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Analysis Of The Installation Of Subsea Pipelines To Support The Need For Clean Water In Supporting Tourism Development On Kayangan Island

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Abstract

Inclusive access to water is very important for the tourism sector to maintain a good reputation among tourists and the social license of the local community to operate. While all stakeholders or stakeholders expect the success of tourism which contributes to economic improvement, community welfare, human resource development, and improvement of public health and the environment, tourism activities on Kayangan Island need clean water for their development. Considering that the island is one of the favorite tourist destinations and is growing quite rapidly at this time, there is no effective source of clean water available on the island. Therefore, it can be attempted to provide clean water by using subsea pipes sourced from PDAM Makassar. According to observations from various aspects, the pipe will cross the ocean with a span of ± 1500 meters by flowing water with a discharge of 10 lt/s using HDPE pipes with a diameter of 140mm PE100, PN 16 according to SNI standards. For a fairly good security system, the jet pump and the pipe will be tied to a 110 mm diameter stainless steel sling bridge. In addition, at every 6 meters distance, the pipe bridge slings are fitted with ballast loads with hanging slings. In this study, the installation of subsea pipelines requires a variety of supporting equipment and also a complicated implementation, but it is can be carried out considering this needs to be done to support the need for clean water on Kayangan Island to support tourism development.

Keywords: Clean Water, Subsea, Pipeline, HDPE, Tourism

1. Introduction

The pipeline is defined as a longitudinal connection of pipe segments, with pumps, valves, control equipment, and other equipment to support the system. Subsea pipelines are used for the transportation of oil, gas, or water fluids in large quantities and long distances by sea or offshore areas. Based on pipeline engineering, the pipe analyzed has three conditions, namely installation conditions, hydro test, and operating conditions [1]. Various piping system configurations can be selected based on various factors such as location, sea level, environmental conditions, function, and design age.

Loads in pipes in seawater can be classified into

two, namely functional loads and environmental loads. These loads must be determined in advance in designing the piping system. Functional load is the load acting on the pipe due to the physical load of the pipe, including the weight of the pipe and its contents, internal and external pressure forces of the pipe, thermal expansion and contraction loads from working temperature, and pre-stress loads due to pressures that occur during pipe installation activities. Meanwhile, the environmental load is the load acting on the pipe due to the influence of environmental conditions around the pipe, such as wind, waves, ocean currents, hydrodynamic loads, and other phenomena such as soil liquefaction which can shift the position of the pipe so that it can cause buckling due to free span and the

occurrence of changes in longitudinal stress on the installed pipe [1].

The seabed surface is generally uneven, therefore the gap between the pipe and the seabed also affects the distribution of hydrodynamic forces on the pipe [4]. The distribution of pressure around the pipe affects the drag and lift forces on the pipe [10]. The coefficients of force not only depend on the gap, but the flow oscillations due to waves and ocean currents cause pipe instability [8]. Ocean waves are generated by wind, which can be assumed that in seawater the vertical component of wave motion tends to be zero near the seabed [6].

The piping system is a complex system, at the time of its design many aspects need to be considered and considered to obtain a good and efficient piping system design [2]. It is necessary to analyze the stress calculation to ensure that the pipeline that has been installed and the pipe pedestal is placed in the right place so that the stress that occurs does not exceed the limit of the maximum amount of stress that has been set. In applying the design standard code, the design of the

piping system must comply with the basic principles of pipe tension and related matters. A pipe is declared damaged or failed if the internal stress that occurs in the pipe exceeds the allowable limit stress of the material. The internal stress that occurs in the pipe is caused by pressure from inside the pipe, external loads such as dead weight and thermal expansion, and depends on the geometry of the pipe and the type of pipe material. While the limit stress is more determined by the type of material and the method of production. Stress in the piping system, among others, can be caused by hydrostatic pressure, water hammer, bending (bending), temperature.

One example of water flow using the method of installing underwater pipes in Indonesia is the underwater pipe that connects Maitara Island and Tidore Island. HDPE pipe is installed on the seabed using the TT (pull-sink) method, as shown in Figure 1 [15].

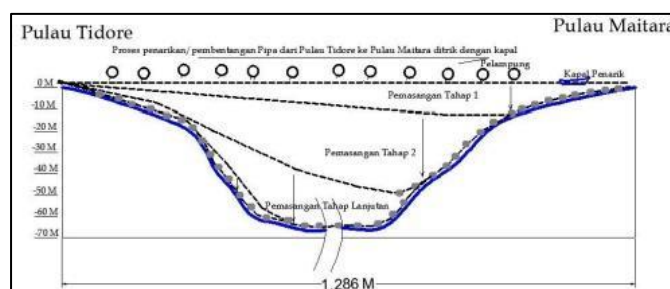


Fig. 1. Underwater Pipeline Installation between Maitara Island and Tidore Island [15]

A big challenge is being faced to distribute clean water from PDAM Makassar City to Kayangan Island through pipes under seawater, namely the method of piping installation, pipe selection, and the limitations of installing pipes under seawater. So it affects how deep the pipe can be installed. Installation of piping under seawater is limited by the ship to install the piping, as well as technical and design solutions to ensure the proper operation and maintenance of the piping system [11].

In addition, pipe size and weight, pipe material, ocean currents and waves, and seabed conditions all contribute to pipe laying challenges. Therefore, it is very important to be able to identify the forces acting on the underwater piping system, especially the sea crossing pipeline between Makassar city and Kayangan island to channel clean water to support tourism in the islands.

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The effect of waves on pipe construction will be large when the pipe is on the surface and will gradually decrease with increasing pipe depth. Likewise ocean currents.

2. Materials and Methods

The method used in this study is quantitative. The quantitative method is a scientific method because it has met scientific principles that are concrete/empirical, objective, measurable, rational, and systematic. This method is called quantitative because the research data is in the form of numbers and the analysis uses statistics or models. Determination of data collection points using the purposive sampling method, namely determining data collection points by only taking a few sampling

points that represent the overall state of the area being studied [9].

The underwater drinking water pipe that connects Makassar City with Kayangan Island was built by considering all existing aspects, namely ocean currents, wave effects, and seabed conditions around Makassar waters. In the application of underwater pipes, the design and installation of PE pipes consist of the following basic steps [12]:

- a) Determination of pipe diameter
- b) Selection of the appropriate pipe SDR (pipe thickness) is included in anticipating the installation and operating conditions.
- c) Planning weight and spacing of ballast weights to sink and stabilize the pipe position.
- d) Selection of suitable locations for laying, joining, and pulling pipes.
- e) The process of installing and fastening pipes to retaining and guiding slings.
- f) Installation and checking of ballast weights.
- g) Filling the pipe with water
- h) Submerge the pipe to the planned depth.
- i) Completion of work in sea crossing pipelines and land pipelines.

The installation path location must be free from any activity. Fishermen and boat traffic were stopped. Looking for the right time with low ocean currents and waves according to data from BMG. In the installation of pipelines at sea, a ship is needed as a towing and loading material.

Modeling of ocean currents around Makassar waters has been identified using the RMA2 numerical model. The current pattern in the dominant surface layer is influenced by the tidal pattern in the area. Surface current pattern at high tide from the south with speeds reaching 0.08 m/s near the coast. The pattern of surface currents at low tide occurs in the opposite current pattern, namely from north to south at speeds of up to 0.05 - 0.30 m/sec. The current velocity is low in the inner waters of Makassar City with a speed of 0.10 m/sec [3].

Therefore, taking into account the existence of large ocean currents around Makassar waters, the installation of drinking water pipes is carried out by submerging them on the seabed. In this method the influence of current waves and deflection due to the weight of the pipe is small. Also be considered on-bottom stability, pressure, and seabed

conditions which will affect the continuity of the pipeline network.

Projection of the number of population and water needs

The need for clean water for various kinds of people's daily needs can generally be divided into two groups, namely domestic needs, and non-domestic needs. Domestic demand is the need for clean water used for household purposes through faucet connections to homes and the public, whose total needs can be seen from the records (data) of the city or area concerned based on the characteristics and developments of consumers who use clean water in the area.

Based on the Regulation of the Minister of Public Works Number: 18/Prt/M/2007 concerning Implementation of Drinking Water Supply System Development, the projected population is calculated using the geometric method, and the domestic water demand with the community's water consumption rate is 130 liters/person/day [5].

Likewise, non-domestic water needs are calculated based on available facilities, and the rate of water loss is planned at 20% of consumption needs. The amount of water used by the community in a clean water distribution network system is not constant but fluctuations occur from one hour to another, as well as from one day to another, the fluctuations that occur depend on the activities of daily water use by the community

3. Results

3.1 Clean Water Needs

The utilization of clean water sources in Makassar City to meet the water needs of Kayangan Island requires a water balance study to determine the remaining discharge that can be utilized. For this reason, it is necessary to first calculate the projected population and water demand for Kayangan Island as shown in Table 1, then the remaining water discharge, as in Table 2, can be channeled to Kayangan Island. So until the projected the year 2043, there is still 177 liter/sec (73%) of water available that can be utilized.

Table 1. Projection of total clean water demand on Kayangan Island

No	Description	Unit	Year				
			2023	2028	2033	2038	2043
A	Parameters defined						
1	Residents/visitors served per connection						
	- Households	soul connect	5	5	5	5	5
	- Public faucets	soul connect	100	100	100	100	100
2	Water consumption factors						
	- Daily maximum		1.15	1.15	1.15	1.15	1.15
	- Peak hours		1.56	1.56	1.56	1.56	1.56
3	Water loss		20%	20%	20%	20%	20%
B	Calculation of water needs						
1	Number of	soul	40,004	41,144	42,362	43,663	45,055
2	residents/visitors	%	60.0%	70.0%	80.0%	90.0%	100.0%
3	Residents/visitors served	soul	24,003	28,801	33,889	39,297	45,055
4	Number of residents/visitors served						
	Domestic water needs	1/person/day	80	80	80	80	80
	a. Household connections	%	70	70	70	70	70
	Water use	soul	16802	20161	23,723	27,508	31,538
	Percentage of services sr	unit	3360	4032	4,745	5,502	6,308
	Number of residents/visitors served	unit		672	1,384	2,141	2,947
	Number of connections	m ³ /day	1344	1613	1,898	2,201	2,523
	Number of additional connections	1/person/day	30	30	30	30	30
	Water demand sr	%	30	30	30	30	30
	b. Connection of public faucets	soul	7201	8640	10,167	11,789	13,516
	Water usage	unit	72	86	102	118	135
	Percentage of services	m ³ /day	216	259	305	354	405
	Number of residents/visitors served						
	Number of connections						
	Public tap water needs						
	Total domestic demand	m ³ /day	1.560	1,872	2,203	2,554	2,929
		l/sec	18.06	21.67	25.50	29.56	33.90
5	Domestic water demand						
	a. office	m ³ /day	49.70	59.21	70.53	84.02	100.09
	b. Worship	m ³ /day	76.38	80.88	80.38	84.88	89.38
	c. Tourism	m ³ /day	199.32	237.44	282.86	336.96	401.41
	d. Economic facilities	m ³ /day	302.35	360.18	360.18	511.14	608.91
	e. Other public facilities	m ³ /day	60.00	60.00	60.00	60.00	60.00
	Total non-domestic water demand	m ³ /day	688	798	854	1077	1260
		l/sec	11.32	13.02	14.75	16.87	19.38
6	Domestic and non- domestic deman	m ³ /day	2248	2670	3057	3631	4189
7	Water loss	m ³ /day	196	196	255	291	335
8	Average water requirement	m ³ /day	2734	2734	3732	4303	4938
9	Max daily requirement	l/sec	36	43	50	57	66
		l/sec	32	32	43	50	57
10	Peak hour requirement	l/sec	49	58	67	78	89

Based on Table 1, it is known that the projected number of residents/visitors of Kayangan Island until 2043 in 45,055 people with domestic clean water needs of 2,929 m³/day (33.90 lt/sec), and non-domestic water needs of 1,260 m³/day (19.38 liters). /s) so that the total discharge requirement is 4,189 m³/day. By adding water loss (20%) of 335 m³/day,

the water demand becomes 4,938 m³/day, with an average discharge of 57 lt/sec, a maximum daily flow of 66 lt/sec, and a peak hourly discharge of 89 lt/sec. So the water balance shows the remaining discharge that can be used to be channeled to Kayangan Island is 177 lt/sec (73%), as shown in Table 2 below.

Table 2. Water balance that can be utilized to be channeled to Kayangan Island

No	Description	Debit (l/sec)				
		2023	2028	2033	2038	2043
1	Resource capacity that can be utilized	243	243	243	243	243
2	Projected water demand	36	43	50	57	66
3	Remaining discharge capacity (lt/sec)	207	200	193	186	177
	Remaining discharge in %	85%	82%	80%	76%	73%

3.2 Pipe Selection

Since it was first introduced in the 1960s, High-Density Polyethylene (HDPE) pipe has continued to increase in its marine applications, mainly because of its resistance to galvanic corrosion. Another advantage is that the density of PE pipes is about 94% of the density of seawater so that they float. Based on the flow rate and static pressure in the pipe as well as the environmental conditions where the pipe is installed, HDPE pipes are planned/selected according to SNI standards. Another consideration

is its flexibility and lightweight making it easy to transport and install. This flexibility allows the HDPE pipe to be submerged slowly and can adapt to the topography of the seabed surface, thereby simplifying the procedure for submerging the pipe [11].

The plan for the clean water piping system from Makassar city water sources to Kayangan Island is as shown in Figure 2.

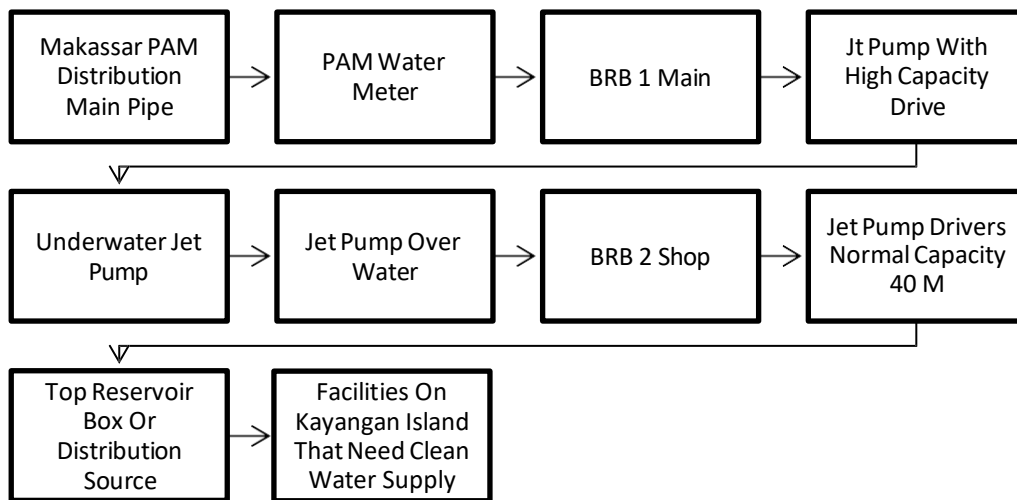


Fig. 2. Clean water supply piping system from Makassar city to Kayangan island

Following the explanation from the PDAM distribution agency, it will take into account the speed of ocean currents, maintenance factors, the consequences of damage that occur, and the placement of a high-capacity jet pump with a fairly good security system. As well as to secure the pipe from the force loads that occur underwater, the pipe will be tied to a 110 mm diameter stainless steel sling bridge. In addition, at every 6 meters distance, the pipe bridge slings are fitted with ballast load

concrete with hanging slings [13].

This system can be done because of the ship's backflow system that passes on the west side. Based on the flow rate and static pressure in the pipe as well as the environmental conditions where the pipe is installed, HDPE pipe is planned/selected according to SNI 4829.2:2012 standard for PE100 pipe with a sea crossing pipe length of ±1500 meters. It is planned to flow water at a flow rate of 10 lt/sec according to the number of intake pumps,

so the HDPE pipe with a nominal diameter of 140 mm PE100, PN 16 bar will be equipped with pipe clamps that will be connected to ballast so that the pipe does not wobble.

3.3 Contours of Sea Depth (Bathymetry)

The figures contained in the contour lines (Figure 3) are numbers that indicate the depth of the waters in meters. The pipe will be laid to a depth of

2 meters on the seabed according to the standard requirements of DNV-OS-F101 Submarine Pipelines Systems 2007 [7]. The pipe will be installed at a depth of ± 16 m below sea level and adjust the shape of the indentation/basin at a depth of 5 m, 13 m, and 15 m below sea level with a sea crossing pipe length of ± 1500 m.

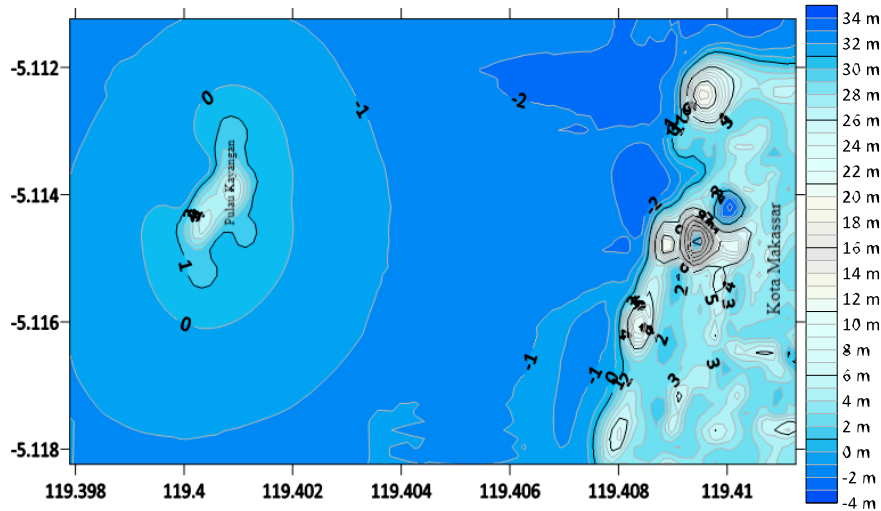


Fig. 3. The results of the contour line of the depth of the waters around the island of Kayangan and the city of Makassar

3.4. The 3D Seabed Bathymetry Model

3D models are made to analyze and determine the bathymetry of the seabed surface [9]. The 3D seabed bathymetry model created using the software is presented in Figure 4. The seabed

surface of the research location is relatively flat, not wavy and there are no basins, which can be seen in Figure 4.

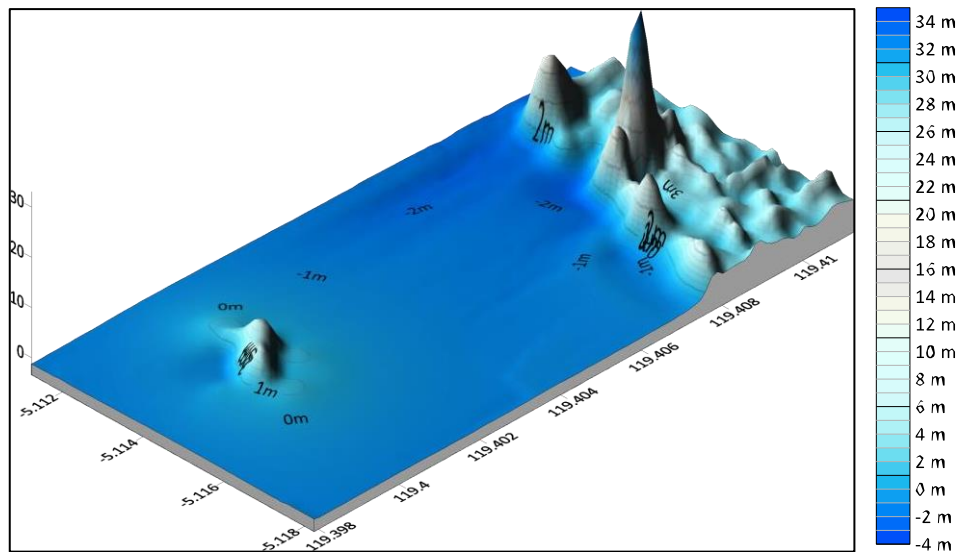


Fig. 4. The 3D Seabed Bathymetry Model The waters around the island of Kayangan and Makassar City

3.5. Seabed Bathymetry

Cross-sections Seabed bathymetry cross-sections were created using the help of software. The seabed bathymetry cross-section is used to

determine the shape of the seabed bathymetry at the research location. The cross-section of the research location can be seen in Figure 5.

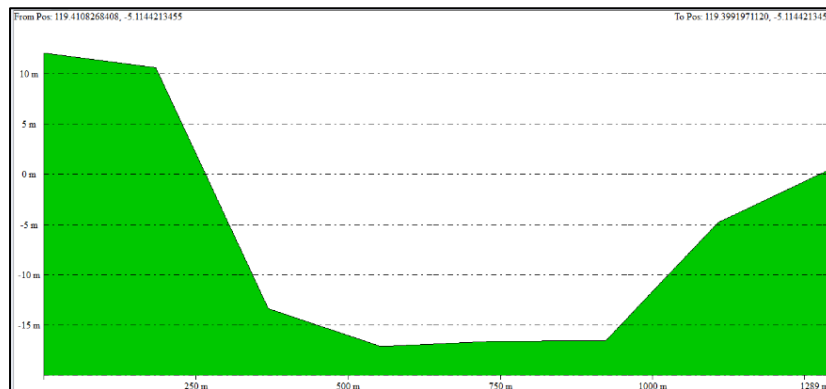


Fig. 5. Cross-section

3.6. Tidal

data were analyzed using the Admiralty method. The results of the analysis are in the form of the values of the tidal components. The results of the hydrodynamic model simulation in the form of

seawater elevation in Makassar waters at positions 119° 21' 49.50" East Longitude and 5° 11' 56.35" South Latitude can be seen in Figure 6 [14].

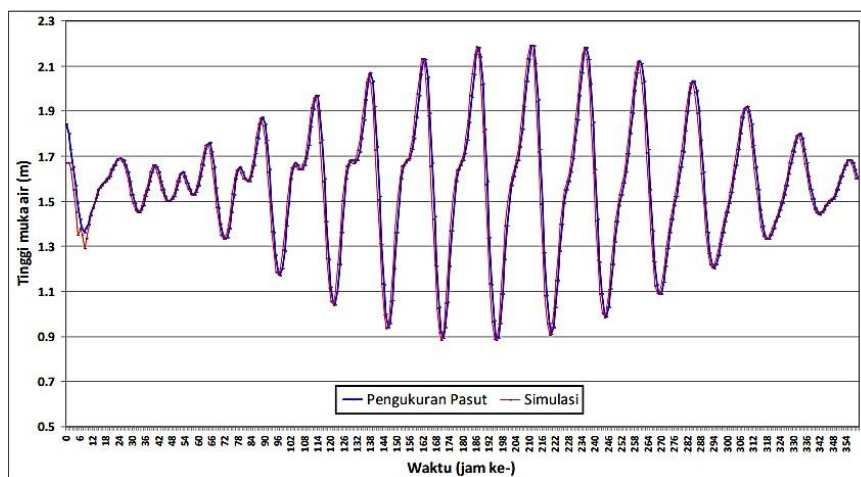


Fig. 6. Tidal Chart for Makassar Waters [14]

Based on the results of the visualization of the image, the tidal type of Makassar Beach waters is a mixed type that tends to be diurnal (single daily) with an amplitude of 0.88 – 2.18 meters from the mean sea level (MSL).

3.7. Subsea Pipe Laying Path

Determination of the submarine pipe laying path requires various considerations, before choosing a submarine pipe laying a path, the depth that will be used as a Single Point Mooring (SPM) must be determined. Single point mooring is a point where the ship moored when the ship stopped in

the middle of the waters for certain purposes. The next step is to determine several possible alternative pipelines. The direct and closest route is the best, so the submarine pipeline chosen is the route that has the shortest distance from the depot location to the SPM.

Based on the standard provisions of DNV-OS-F101 Submarine Pipelines Systems 2007, the following are the provisions for the depth of subsea pipeline placement: 1. Pipes are placed 3 meters deep on the seabed for a depth of 0 – 3 meters from the Mean Sea Level (MSL). 2. Pipes are placed as deep as 2 meters on the seabed for a depth of 10 –

28 meters from MSL. 3. Pipes are placed directly above the seabed for a depth of more than 28 meters from MSL [7]. Information on the seabed bathymetry that has been obtained by the sea can be used as a consideration in pipe laying activities at a later stage. The laying of the pipe is planned at a depth of ± 16 m below sea level (adjusting to the shape of the indentation/basin at the depth of the seabed), with a sea crossing pipe length of ± 1500 m.

The selected pipeline is the path that has the shortest distance. By choosing the shortest subsea pipeline route, it will minimize the costs to be incurred for pipe installation and make the use of subsea pipelines effective in terms of distribution from one place to another. The undersea pipeline laying route connecting Makassar city and Kayangan island can be seen in Figure 7.

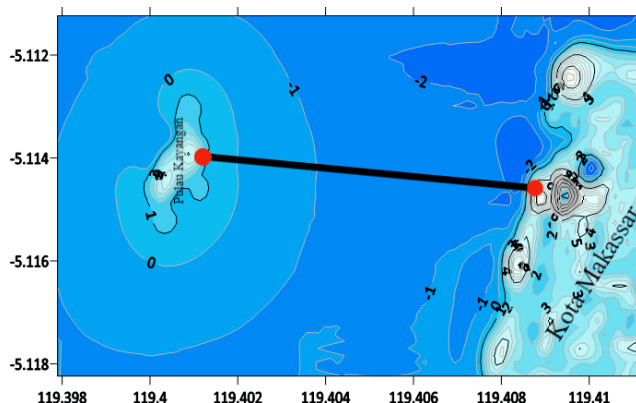


Fig. 7. Map of Selected Subsea Pipeline Laying

4. Conclusions

The underwater drinking water pipe that connects Makassar City with Kayangan Island was built by considering all existing aspects, namely ocean currents, wave effects, sea depth, and seabed conditions around the waters of Makassar City - Kayangan Island. Based on the flow rate and static pressure in the pipe as well as the environmental conditions where the pipe is installed, HDPE pipes are planned/selected according to the SNI 4829.2:2012 standard for pipes for PE100 pipes where pipe laying is planned at a depth of ± 16 m below sea level (according to the shape of the indentation). /basin at seabed depth), with a sea crossing pipe length of ± 1500 m. The pipe-laying path chosen is the path that has the shortest distance to minimize the costs to be incurred.

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