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Raw Water Supply System Analysis at Randugunting Dam, Blora Regency Province of Central Java

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Abstract: Randugunting Dam is one of the government's national strategic projects which has a role in supporting food security. The benefits that will be felt are for flood control, irrigation and raw water. Allocation of raw water 200 lt/sec for three regions, namely Blora Regency 100 lt/sec, Pati Regency 50 lt/sec and Rembang Regency 50 lt/sec. The purpose of this study is to provide an analysis of the hydraulic design of the piping system to each WTP and water quality. The system used is the intake of raw water from the dam intake distributed to a centralized WTP then to the District WTP. The first analysis obtained the results of intake to a centralized WTP using PE pipe 400mm the average HGL value is 78.75m higher than the average elevation hs 68.79m, 9.97m residue, final pressure 0.128bar; the second condition is centered on the Blora IPA using PE pipe 350mm plus a pump capacity of 100 lt/s the average HGL value is 202.17m higher than the average elevation hs 114.94m, residue 87.23m, final pressure 0.977bar; the third condition is centered on the IPA Pati using PE pipe 400mm, the average HGL value is 66.27m higher than the average elevation hs 54.41m, residue 11.85m, final pressure 1.831bar; the condition of the four IPA centered on the IPA Rembang using PE pipe 400mm obtained an average HGL value of 64.99m higher than the average elevation hs 44.11m, residue 20.88m, final pressure 2.162bar. The evaluation of the pollution index against the class II water quality standard in the three samples is classified as good water condition.

Keyword: *distribution system, hydraulic design, water quality*

1. Introduction

1.1. Background

Blora Regency is a relatively dry area, the available water sources are relatively few (small) compared to other areas in Central Java province.To meet the demand for raw water in a sustainable manner with these limited water resources, efforts are needed to develop, control, utilize or use and conserve existing water sources as optimally as possible.

Blora Regency in the dry season is very short of water from June to October. In 2010 the population of Blora Regency who used water from PDAM was only around 35%, while the rest used water sourced from dug wells and artesian wells. Seeing this, the role of water is very important for the survival of the community, it is necessary to plan a raw water supply system from the intake of the dam to the WTP of each district.

1.2. Research purposes

Provide an analysis of the hydraulic design of the piping system from the intake of the dam to each IPA and the quality of the water to be used.

1.3. Benefits of research

This research is expected to be a support for planning the distribution of raw water from the Randugunting Dam.

2. Literature Study

2.1. Raw Water Unit

The raw water unit consists of a water storage building, a capture/tapping building, measurement tools and monitoring equipment, a pumping system, and/or a carrier building and its accessories.

2.2. Raw Water Needs

1. Domestic Water Needs

Domestic water demand is the need for water for household purposes which is carried out through a house connection (SR) and general needs provided through public hydrant facilities (HU) or Common Faucet (KU) [1].

$$Qd = Y \ x \ Sd \tag{1}$$

Qd = Discharge Domestic water demand (liters/day)
Sd = Domestic water demand standard (liters/day)
Y = Total population (person)

2. Non-Domestic Water Needs

Non-domestic water needs are water needs for regional facilities and infrastructure that are identified to exist or will exist based on the spatial plan. Facilities and infrastructure in the form of social/public interests such as for education, places of worship, health and also for commercial purposes such as for hotels, offices, restaurants and others.[1].

$$Qn = Qd \ x \ Sn \tag{2}$$

Qn = Discharge non-domestic water needs (liters/day)
Qd = Domestic water demand (liters/day)
Sn = Standard non-domestic water needs (%)

Tabel 1. Criteria/Standards for Rural Water System Planning (Departemen Pekerjaan Umum Direktorat Jenderal Cipta Karya, 1990)

No	Description	Criteria
1	Hydrant (HU)/ faucet	30 l/org/day
2	Home Connection (SR)	90 l/org/day
3	Scope of Service	60-80%
4	Ratio HU/KU-SR	20-80 – 50-50
5	Non-Domestic Needs	5%
6	Water Loss Due to Leaks	15%
7	Peak factor for daily max	1,5
8	Service HU/KU	100 org/unit
9	Service SR	10 org/unit
10	Hours of Operation	12 hour /day
11	Max Flow HU/KU	3000 l/day
12	Max Flow SR	900 l/day
13	Planning Period	10 year

Source : Lambertus Tanadjaja, 2011

2.3. Looses

Looses is generally caused by water leaks in transmission and distribution pipes and errors in meter readings. The percentage of water loss for rural water supply system planning is 15% of the average requirement where the average demand is the sum of domestic needs plus non-domestic needs.(Tanudjaja, 2011)

$$Qa = (Qd + Qn) \times ra \quad (3)$$

Where :
Qa = Water loss discharge (liters/day)
Qd = Domestic water demand (liters/day)
Qn = Discharge of non-domestic water needs (liters/day)
ra = Percentage of water loss (%)

2.4. Total Need for Water

Total water demand is the total water demand for both domestic and non-domestic plus water losses. (Departemen Pekerjaan Umum Direktorat Jenderal Cipta Karya, 1990)

$$Qt = Qd + Qn + Qa \quad (4)$$

Where :
Qt = Total water demand discharge (liters/day)
Qd = Domestic water demand (liters/day)
Qn = Discharge of non-domestic water needs (liters/day)
Qa = Water loss discharge (liters/day)

2.5. Distribution System and Water Supply System

1. Water Distribution System

The distribution system is a system that is directly related to consumers, which has the main function of distributing water that has met the requirements to all service areas. Two important things that must be considered in the distribution system are the availability of an adequate amount of water and sufficient pressure (continuity of service), as well as maintaining the security of water quality coming from the treatment plant.[1].

2. Water System

The gravity flow method is used if the elevation of the water source has a large enough difference with the elevation of the service area, so that the required pressure can be maintained. In the gravity piping system, the elements that exist include:[1]:

a. Broncaptering
   This tub serves to protect and collect water from springs.
b. Hider Tank
   - Prevents a sudden increase in the spring if there is a blockage in the piping network, so as not to cause back pressure on the water source.
   - It is a place of deposition if there is sand or mud carried from the water source before the water enters the pipe.
   - Stabilize the flow of water coming from water sources.
c. Transmission Pipeline
   - Function to drain water to the user or to the reservoir if there is one.
d. Reservoir
   - Functions to store water when user needs are low, and provide water when user needs increase.
   - It also functions as a place for small sediments to be deposited.
e. Pressure Relief Body (BPT)
   - Functions to make pressure become 0 (zero).

- Release pressure that exceeds nomination pressure (pressure that exceeds the resistance of the pipe) so as not to cause damage to the pipe and its accessories due to high pressure.

f. Distribution Pipe
- Serves to drain water from the reservoir to the Public Faucet Monument/Public Hydrant where the final collection is.

2.6. Energy Loss

The major energy loss is caused by friction or friction with the pipe walls. Energy loss due to friction is caused by the fluid or fluid having a viscosity, and the pipe wall is not perfectly smooth. The Hazen Williams equation is:

$$\mathrm{Q} = Cu.\, C_{HW}.\, D^{2.63}.\, i^{-0.54} \tag{5}$$

with C_u = 0,2785, then the above equation can be written as:

$$Q = 0{,}2785\; C_{HW} D^{2.63} i^{-0.54} \tag{6}$$

Where :

CHW = Hazen Williams coefficient

i = the slope or slope of the power line ($i = \frac{hf}{L}$)

D = pipe diameter

Q = flow (m3/s)

The amount of energy loss in the pipe is determined by the following equation:

$$hf = \frac{10.675 \times Q^{1.852}}{C_{hw^{1.852}} \times D^{4.8704}} \times L \tag{7}$$

3. Methodology

3.1. Research sites

Randugunting Dam is administratively located in Kalinanas Village, Japah District, Blora Regency, Central Java Province. Geographically, the location of the dam is at the coordinates of - 6° 52' 22.77" South Latitude and 111° 15' 27,359" East Longitude.

Blora Regency is located between 60528' - 70248' South Latitude and 111016' - 1110338' East Longitude. It is bordered in the west by Grobogan Regency, in the east by East Java Province. Pati Regency is located between 6025' - 7000' south latitude and between 100050' - 111015' east longitude. Based on its geographical position, Pati Regency has boundaries: North – Kab. Jepara and the Java Sea, South – Kab. Grobogan and Blora, West – Kab. Kudus and Jepara, East – Kab. Rembang and the Java Sea. Rembang Regency is located between 60 30' - 70 06' South Latitude and between 1110 00' - 1110 30' East Longitude. Based on its geographical position, the state of Rembang Regency has boundaries: North – Java Sea; South - Blora Regency; West - Pati Regency; East - East Java Province.

3.2. Survey and Analysis of Raw Water Availability

The hydrological analysis includes the availability of water as seen from the mainstay discharge of the reservoir and its reservoir as well as the discharge of needs in the form of the need for irrigation of an area of 630 ha and raw water of 200 lt/s consisting of Blora 100 lt/s, Pati 50 lt/s and Rembang 50 lt/s [2].

3.3. Population Development Survey and Analysis

Every year population growth is increasing. The population in an area greatly affects the amount of water demand in the area, so it is necessary to collect data on the population that will be used for population projections until the planning year.

3.4. Survey and Investigation of Raw Water Needs for Water

Surveys and investigations are carried out in coordination with the PDAM of Blora, Pati, Rembang districts in accordance with the raw water development plan for each district.

3.5. Water Supply System Design

Planning the raw water supply system for water, it is necessary to know the pattern or scheme for the distribution of water from water sources to residential areas. The stages of water distribution from water sources to residential areas can be :
a. Springs
The selection of water sources must be carried out directly in the field survey. Looking for a decent water source that can meet the planned amount of water demand.

b. Brocaptering
Broncaptering is a building to catch springs, it can also be useful for protecting springs.

c. Press Release Body (BPT)
Made to release pressure that exceeds the nomination pressure (pressure that exceeds the resistance of the pipe) so as not to cause damage to the pipe, then it is distributed to service/consumer areas through distribution pipelines..

d. Pipeline system design (transmission and distribution)
The design of the pipe network system or network hydraulic system can be done manually using the formula Hazen-Williams.

4. Analysis

4.1. Blora regency's raw water needs

From the data obtained from PDAM Blora Regency, Pati Regency, Rembang Regency, it was found that the requested needs are as follows: raw water of 200 liters/sec consisting of Blora 100 liters/sec, Pati 50 liters/sec and Rembang 50 liters/sec.

Table 2. Pati Regency's raw water needs

No	Village	Districts	Debit	description
1	Srikaton	Jaken	36,84 lt/s	Service 0%
2	Sukorukun			
3	Manjang			
4	Tamansari			
5	Sumberarum			
6	Sriwedari			
7	Tegalarum			
8	Sumberejo			
9	Tompomulyo	Balangan	16,03 lt/s	Service 0%
10	Kuniran			
11	Gunungsari			

Source: PDAM Pati Regency

Table 3. Blora Regency's Raw Water Needs

No	Village	Districts	Debit	description
1	Kalinanas	Japah	10 lt/s	Service 0%
2	Bogem			
3	Japah			
4	Gapokan			
5	Ngawen	Ngawen	30 lt/s	Service 15%
6	Punggursugih			

7	Sarimulyo			
8	Semawur			
9	Trembulrejo			
10	Kebonrejo	Banjarejo	20 lt/s	Service 0%
11	Karangtalun			
12	Banjarejo			
13	Kembang			
14	Sendangwungu			
15	Plosorejo			
16	Adirejo	Tunjungan	10 lt/s	Service 0%
17	Tamanrejo			
18	Tutup			
19	Tunjungan			
20	Blora	Blora	30 lt/s	Service 55%

Source: PDAM Blora Regency

Table 4. Rembang Regency's raw water needs

No	Village	Districts	Debit	description
1	Sumber		10 lt/s	Service 20%
2	Kaliori		15 lt/s	Service 30%
3	Rembang		25 lt/s	Service 50%

Source: PDAM Rembang Regency

Table 5. Total population in the area of raw water service

No	Regency	Districts	total population (person)	Total (person)
1	Blora	Japah	8172	148119
2		Ngawen	15071	
3		Banjarejo	15362	
4		Tunjungan	14493	
5		Blora	95021	
6	Pati	Jaken	18438	26448
7		Batangan	8010	
8	Rembang	Kaliori	42779	171374
9		Rembang	91557	
10		Sumber	37038	

Source: Central Bureau of Statistics, 2021

4.2. Raw Water Availability

Availability of raw water is taken from the data on Optimization of Water Resilience in the Randugunting Reservoir Design [2].

In accordance with the optimization analysis of Water Reliability of the Randugunting Reservoir, the discharge given to the reservoir is 100 liters/sec for Blora Regency, 50 liter/sec for Pati Regency, 50 liters/sec for Rembang

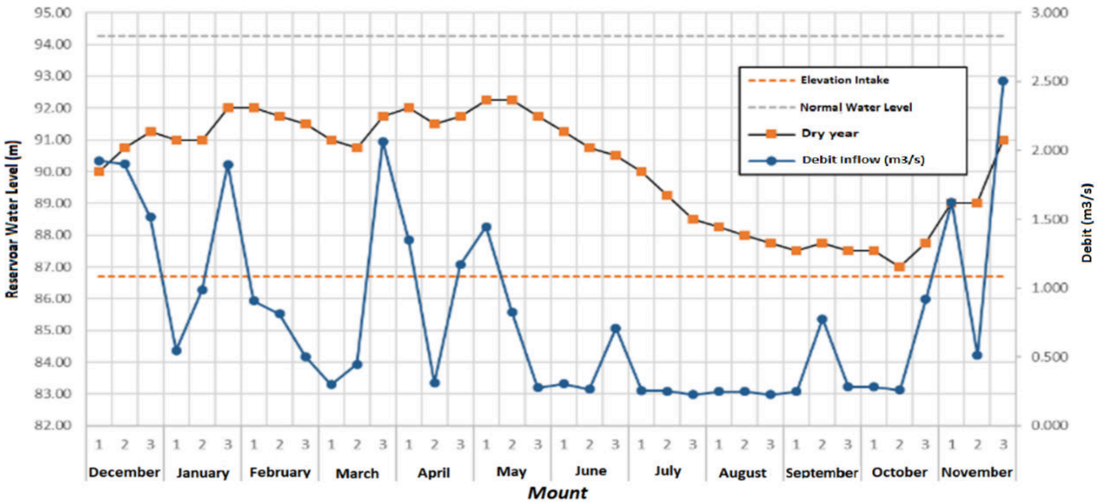

Fig. 1. Dry Year Discharge Reliability Simulation *(BBWS Pemali Juana, 2021)*

4.3. Water quality

Water quality conditions are in accordance with the requirements of using class 2 quality standards. Water samples were taken while the dam construction construction work was being carried out.

Table 6. Recapitulation of Water Testing of Ronggo River, Gaplokan River, Banyuasin River.

No	Test Parameter	Unit	S. Ronggo	S. Gaplokan	S. Banyuasin	Quality standards	
						II	III
	Physics						
1	Temperature	˚C	33	29	32	Deviasi 3	Deviasi 3
2	Dissolved Solids	mg/L	321	467	338	1000	1000
3	Suspended Solids	mg/L	95	30	134	50	400
	Chemistry						
1	Mercury	mg/L	<0.0002	<0.0002	<0.0002	0.002	0.002
2	Arsen	mg/L	<0.01	<0.01	<0.01	1	1
3	BOD	mg/L	<1	<1	<1	3	6
4	COD	mg/L	<14.2	16.4	<16.4	20	50
5	Detergent	mg/L	82	<66	186	200	200
6	DO	mg/L	4.6	4.5	4.1	4	3
7	Phenol	mg/L	<100	<100	<100	1	1
8	fluoride	mg/L	0.45	0.46	0.42	1.5	1.5
9	Phosphate	mg/L	0.7	0.75	0.6	0.2	1
10	Cadmium	mg/L	<0.008	<0.008	<0.008	0.01	0.01
11	Cobalt	mg/L	<0.07	<0.07	<0.07	0.2	0.2
12	Chromium Vol.6	mg/L	<0.03	<0.03	<0.03	0.05	0.05
13	Oil & Fat	mg/L	2380	1430	1360	1000	1000
14	Nitrates as N	mg/L	<1	1	<1	10	20
15	Nitrite as N	mg/L	<0.04	<0.04	<0.04	0.06	0.06
16	pH	mg/L	7.6	7.9	7.9	6.0-9.0	6.0-9.0
17	Selenium	mg/L	<0.005	<0.005	<0.005	0.05	0.05
18	Zinc	mg/L	0.13	0.1	0.13	0.05	0.05
19	Cyanide	mg/L	0.011	0.009	0.025	0.02	0.02
20	Remaining Chlor	mg/L	0.31	0.23	0.38	0.03	0.03
21	Sulfide	mg/L	0.05	0.05	0.07	0.002	0.002
22	Copper	mg/L	<0.01	0.01	0.01	0.02	0.02
23	Lead	mg/L	0.039	<0.028	0.061	0.03	0.03
	Biology						
1	Total coliform	Total/100 ml	9200	>16000	3500	5000	10000
2	Total Fecal Coli	Total/100 ml	2400	>16000	1700	1000	2000

Source: Calculation Results

Laboratory results from 3 samples of river water and compared with quality standards in accordance with Government Regulation Number 82 of 2001 concerning Implementation of Environmental Protection and Management, it was found that the values of Temperature, Oil & Fat, Zinc, Residual Chlorine, Lead, Total Coliform and Total Fecal Coli exceeded the quality standards. class 2. Evaluation of the pollution index against the class II water quality standards in the three samples classified as good / lightly polluted water conditions.

4.4. Raw Water Network Hydraulic Design

The Network System that will be designed in accordance with the Planning :

1. Intake of Randugunting reservoir to Centralized WTP to WTP each district with distribution pipe

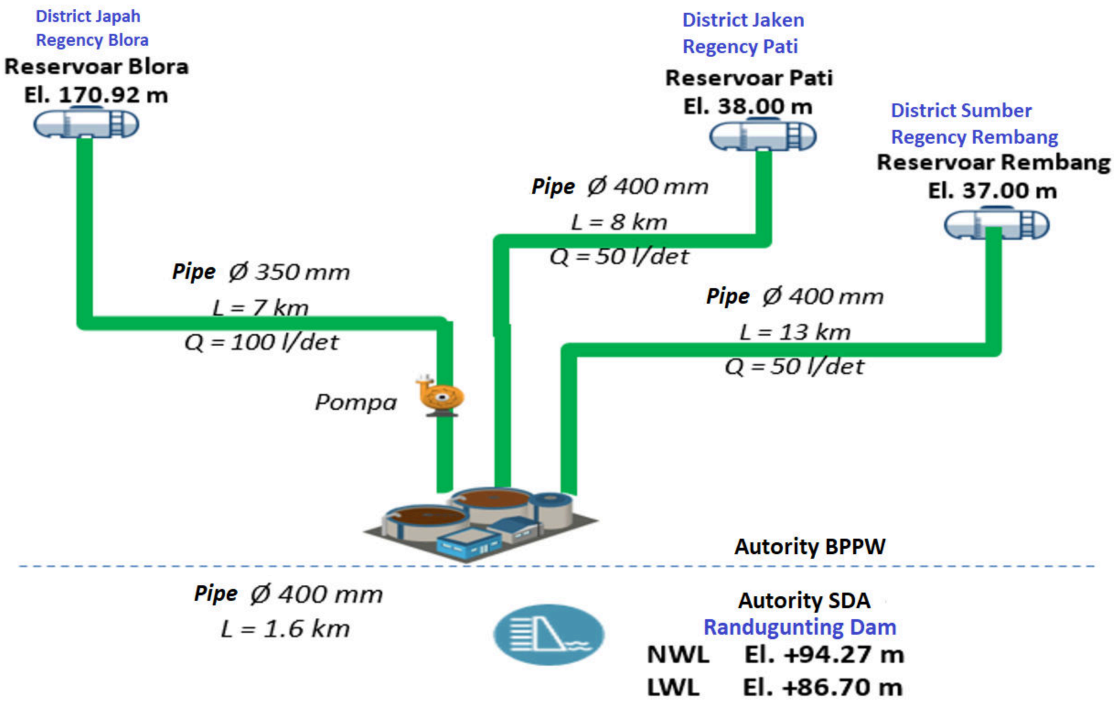

Fig 2. Randugunting Dam raw water network planning system

The results of the hydraulic analysis of the Randugunting intake to a centralized WTP are about 1,7 km using a PE pipe 400 mm with a flow rate of 100 lt/sec. analysis obtained results from the intake to a centralized WTP. The average HGL value was 78,75m higher than the average elevation hs 68,79m, 9,97m residue. The HGL value is higher than the hs elevation, the residue is positive, end pressure 0,128 bar, water can flow. The calculation results can be seen in the image:

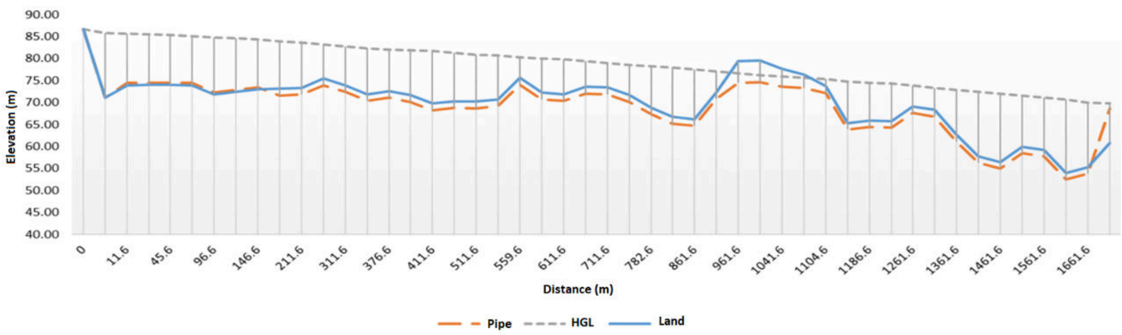

Fig. 3. Hydraulic profile of Randugunting intake to centralized WTP

The results of the hydraulic analysis of the WTP are concentrated in the WTP distribution, Blora Regency, about 7 km away using PE pipe 350 mm with a flowrate of 100 lt/s plus a booster pump with a flow rate of 100 lt/s with a height difference of approximately 100 m. the second condition is centered on the WTP Blora, the average HGL value is 202,17m higher than the average elevation hs 114,94m, residue 87,23m, end pressure 0,977bar The HGL value is higher than the hs elevation, the residue is positive, water can flow. The calculation results can be seen in the image:

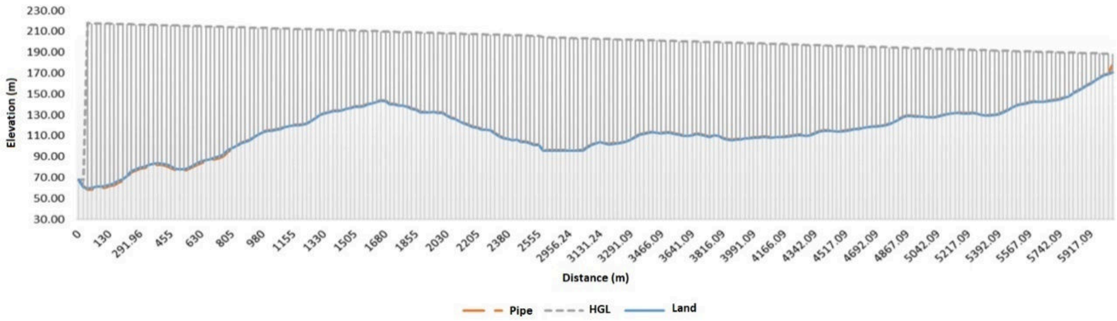

Fig. 4. Hydraulic Profile of Centralized WTP Randugunting ke IPA Blora

The results of the hydraulic analysis of the WTP centered on the WTP Pati is about 13 km using PE pipe 400 mm with a discharge of 50 lt/sec. The condition of WTP centered on the WTP Pati, the average HGL value is 66.27m higher than the average elevation hs 54.41m, residue 11.85m, final pressure 1.831bar The HGL value is higher than the hs elevation, the residue is positive, water can flow. The calculation results can be seen in the image:

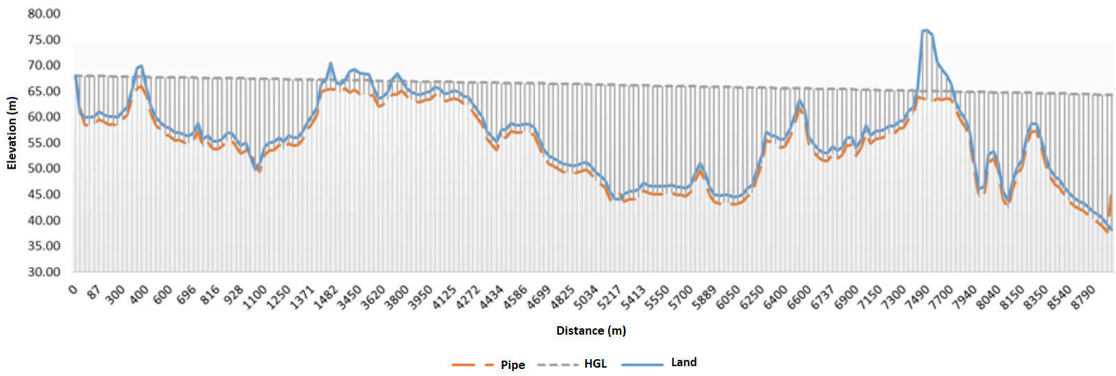

Fig. 5. Hydraulic Profile of Centralized WTP Randugunting to IPA Pati

The results of the hydraulic analysis of the WTP centered on the WTP Rembang, is about 8 km using PE pipe 400 mm with a discharge of 50 lt/sec. The condition of WTP centered on the WTP Rembang the average HGL value of 64.99m higher than the average elevation hs 44.11m, residue 20.88m, final pressure 2.162bar. The HGL value is higher than the hs elevation, the residue is positive, water can flow. The calculation results can be seen in the image:

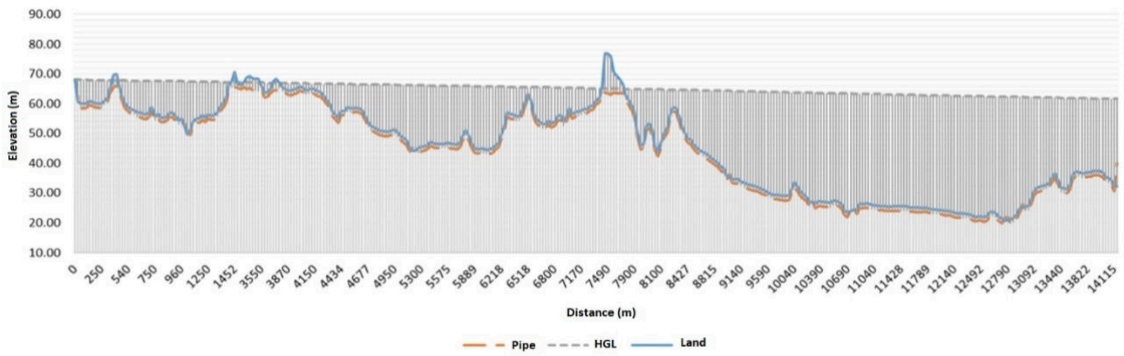

Fig 6. Hydraulic Profile of Centralized WTP Randugunting to IPA Rembang

5. Conclusion

From the results of the analysis obtained the following conclusions :

1. Planning of the raw water supply system from the Randugunting Dam intake distributed to the respective WTPs in Blora, Pati, Rembang Districts. The first analysis obtained results from the intake to a centralized WTP using PE pipes 400mm the average HGL value was 78.75m higher than the average elevation hs 68.79m, 9.97m residue, 0.128bar final pressure; the second condition is centered on the WTP Blora using PE pipe 350mm plus a pump capacity of 100 lt/s, the average HGL value is 202.17m higher than the average elevation hs 114.94m, residue 87.23m, final pressure 0.977bar; the third condition is centered on the WTP Pati using PE pipe 400mm, the average HGL value is 66.27m higher than the average elevation hs 54.41m, residue 11.85m, final pressure 1.831bar; the condition of the four WTP centered on the WTP Rembang using PE pipe 400mm obtained an average HGL value of 64.99m higher than the average elevation hs 44.11m, residue 20.88m, final pressure 2.162bar.
2. Evaluation of the pollution index against class II water quality standards in the three samples classified as good/lightly polluted water conditions. Because at the time of collection it was still in the condition of carrying out the work.

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