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Numerical Modelling of Shoreline changes of Galesong, Takalar's coast

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Abstract : Morphological changes of Talakar's coastline covering three administrative subdistrict has been modelled numerically in terms of sedimentation build up. Shoreline changes is one of the dynamic processes as parts of natural processes for coastline to reach their subsequent equilibrium resulting in bathimetrical alteration of coastal bed. Sedimentation modeling simulation has been conducted for the coastlines of North Galesong, Galesong, and South Galesong subdistricts. As the location is physically affected by the oceanoghrapic dynamics of Makassar Strait, Flores Sea as well as the river hydraulics of Jeneberang and Pappa rivers' estuaries. Shoreline accretion and abbrasion are distincted by data analysis. Sedimentation model shows shallowing process (pendangkalan) of 0.0136m to 0.05977m with 0.000006 m/day to 0.013 m/day growth near shorelines of North Galesong, 0.025202m to 0.1194 deepening and 0.02526m to 0.16736m shallowing with 0,0013 m/day to 0,013 m/day growth near shorelines of Galesong, and 0.014148 m to 0.11948 deepening and 0.01351 m - 0.16736 shallowing with 0.01m/day to 0.026 m/day growth near shorelines of South Galesong.

Keywords : shoreline changes, bed morphology, bathymetry

1. Introduction

Understanding variability of shoreline, including the erosion-accretion processs is a crucial issue in the eyes of researcher and stakeholders in the field of coastal science, engineering, and management. As the interface of of water and land masses, the dynamic nature of coastline on the temporal and spatial scale creates an importance of various definitions of shoreline indicators [1]. The coastline is the boundary line of the meeting between land and sea water whith tendencies to displace in effect of tidal conditions, resulting in coastal defined as accreting if there are indications of continuous deposition, and defined as retreating if the abrasion process is still ongoing [2]. Coastal process is a continuous adjustment towards a natural balance to the impacts that occur that affect shoreline changes. Coastline change is a fairly dynamic process which includes changes in the bathymetry of coastal waters [3]. Coastline changes are influenced by sediment movement, longshore current, sea surface waves and land use [4]. Changes in coastlines can occur from time to time on a seasonal or annual scale, depending on the durability of coastal conditions in the form of topography, rocks and their properties with ocean waves, tides and wind [3]. Changes in coastlines are indicated by changes in their position, not only determined by a single factor but by a number of factors and their interactions which are the result of a combination of natural and human processes. Natural factors come from the influence of hydro-oceanographic processes that occur in the sea such as wave crashes, changes in current patterns, tidal variations. In response to the locality, some research have been conducted in near by region [5]–[11]

2. Methodology

The computation modelling of shoreline changes have been conducted in MIKE software by Danish Hydraulics Institute. The stages include the pre-processing of model development. The pre-processing includes secondary data collection, as the basic input in carrying out the modeling; determination of model boundaries, as the boundaries in making the domain consist of open boundaries, friction boundaries, and close-boundaries; development of a grid model based on bathymetric data, the grid used is an irregular grid (flexible-mesh) built in MIKE Zero.

The research location as the domain of the modeling is the coasts of Takalar Regency, Spouth Sulawesi, Indonesia, which includes the coastlines of North Galesong, Galesong, and South Galesong subdistricts, as shown in Fig. 1.

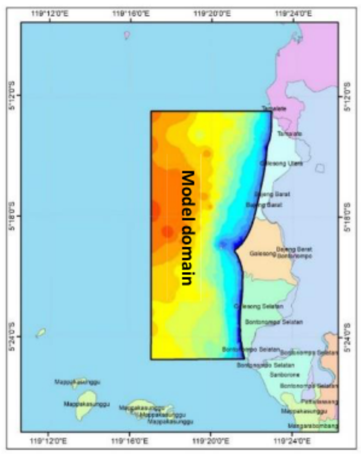

Figure 1. Model domain in coast of Takalar

2.1 Data

Bathymetry Data

The detailed bathymetry data used is sourced from secondary data obtained from the National Bathymetry data scale 1: 50000 6-arcsecond resolution issued by the Indonesian Geospatial Information Agency.

Tidal Data (open boundaries conditions)

The tidal data used is derived from the results of modeling forecasting on Mike 21 tidal analysis. The elevation data given is 1 year with an interval of 1 hour in the period from 2020 to 2021.

Wind data (friction condition)

Wind data is used in the model scenario to provide surface friction against current movement. This will have a direct effect on the transport force exerted by the current as a carrier for the diffusion of sedimentation.

2.2 Hydrodynamic modeling

The hydrodynamic modeling in this paper is carried out using a mathematical equation as the governing equation and the boundary conditions of the model.

- Continuity equation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = S \quad (1)$$

- Horizontal momentum equation for x direction

$$\frac{\partial u}{\partial t}+\frac{\partial u^2}{\partial x}+\frac{\partial vu}{\partial y}+\frac{\partial wu}{\partial z}=fv-g\frac{\partial \eta}{\partial x}-\frac{1}{\rho_0}\frac{\partial p_a}{\partial x}-\frac{g}{\rho_0}\int_z^{\eta}\frac{\partial \rho}{\partial x}dz-\frac{1}{\rho_0 h}\left(\frac{\partial S_{xx}}{\partial x}+\frac{\partial S_{xy}}{\partial y}\right)+F_u+\frac{\partial}{\partial z}\left(v_t\frac{\partial u}{\partial z}\right)+\ u_s S \quad (2)$$

- Horizontal momentum equation for y direction

$$\frac{\partial v}{\partial t}+\frac{\partial v^2}{\partial y}+\frac{\partial uv}{\partial x}+\frac{\partial wv}{\partial z}=-fu-g\frac{\partial \eta}{\partial y}-\frac{1}{\rho_0}\frac{\partial p_a}{\partial y}-\frac{g}{\rho_0}\int_z^{\eta}\frac{\partial \rho}{\partial y}dz-\frac{1}{\rho_0 h}\left(\frac{\partial S_{yx}}{\partial x}+\frac{\partial S_{yy}}{\partial y}\right)+F_v+\frac{\partial}{\partial z}\left(v_t\frac{\partial v}{\partial z}\right)+\ v_s S \quad (3)$$

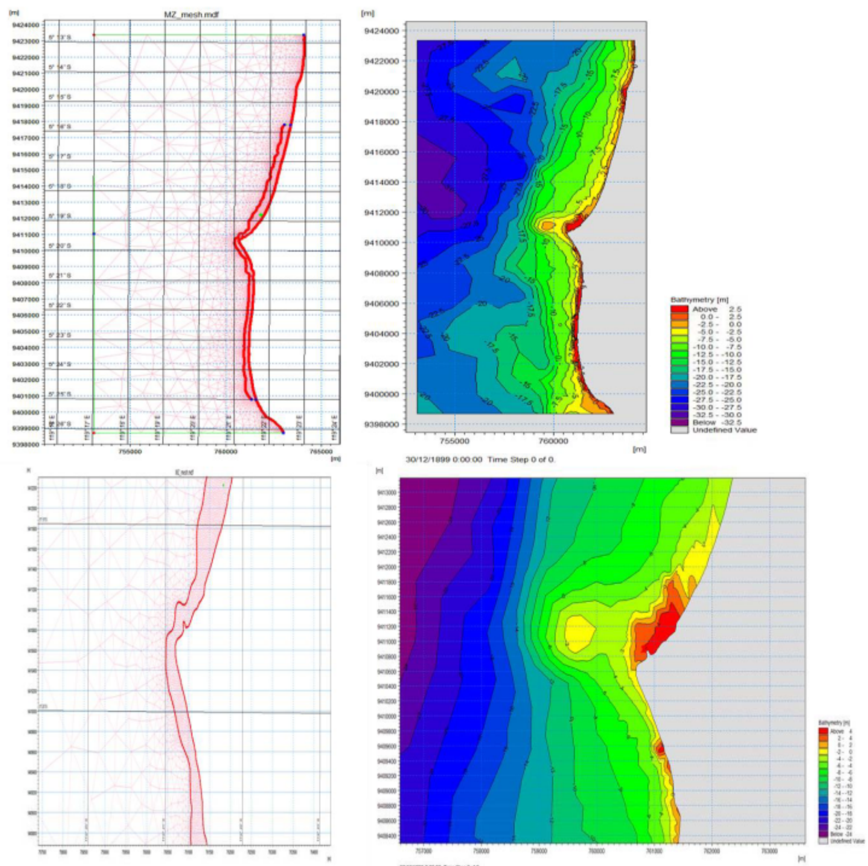

Figure 2. Coarse area and finest area

From the continuity equation, the value of the change in water elevation with time $\eta(t)$ could be obtained, while from the horizontal equation for the momentum in the x,y direction, the current velocity value will be obtained. The mesh model for the current model is carried out using input data in the form of shoreline and bathymetry data. The converted points from the bathymetric data are entered as the basic morphology in the domain area. The domain area is divided into two parts in one large square, namely a large area (coarse area) and a small area (finest area). Large area (coarse area) is an area that supports the coverage of small areas. Takalar waters with an area of 209.3 km2. The large area has 29,103 elements with 15,239 connected nodes, the maximum element area is 0.0002º with the smallest angle of the triangle element is 30º . Small area (finest area) is the area that becomes the main objective in the implementation of modeling, studied within the scope of sedimentation. This area covers the three sub-districts, namely North Galesong District, Galesong District and South Galesong District as well as in areas close to the coastline. The area close to the shoreline has a maximum area of 8e-008º and the smallest element angle is 30º (Figures 2 and 3). The presentation of the modeling results in the sedimentation model is shown in cross-shore and long-shore sections, to describe changes in the modeling period (Figure 3).

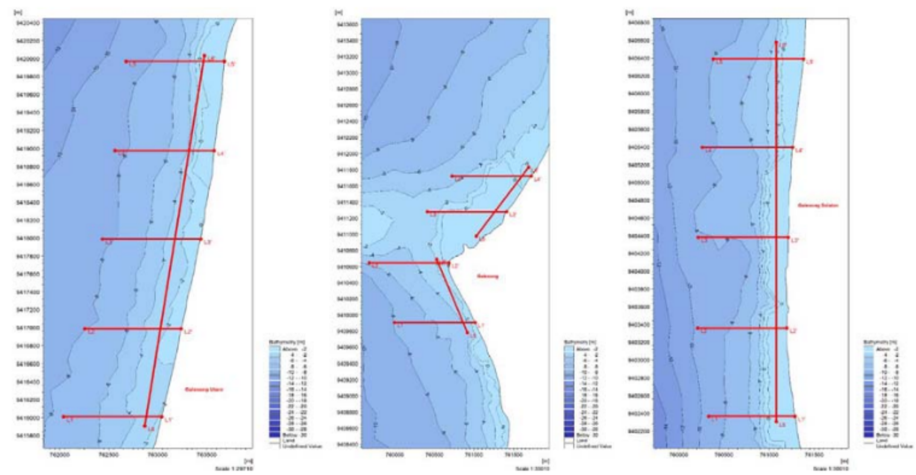

Figure 3. Cross section of the area of North Galesong District, Galesong District and South Galesong District

Open boundary conditions are given at the west, north and south boundaries, each of which is given 1(one) open boundary condition. The closed boundary condition is the land boundary given to the east, the coastline of the western coastal waters of Takalar Regency (Figure 4)

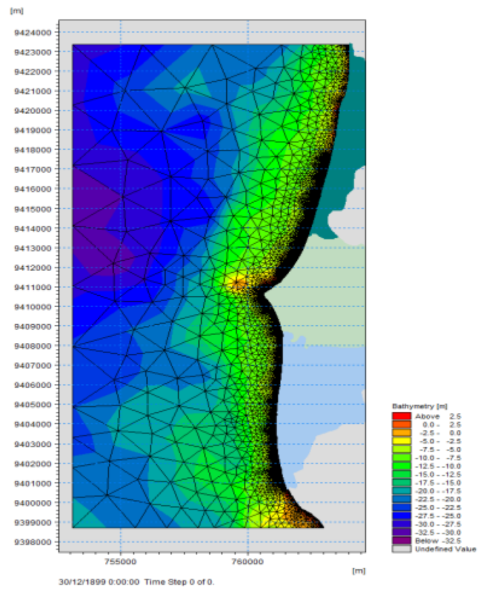

Figure 4. Closed and Open boundary conditions in area of modelling in the coast of Takalar

3. Results and discussion

Sedimentation modeling in coastal waters of Takalar Regency

The results of the sedimentation simulation in the Takalar waters in the coastal area of North Galesong District obtained the results of sediment distribution patterns, changes in basic morphology, and sedimentation as shown in Figures 5, 6, 7.

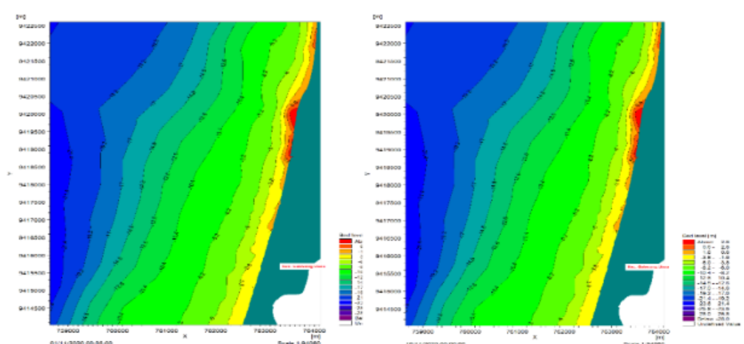

Figure 5. Depth of North Galesong waters before ($\Delta t = 0$) and after simulation ($\Delta t = 1$)

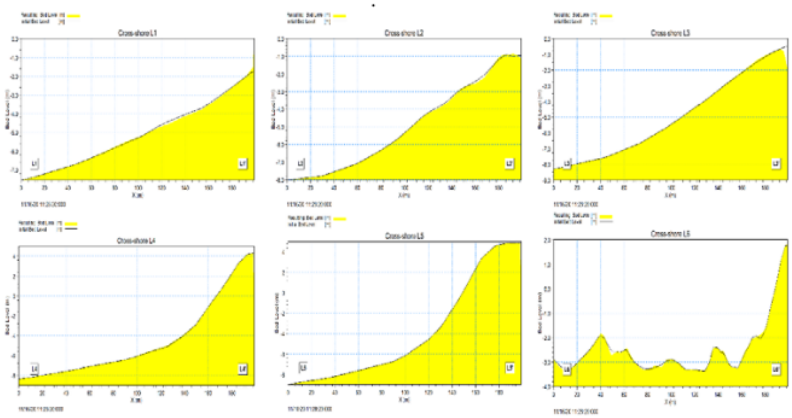

Figure 6. Profile of depth in of North Galesong waters

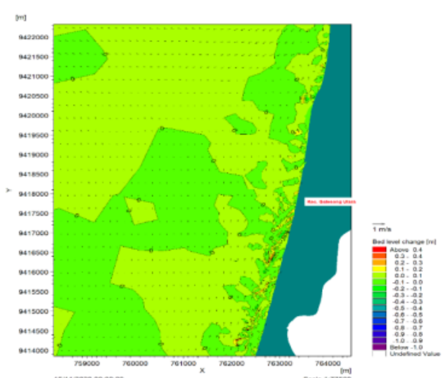

Figure 7 Results of morphological change simulation of North Galesong waters after simulation

The modeling results show the results on a cross-section of the coast in North Galesong District L_1,L_2,L_3,L_4,L_5, and L_6 as shown in Table 1

Table 1. Average values for changes in coast bed morphology in North Galesong District

Morphological change	**Lines**					
	L1 (m)	**L2 (m)**	**L3 (m)**	**L4 (m)**	**L5 (m)**	**L6 (m)**
Deepening	0.06448	0.026827	0.089068	0	0.019119	0.03385
Shallowing	0.02365	0.05977	0.02035	0.0236	0.0136	0.03588

Simulation of sedimentation in the Takalar waters in the coastal area of Galesong District produces sediment distribution patterns, basic morphological changes, and sedimentation as shown in Figures 8, 9, and 10.

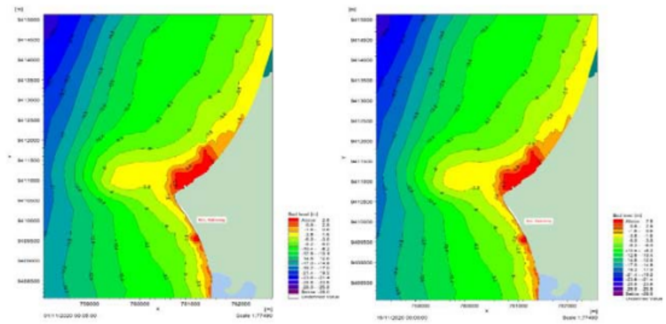

Figure 8. Depth of Galesong waters before (Δt = 0) and after simulation (Δt = 1)

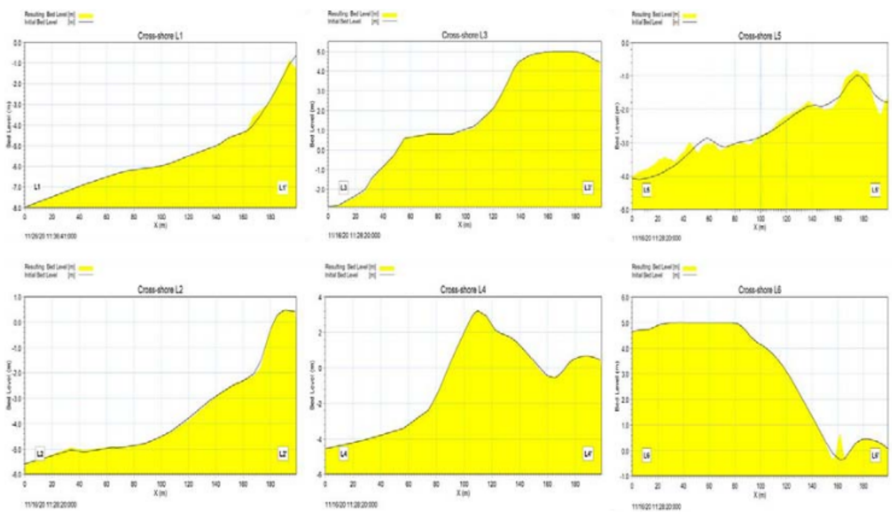

Figure 9. Profile of depth in of Galesong waters

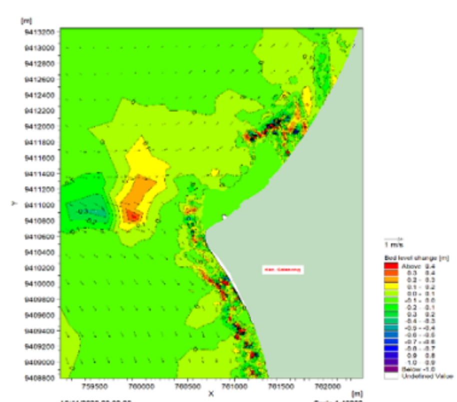

Figure 10. Results of morphological change simulation of Galesong waters after simulation

The modeling results show the results on a cross-section of the coast in Galesong District L_1,L_2,L_3,L_4,L_5, and L_6 as shown in Table 2

Table 2. Average values for changes in coast bed morphology in Galesong District

Morphological change	Lines					
	L1 (m)	**L2 (m)**	**L3 (m)**	**L4 (m)**	**L5 (m)**	**L6 (m)**
Deepening	0.025202	0.044968	0.045344	0.026613	0.11948	0.039544
Shallowing	0.1041	0.03524	0.02605	0.02526	0.16736	0.22366

Simulation of sedimentation in the Takalar waters in the coastal area of South Galesong District produces sediment distribution patterns, basic morphological changes, and sedimentation as shown in Figures 11, 12, and 13.

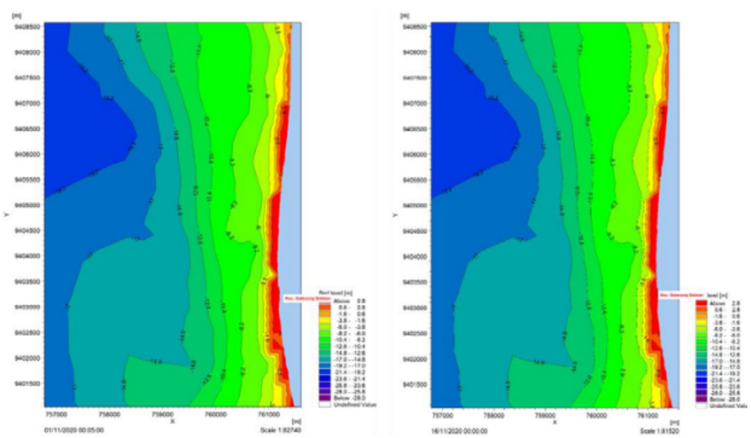

Figure 11. Depth of South Galesong waters before (Δt = 0) and after simulation (Δt = 1)

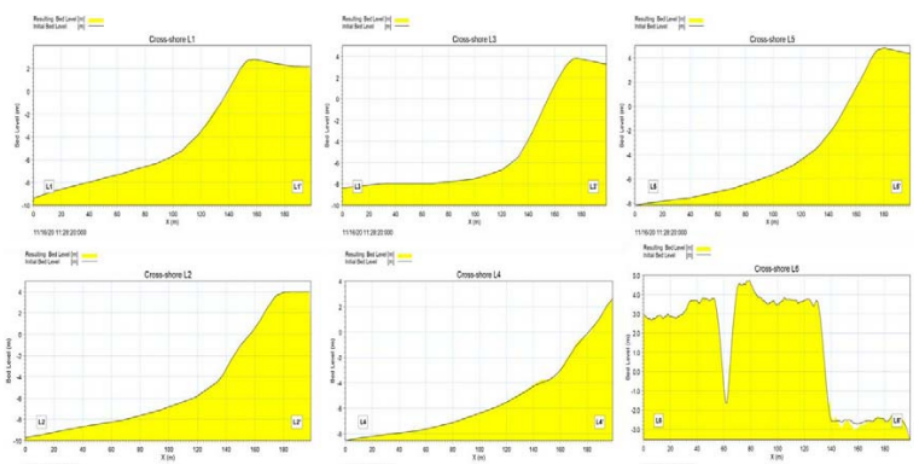

Figure 12. Profile of depth in of South Galesong waters

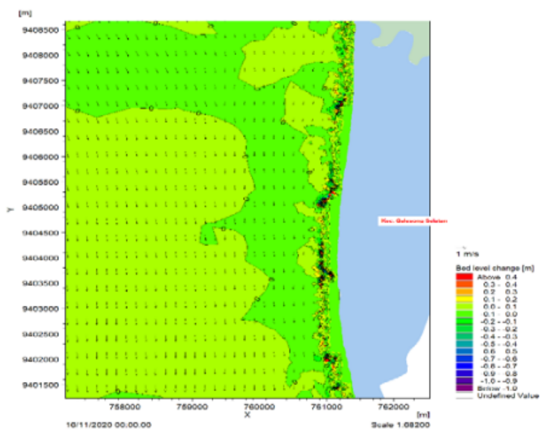

Figure 13. Results of morphological change simulation of Galesong waters after simulation

The modeling results show the results on a cross-section of the coast in South Galesong District L_1,L_2,L_3,L_4,L_5, and L_6 as shown in Table 3

Table 3. Average values for changes in bed morphology of water in South Galesong District

Morphological change	Lines					
	L1 (m)	L2 (m)	L3 (m)	L4 (m)	L5 (m)	L6 (m)
Deepening	0.027304	0.014148	0.019003	0.017392	0.11948	0.109836
Shallowing	0.03961	0.02205	0.01351	0.08067	0.16736	0.11177

4. Conclusion

1. The results of sedimentation modeling in the area of North Galesong District show that there is a bottom deepening between 0.019119 m - 0.089068 m and a shallow depth of 0.0136 m - 0.05977 m. In the area near the shoreline, the depth changes towards siltation with variations in depth reduction from 0.0001 m to 0.2 m or 0.000006 m/day – 0.013 m/day.
2. The results of sedimentation modeling in the Galesong District area show that there is a bottom deepening between 0.025202 m - 0.11948 m and a shallow depth of 0.02526 m - 0.16736 m. In the area near the shoreline, the depth changes towards siltation with variations in depth reduction from 0.02 m to 0.2 m or 0.0013 m/day – 0.013 m/day.
3. The results of sedimentation modeling in the area of South Galesong District show that the depth of the water base is between 0.014148 m - 0.11948 m and siltation of 0.01351 m - 0.16736 m. In areas near the shoreline, the depth changes towards siltation with variations in depth reduction from 0.15 m to 0.4 m or 0.01 m/day – 0.026 m/day.

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