resulted in changes in land function and an imbalance of available natural resources. As a result, the existence of raw water sources is becoming increasingly limited while the need for raw water supply for drinking water continues to increase every year. Some of the problems in fulfilling raw water in Bali are; The availability of raw water is not constant, and the uneven potential of raw water sources in 8 districts and cities. One of these districts is in Buleleng Regency (Suhardi & Darmansyah, 2019). Problems in the development and management of natural resources across regions, conflicts over water use with subak (irrigation water), and imbalances between the development of drinking water infrastructure with population growth and the development of residential areas Population growth in Buleleng Regency (Mohan, Yadav, Panchal, & Brahmbhatt, 2019). In response to this increase, it is necessary to increase access to adequate facilities and infrastructure, one of which is to increase the development of the area, especially in meeting drinking water needs (Wibawa & Sastra, 2022).

Since 1970, the Government has made efforts to develop drinking water supply systems until now the provision of access to drinking water including piping systems has been developed and built using various approaches and regions (urban and rural). Based on the Drinking Water Supply System Master Plan, Buleleng Regency has an area of 136,588 Ha which has sufficient raw water potential, but the fulfillment is not evenly enough, where there are still villages located in areas with topography in the highlands that are still far from the water distribution pipe system (Malau & Sulandari, 2020).

In increasing the fulfillment of access to drinking water in Buleleng Regency, the government made efforts, namely the construction of the Titan Dam which was carried out for four years starting from 2011 to 2015 and began to be filled with a water holding capacity of 10.08 million m3 (Harmayani, Yekti, Suputra, & Putra, 2019). Titab Dam is used as a source of raw water that serves four districts, namely Gerokgak District, Banjar District, Seririt District, and Busungbiu District. In service access, the water service system is called "Burana SPAM (Buleleng-Jembrana)" with a planned discharge of 350 lt/s which is expected to provide standards of quantity, quality, continuity, and affordability of services for 28,000 SR covering West Buleleng Regency reaching 24,000 SR and Jembrana Regency (Gilimanuk Area) reaching 4,000.

Burana SPAM consists of two IPAs, namely the upper Titab IPA which is planned to serve villages in the Busungbiu District, Banjar District, and part of Seririt District with a capacity of 150 l / s, then the lower Titab IPA serves the water needs of parts of Seririt District, Gerokgak District, and Gilimanuk Area with a capacity of 200 l / s. Water from the Lower Titab IPA and Lower Titab IPA will be distributed to each distribution reservoir using a pumping and gravity system (Amilia Agustin & Dian Pramirasuci, 2022).

From the description above, while still paying attention to the interest and sustainability of water resources development programs in the Buleleng Regency area, especially the fulfillment of water distribution in the Burana SPAM service, it is necessary to plan the main distribution of reservoirs. The system carried out is currently still under construction, namely the installation of the main distribution pipe of the Singaraja-Gilimanuk road. The plan has not reviewed the reservoir capacity plan and the distribution pipeline length plan from Gerokgak Reservoir for its service area (Wutich, 2020).

The location planning of Gerokgak Reservoir is located in Gerokgak District with an elevation of ±60m above sea level. Based on the area according to the area of use, it is known that Gerokgak District has an area of 87,586 km². For the geographical location of the region, Gerokgak District is located between 8o 15' 31" - 3o 49' 70" South Latitude and 114o 46' 28" - 3o 96' 20" East Longitude (Dosu & Hanrahan, 2021). Gerokgak District is a coastal area on the North Coast of Bali Island with the current condition of raw water which is 10.23% for PDAM, then PAMDESA 47.27%, and Non-Piping 47.50% (BPPW Bali 2020). From this description, the largest use of raw water is non-piped, this has the potential to cause a water deficit over the next few years, thereby reducing the fulfillment of clean water requirements, namely (4k).

Therefore, an analysis of clean water needs for the next 15 years is needed, namely planning the Main Distribution Network of Gerokgak Reservoir to serve 5 (five) villages including Penyabangan Village, Musi Village, Sanggalangit Village, Gerokgak Village, and Patas Village (Exposto, Lino, Quim, Goncalves, & Vicente, 2021).

Research Methods

The scope of research on the planning of the main distribution network of the Gerokgak Reservoir using this WATERNET hydraulic simulation includes the design of a water distribution network covering the raw water resources of Burana SPAM to the Gerokgak reservoir for 5 Service Villages, Gerokgak District, Buleleng Regency. population data, topographic maps of pipelines, Burana SPAM schemes, and planning water needs in 5 service villages using secondary data. For Existing Conditions, SPAM Burana uses primary data. Hydraulic simulation of the water distribution network in the WATERNET application was carried out using a Hazen-Williams calculation basis.

A. Research Location

The primary data collection location is at Burana SPAM for the Gerokgak Reservoir drinking water distribution network system development plan in 5 Service Villages, Gerokgak District, Buleleng Regency, Regency The primary data collection location is on the Gerokgak Reservoir drinking water distribution network system development plan pipeline located in Gerokgak District.

B. Data Collection

Data collection consists of primary data and secondary data. The primary data used in this study was obtained by direct survey of the existing network to determine the progress of Burana SPAM development to date and interviews were conducted by meeting directly with the Burana SPAM management to find out the performance and service conditions of Burana SPAM. Secondary data in the form of the population in each service village, Topographic data used as a basis in piping network simulation, Burana SPAM scheme is used to determine the dimensions and types of pipes that have been planned to be used as input data for existing models. Meanwhile, water needs are planned in 5 villages as additional water needs are in demand in SPAM Burana.

C. Design and input of attribute information of the main distribution network of drinking water

To design the Gerokgak Reservoir distribution network, the first step is to import elevation data from Google Earth. In this way, the main distribution network of geographically referenced drinking water will be formed based on the digitized results of Google Earth. The drawing of the pipe is in the form of a line connecting the specified points (nodes). Pipe length and elevation are manually inputted in the WATERNET system. In addition, it is possible to assign roughness values to pipes by entering standard roughness values according to the type of pipe material (steel, GIP iron, PE, and others). Furthermore, valves and pumps are treated like connecting objects (e.g., pipes) in a WATERNET application, so it is necessary to specify two new start and end points to insert them automatically, between existing pipes.

Results and Discussion

Planning of a Gerokgak reservoir distribution system network that distributes raw water from Burana SPAM located in the planned Titab Reservoir in Sanggalangit Village, Musi Village, Logging Village, Gerokgak Village, and Patas Village, Gerokgak District, Buleleng Regency. This study begins with a projection of the number of residents in each service area. The population data used was obtained from the Central Bureau of Statistics of Buleleng Regency. The population data is based on population data for each sub-district in Buleleng Regency 5 years before planning, namely from 2018 to 2022. For analysis of calculation methods using 3 general methods including Arithmetic Method, Geometric Method, and least square method. Furthermore, based on the calculation results of 5 villages of the Gerokgak Reservoir service plan, the Geometric Method produces the smallest average standard deviation value of 185.368 with the closest correlation coefficient (r) to 1, which is with an average value of 0.877. The formula of the Geometry Method is written like the equation: $Pn=Po(1+r)^n$

So that in the next calculation using the population based on geometric methods according to Tables 1 and 2 From this rate with the above formula approach, the population in 2037 is 44,963 people spread across 5 villages.

Table 1
Standard deviation results from the calculation of each village

Village	Standard Deviation		
	Arithmetic	Geometric	Least Square

1	Sanggalangit	111,96	112,18	143,41
2	Must	30,65	30,76	32,74
3	Penyabangan	406,98	417,34	565,34
4	Legs	239,32	116,53	152,59
5	Gerokgak	246,16	250,03	283,71
	Average	207,014	185,368	235,558

Table 2

The correlation coefficient of results from each village

	Village	**Correlation Coefficient**		
		Arithmetic	**Geometric**	**Least Square**
1	Sanggalangit	0,887	0,893	0,651
2	Must	0,827	0,822	0,653
3	Penyabangan	0,851	0,876	0,625
4	Legs	0,943	0,987	0,700
5	Gerokgak	0,828	0,811	0,653
	Average	0,867	0,877	0,656

Then the results of the analysis of drinking water needs in the plan of 5 Gerokgak Reservoir service villages with calculations based on this study from the beginning of 2022 to the planning year of 2037 obtained the results of the total water demand in the Gerokgak Reservoir of 82.39 lt / second.

So that the planning of the Gerokgak Reservoir Main Distribution Network as a new source of raw water supplied from Burana SPAM to 5 service villages can meet drinking water needs with a discharge of 82.39 l / s for the next 15 years starting from the planning year 2022 to 2037. The following are the results of the analysis of the Water Needs of the Gerokgak Reservoir Service Area in 2037 shown in Table 3:

Table 3

Water Needs Analysis of Gerokgak Reservoir Service Area in 2037

No	**Village**	**Total Population**	**Water Requirement (l/s)**	**Water Requirement (l/s)**

		Served in 2037 (Soul)	House.	Non Dom.	Water Loss (l/s)	Total	Max Day.	Jam Top
1	Sanggalangit	7410	8,57	1,71	2,058	10,29	13,58	20,4
2	Must	3895	4,50	0,90	1,25	5,41	7,14	10,7
3	Penyabangan	11068	12,81	2,56	3,074	15,37	20,29	30,4
4	Gerokgak	9900	11,45	2,29	2,75	13,75	18,15	27,2
5	Legs	12670	14,66	2,93	3,52	17,60	23,23	34,8
	Total	**44943**	**51,99**	**10,39**	**12,652**	**62,42**	**82,39**	**123,5**

To accommodate the production capacity of raw water sources which will be associated with the projected amount of water demand, the calculation of the capacity of the Gerokgak Reservoir concerning the dimensions of the reservoir is based on the volume of 15 - 20% of the total production per day and 10% of the volume for the power room of the reservoir volume. For the results of the analysis, the volume capacity of Gerokgak Reservoir needed for 15 years of planning for 5 service villages is 1400m3, with an area of 467m2, and a height of 3m. The calculation results are presented in Table 4.

Table 4

No	Village Name	Unit	Debit
1	Patas Village	l/det	23,23
2	Gerokgak Village	l/det	18,15
3	Sanggalangit Village	l/det	13,58
4	Musi Village	l/det	7,14
5	Logging Village	l/det	20,29
	Total	**l/det**	**82,39**
1	Volume Reservoir	m³	1423,78
2	Reservoir Rounding	m³	1400
3	High Reservoir	m	3
4	Area of Reservoir Base	m2	467
5	Reservoir Length	m	22
6	Reservoir Width	m	22
	Reservoir Dimension Analysis		
1	Reservoir Length	m	22
2	Reservoir Width	m	22
3	High Reservoir	m	3

To be able to achieve a maximum residual pressure of 100 m, it is planned to use a Galvanized Iron Pipe (GIP) type pipe from the results of the analysis of the Hydraulic Profile of the Gerokgak Distribution Conservatory, obtained from the dimensions of the pipe used with a diameter of 40 cm from the Gerokgak Reservoir to the tapping fork of Sanggalangit Village, followed by a 20 cm diameter pipe from Sanggalangit Village to the position of Musi Village, and continued with a pipe diameter of 25 cm for Logging Village, Gerokgak Village, and Patas Village with a length ranging from 910 m to 425 m. For major energy loss, flow speed, and residual pressure, 2 methods of manual calculation and simulation of the WATERNET program are used. For manual calculations, major energy loss results are obtained in manual calculations, namely 0.232144015 - 1.191281805 m, drainage speed of 0.2548 - 0.6608 m/s, and remaining pressure 34.69 - 43.73m. To calculate the discharge can be calculated by the following equation:

$D = [Q/(0{,}27853.C.S^{0{,}54})]^{0.38}$ (2)

To calculate the Flow Speed can be calculated by the following equation:

$V = [Q/((0{,}25 \times 3{,}14 \times (D \times 100^2)]$ (3)

To calculate *Head Loss* can be calculated by the following equation:

$sf = [(Q/(0{,}27853.C.D2.63)]1.85$ (4)

$hf = S \times L$ (5)

To calculate the remaining pressure can be calculated by the following sum:
Residual Pressure = High Pressure + Remaining Pressure

The Gerokgak Reservoir distribution piping planning system is planned by gravity by referring to the criteria of water flow in the pipe, namely flow velocity between 0.3 m/s - 1m/s, pressure of more than 10 m, major energy loss (< 10 m/m), and residual pressure (15 to 100 m) for the type of Galvanized Iron Pipe (GIP). Based on the criteria, the results of manual calculations have not produced a flow speed above 0.3, which is 0.2548.

The next calculation uses a calculation simulation from the internet program to find out the final result of the analysis. The input steps of the pipeline network at the node elevation points on the Waternet are by the plan such as The dimensions of the pipe used; Knowing how much energy is lost on the planned pipeline, and Knowing water fluctuations in service hour reservoirs. In the installation of pipes in water nets, in general, the data inputted include pipe length, pipe type, and primary and secondary energy loss coefficients. In the simulation on the internet, the shape of the pipe is in the form of a straight line. From the results of network simulations for drinking water distribution networks in 5 service planning areas of the Gerokgak Reservoir Main Distribution Network, namely Sanggalangit Village, Musi Village, Logging Village, Gerokgak Village, and Patas Village, there is no problem (not laminar). This means that hydraulically the network can provide services as desired at each node. Network scheme The Scheme under Constant Conditions 5 Service Areas can be shown in Figure 1.

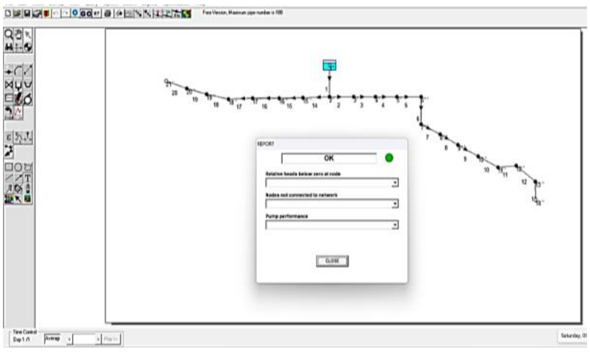

Figure 1
Network scheme under constant conditions 5 service areas

Then the results of the internet hydraulic simulation show that the piping network designed meets the design criteria. Where for speeds of 0.3548 to 0.6608 m/s (0.3 - 1 m/s), headloss (major energy loss) 0.00 – 9.819 m (< 10 m/m), and remaining pressure 33.28 to 43.73 m (15 to 100 m) for Galvanized Iron Pipe (GIP) types. the results of the Pipeline and Flow Data (Last hour on Constant flow) can be shown in Figure 2.

Pipe	From Node	To Node	Length (m)	Diameter (m)	Dischg (l/s) C	hf (m)	Slope m / m
1	1	2	910,00	0,4000	164,78120,0000	4,196	0,0046
2	2	3	1346,00	0,2000	41,01120,0000	9,819	0,0103
3	3	4	546,00	0,2000	41,01120,0000	5,605	0,0103
4	4	5	520,00	0,2000	41,01120,0000	5,339	0,0103
5	5	6	980,00	0,2000	27,43120,0000	4,781	0,0049
6	6	7	607,00	0,2000	27,43120,0000	2,961	0,0049
7	7	8	562,00	0,2000	20,29120,0000	1,570	0,0028
8	8	9	461,00	0,2000	20,29120,0000	1,288	0,0028
9	9	10	1121,00	0,2500	20,29120,0000	1,057	0,0009
10	10	11	738,00	0,2500	0,00120,0000	0,000	0,0000
11	11	12	568,00	0,2500	0,00120,0000	0,000	0,0000
12	12	13	875,00	0,2500	0,00120,0000	0,000	0,0000
13	13	14	948,00	0,2500	0,00120,0000	0,000	0,0000
14	2	15	879,00	0,2500	41,38120,0000	3,097	0,0035
15	15	16	729,00	0,2500	41,38120,0000	2,569	0,0035
16	16	17	642,00	0,2500	23,23120,0000	0,777	0,0012
17	17	18	868,00	0,2500	23,23120,0000	1,051	0,0012
18	18	19	978,00	0,2500	0,00120,0000	0,000	0,0000
19	19	20	694,00	0,2500	0,00120,0000	0,000	0,0000
20	20	21	466,00	0,2500	0,00120,0000	0,000	0,0000

Figure 2
Pipeline and Flow Data (Last hour on Constant flow)

Conclusion

Drinking water needs in 5 service areas for the next 15 years in 2037, for Sanggalangit Village 13.58 l/s, Musi Village 7.14 l/s, Penyabangan Village 20.29 l/s, Gerokgak Village 18.15 l/s, and Patas Village 23.23 l/s. For the total drinking water needs in all 5 service areas, it is 82.39 l/s. Hydraulic simulations show that the calculation results of pipe analysis with diameters of 40cm, 20cm, and 25cm with the total length of the entire water distribution pipeline system is 15438m, the piping network designed meets the design criteria for speeds of 0.3548 to 0.6608 m/s (0.3 - 1 m/s), headloss (major energy loss) 0.00 – 9.819 m (< 10 m/m), and remaining pressure 33.28 to 43.73 m (15 to 100 m) with the volume capacity of Gerokgak Reservoir needed for 15 years Planning for 5 service villages is 1400m3, with an area of 467m2, and a height of 3m. Hydraulical analysis based on the Internet program showed a more timely and cost-effective alternative method for conducting preliminary studies of the Gerokgak Reservoir distribution system development plan. Furthermore, future studies can be carried out by integrating the focus on drinking water needs for public facilities in densely populated locations and supporting the maintenance of the main distribution network in each Burana SPAM reservoir planning.

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