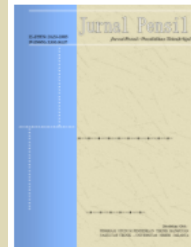


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## LONG STORAGE APPLIED STUDY TO MANAGE FLOODING IN SRIWIJAYA AREA KEDIRI CITY

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### Abstract

The 508 meters of drainage channel in Sriwijaya street is divided in half due the railway. Therefore, a culvert is constructed to enable the discharge to flow through the railway. The flow in drainage channel system is changes gradually as a result of the culverts's smaller dimension than the drainage channel's existing dimension and forming backwater. As a result, occured flooding area in Sriwijaya street. Long storage planning in drainage channel's main can optimizes the productivity of drainage system to manage regional flooding. The optimum long storage within the drainage channel design can be identified by the annual maximum daily rainfall data record and the water profile simulation using HEC RAS. The drainage channel is designed to be 1.2 m x 1.2 m to accomodate a 10-year flood discharge of 1.31 m<sup>3</sup>/sec for Trace 1 and 0.65 m<sup>3</sup>/sec for Trace 2. Trace 1 is the main part of the Jalan Sriwijaya drainage system, that is designed to be a long storage area, because it is located upstream of the railway culvert. Considering a volume capacity of 1808.84 m<sup>3</sup>, the long storage in Trace 1 is able to accommodate the maximum flood volume of 1780 m<sup>3</sup>.

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**Keywords:** Drainage, Long Storage, Backwater, HEC-RAS

## Introduction

The road surface of Sriwijaya Street in Kediri City is waterlogged yearly, reaching a depth of 50 cm and a length of 100 meters. According to the interviews with locals and the Kediri City government, the flood is reducing slowly, because it is a densely populated urban area and there is no area could infiltrate the runoff. This flooding occurs due to a culvert that crosses the railroad that restricts the drainage channel's capacity to transfer the runoff quickly. The culvert function is to flow the discharge to the downstream under an obstacle such as a road or a railway (Nuannukul et al., 2021). Along with constriction, sedimentation and garbage accumulation also have an impact on the culvert's current state. Due to utility concerns, it is not permitted to modify the culvert proportions. The culvert could make backwater effect in the upstream because of the narrowing culvert (Chow, 1985). Backwater occurs when conditions such weir flow, culverts, or tides, prevent water from flowing downstream, increasing the water depth upstream (Sturm, 2001). Therefore, designing a retention pond could preventing overflow in the drainage channel and increasing the drainage capacity (WIdianto & Wibisono, 2023).

The function of a retention pond is to store certain amounts of the discharge and drain it into the ground (PERMEN PUPR, 2014). One type of retention pond is the long storage system, that takes full advantage of the channel's flow area (Ignes & Arbaningrum, 2021). The application of extended storage to accommodate flood discharge is an effective option considering Sriwijaya Street's drainage system is situated in an urban traffic network and a highly populated residential area (Cunha et al., 2016). Several studies have been carried out concerning the application of long storage, including for agricultural water demands (Fathurrahman et al., 2023), distribution of freshwater (Trisdiana et al., 2021) and water resources infrastructure (Saraswati & Mojopahit, 2020). Long storage can be applied for urban flood management, including flood discharge control systems with sluice gates and pump houses (Damayanti et al., 2017).

Due to the urban environment and limited amount of obtainable land, the storage in this study is planned to be designed within the channel. The primary objective of this study is to identify the ideal dimensions of the retention pond that is required to be designed on Sriwijaya Street in accordance with the required urban drainage regulations.

## Research Methods

In this study both primary and secondary data were collected. The primary data is measurements of the 508 meter long the existing channel. Figure 1 shows the drainage system on Sriwijaya Street and according to the drainage system there are three lateral outflows that contribute to the drainage. The Sriwijaya drainage channel's outlet is on Dhoho Street channel.



Figure 1. Drainage System in Sriwijaya

Figure 2 shows the catchment area that determined by the road width and the area beside the road. The road width is 6 m and the urban area width determined to this study is 20 m. The total width for catchmen area is 26 m. Therefore, the catchment for Trace 1 is 6760 m<sup>2</sup> and Trace 2 is 8329 m<sup>2</sup>.



Figure 2. Catchment Area

Daily rainfall data from Kediri City's Department of Public Works and Spatial Planning is one of the secondary data sources applied to this study. The Kediri rain gauge is the one affecting the drainage catchment area, as shown in Figure 3. Therefore, as Figure 4 shows, the Annual Maximum Daily Rainfall data used for the years 2010 to 2019. During that period, the Kediri rain gauge recorded the highest Annual Maximum Daily Rainfall of 148 mm.



Figure 3. Rain Gauge in Catchment Area

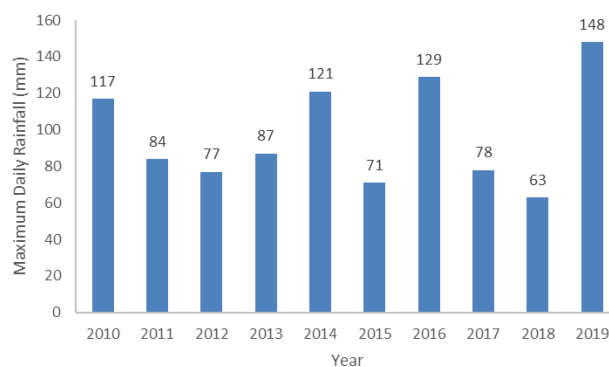


Figure 4. Kediri Rain Gauge Annual Maximum Daily Rainfall  
Source: Dinas Pekerjaan Umum dan Penataan Ruang Kota Kediri (2020)

The flood discharge analysis in this study using Rational Method with a 10 year return period and the results will be used to analyse the channel hydraulic profile. In this study the hydraulic profile analysis using the HEC-RAS software.

**Research Results and Discussion**

***Rainfall Analysis***

Rain gauge is required to verify the correlation between rainfall data and water structure plan (Nugrahanto et al., 2022). The Gumbel and Log Pearson Type III distribution methods were applied in this study's design rainfall analysis due to the Annual Maximum Daily Rainfall (AMDR) data in Figure 3 contained skewness coefficients (Ck) and coefficients of variation (Cs) of 0.59 and 2.96, respectively. The results indicate that Gumbel and Log Pearson Type III are the optimal statistical distributions for the data according to the distribution criteria (Harto, 1993).

Table 1. Rainfall Analysis

Return Period (Year)	Distribution Method (mm)	
	Gumbel	Log Pearson III
1.25	69.15	73.37
2	94.66	95.22
5	128.98	119.00
10	151.71	136.89

According to the fundamental urban drainage system regulations, the rainfall return period for this study is 10-year return period (PERMEN PUPR, 2014). The design rainfall with a 10-year return period is 136.89 mm using the Log Pearson Type III distribution and 151.71 mm using the Gumbel distribution, as seen in Table 1. According to the regulation (BSNI, 2016), the Gumbel method result is used in this study because it most closely aligns with the highest rainfall data that has been obtained during the last ten years and is shown in Figure 3.

***Flood Discharge Analysis***

According to the regulation, the basis for determining the Catchment Area is the road width and the length (SNI, 2006). Beside the discharge from the catchmen area, the lateral inflow is required to be considered in flood management (Udom et al., 2018; Zhou et al., 2019). The channel design includes the lateral inflow from the tertiary drainage that contribute the discharge into the Sriwijaya channel. As shown in Figure 5, the drainage alignment is analyzed in two sections: ahead and behind of the railway, considering the current state of the railway crossing Sriwijaya Street. Table 2 shows the results of the design flood discharge analysis for every segment.



Figure 5. Sriwijaya Drainage Trace

Table 2. 10 Year Period Discharge Analysis

Segment	CA (km <sup>2</sup> )	L (km)	Tc (hour)	R (mm)	I (mm/hour)	C	Q (m <sup>3</sup> /sec)
Trace 1	0.006	0.26	0.2	151.7	150	0.95	0.27
Trace 2	0.008	0.32	0.3	151.7	131	0.95	0.33

The various types of land cover and land use have significant effects on runoff discharge (Muhammad & Nugroho, 2024), considering every type of land cover and usage has a particular runoff coefficient (Bc & Mutia, 2013). Table 2 assumes a runoff coefficient of 0.95 to indicate residential regions in densely populated urban areas (Haribowo & Suhardjono, 2022; Suripin, 2004). As a result, Trace 1's design flood discharge is 0.27 m<sup>3</sup>/s and Trace 2's discharge is 0.33 m<sup>3</sup>/s.

Table 3. Tertiary Discharge

Tertiary Segment	Dimension Channel		
	W (m)	D (m)	Q (m <sup>3</sup> /sec)
Upstream Sriwijaya Channel	0.5	0.8	0.28
Tertiary 1	0.8	0.85	0.68
Rail Culvert	0.6	0.6	0.24
Tertiary 2	0.3	0.4	0.08

According to Table 3, each of the tertiary drainage system is analyzed to contribute the maximum flow to the main drainage system, as shown in Figure 1. The total inflow from the upstream section of the Sriwijaya Channel, Tertiary Channel 1, street ponding and surface runoff from the Catchment Area is 1.31 m<sup>3</sup>/s that flows through the Trace 1. According to Table 4, the Trace 2's total discharge is 0.65 m<sup>3</sup>/s, including runoff from the downstream Catchment Area, Tertiary Channel 2 and railway culvert outflow.

Table 4. Traces Flood Discharge

Segment	Total Discharge (m <sup>3</sup> /sec)			Total Q (m <sup>3</sup> /sec)	Total Volume (m <sup>3</sup> )
	Q Tr 10	Street Ponding	Tertiary Channel		
Trase 1	0.27	0.08	0.96	1.31	980
Trase 2	0.33	0	0.32	0.65	598

The Catchment Area dividing obtaining the various time of concentration (tc) (Triatmodjo, 2019). The difference contribute to the flood discharge result for each traces, regardless being in the same system (Nurhayati et al., 2024). This result is confirming to the prior study that divided Catchment Area by hydraulic structures or the watershed has different results for flood discharges and the time of concentration (tc) is the main variables responsible (Nurhayati & Teguh, 2023).

### Channel Dimension and Long Storage Analysis

Considering the objective of this study is to identify the hydraulic profile drainage channel, the hydraulic profile analysis is conducted using the HEC-RAS 1D program (Desromi et al., 2022; Elli Senjawati et al., 2025; Suryatmaja et al., 2024). The Sriwijaya drainage channel's current measurements are 0.55 m x 0.8 m and beneath the railway there is a circular culvert in 10 m length and 0.60 in diameter. Figure 6 illustrated the hydraulic profile in existing condition.

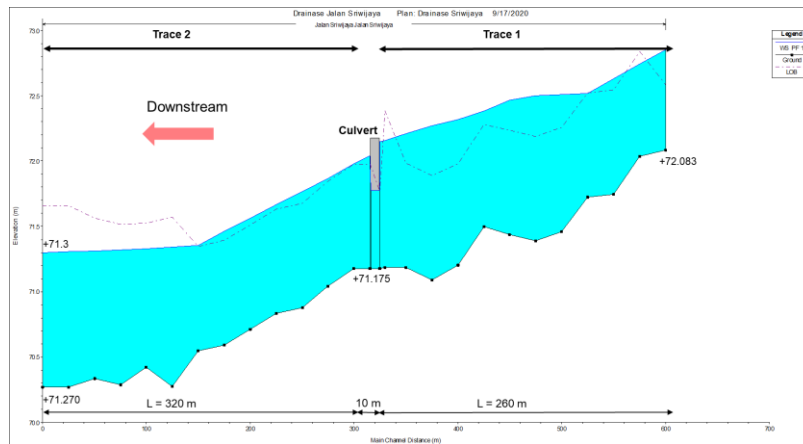


Figure 6. Maximum Water Level in Existing Condition Tr 10

The hydraulic profile in this study modelling by the HEC-RAS program. Considering the drainage system, the maximum water level in the downstream, in this study is Dhoho drainage, is applied for the set boundary condition in elevation +71.3, as illustrated in Figure 6, by putting the known water depth in the downstream this modelling is aligns to the backwater computation (Chanson, 2004). The high water level in the downstream can create backwater and have an effect to the upstream (Moglen, 2015). According to the modelling results as shown in Figure 6, the overtopping occurs when a 10-year return period comes along with backwater. This results validates that the downstream depth affect the upstream flow condition (Awang Shariee et al., 2020; Monica et al., 2020; Zhang et al., 2023) due the backwater impact (Suripin, 2019).

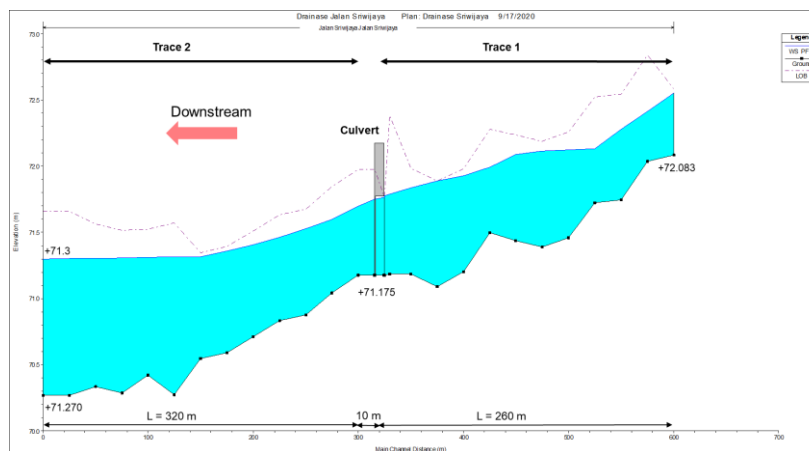


Figure 7. Maximum Water Level in Existing Condition Q 0.4 m<sup>3</sup>/sec

The Sriwijaya existing drainage system can only accommodate the 0.4 m<sup>3</sup>/sec of total flood discharge as shown in Figure 7. Therefore, it is essential to redesign the dimension channel initially (Ritaka Wangsa et al., 2023). As shown in Table 5, the channel is designed using the geometry channel concept (Chaudry, 2008).

Table 5. Designed Dimension

Segment	W (m)	D (m)	A (m <sup>2</sup> )	P (m)	R (m)	S
Trace 1	1.2	1.2	1.4	3.6	0.4	0.51%
Trace 2	1.2	1.2	1.4	3.6	0.4	0.21%

Table 6. Designed Channel Discharge and Volume Capacity

Segment	W (m)	D (m)	V (m/sec)	Q (m <sup>3</sup> /sec)	Volume (m <sup>3</sup> )
Trace 1	1.2	1.2	1.55	2.33	1663.1
Trace 2	1.2	1.2	1.00	1.45	1332.7

According to Table 5, the necessary channel dimensions are 1.2 m × 1.2 m, with a slope of 0.51% for Trace1 and 0.21% for Trace 2, in order to accommodate the 10-year return period discharge. Considering the flow velocity as the parameter (SNI, 2006) the maximum flow velocity for concrete channel is 3 m/sec (PERMEN PUPR, 2014), the designed flow velocity is 1.55 m/sec for Trace 1 and and 1 m/sec for Trace 2, hence the channel can accommodate the 2.33 m<sup>3</sup>/sec of flood discharge for Trace 1 and 1.45 m<sup>3</sup>/sec for Trace 2 as indicated in Table 6.

As shown in Table 6, total volume of storage for Trace 1 is 1663.1 m<sup>3</sup> and 1332.7 m<sup>3</sup> for Trace 2. Trace 1 is designed to accommodate 1.31 m<sup>3</sup>/sec the total of discharge and the runoff that cannot streaming down due the culvert condition. Hence the total volume that remains in Trace 1 can be analyzed below:

$$\begin{aligned}
 Q_{CA} \text{ Trace 1} &= 1.31 \text{ m}^3/\text{sec} = 980 \text{ m}^3 \\
 Q_{out} \text{ culvert} &= 0.241 \text{ m}^3/\text{sec} \\
 Q \text{ remain in Trace 1} &= 1.07 \text{ m}^3/\text{sec} = 800 \text{ m}^3 \\
 Q \text{ total in Trace 1} &= 2.38 \text{ m}^3/\text{sec} = 1780 \text{ m}^3
 \end{aligned}$$

The total designed channel volume capacity not be able to accommodate the total discharge volume. Therefore, the channel volume capacity Trace 1 is unable to accommodate the total flood volume. As shown in Figure 8, adding the storage depth from 1.2 m to 1.7 m in 70 m length and 2.2 m of depth in 1 m length are required as an addition of 145.44 m<sup>3</sup> of storage. Hence, the long storage is able to accommodate the total flood volume and the hydraulic profile in Trace 1 is illustrated in Figure 8.

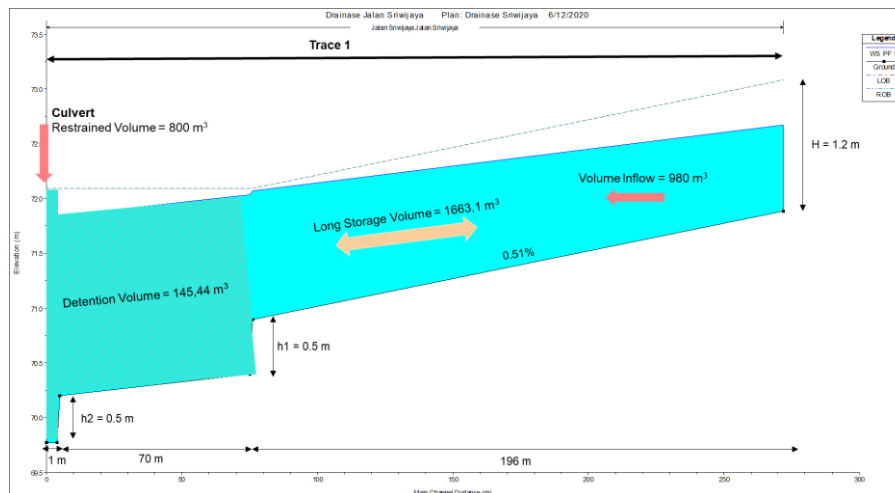


Figure 8. Long Storage Capacity in Trace 1

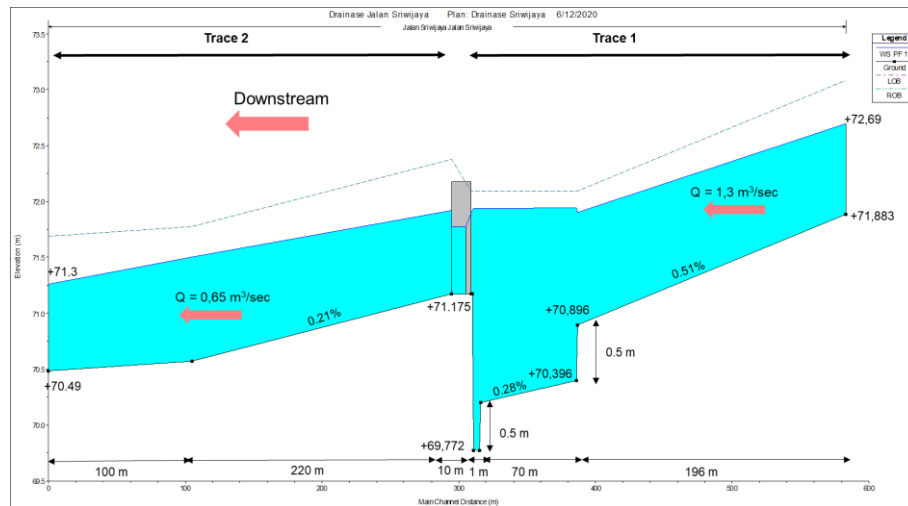


Figure 9. Maximum Water Level in Trace 1 and Trace 2

Figure 9 shows that the culvert beneath the railway has a higher invert than the drainage channel and creating the backwater due to the damming effect (Subramanya, 2009). This results in alignment with the prior studies confirming that the water structure such as weir, dam, and sluice gates are able to increase the water level in the river (Aryani et al., 2025; Kartikaningrum et al., 2022). The maximum water level for Trace 1 and Trace 2 is illustrated in Figure 8. The maximum water level occurred during the 10-year return period and the downstream level in Trace 2 is +71.3 m. As a result, the designed long storage in Sriwijaya drainage system able to accommodate the maximum discharge in 10-year period and backwater effect.

## Conclusion

Flood mitigation for Sriwijaya area requires not only designed main channel's dimension, but also designed the long storage within the channel. The drainage system not only streaming the flow to the downstream, but also temporarily store some of the discharge. As a result, the designed long storage within the main channel could prevent the flood caused by backwater due the railway's culvert condition. This results in alignment with previous studies indicating that drainage channel is able to function as temporary storage for surplus discharge and can optimize the drainage system for flood management (Abrianto et al., 2022; Syahrani & Andayani, 2024). Suggestion for further study on this research is designed the pump capacity or under drain box to reduce the storage discharge.

## References

- Abrianto, R. H., Subari, S., & Farid, A. (2022). Strategi Pengelolaan Sistem Drainase Perumahan Soka Park Kabupaten Bangkalan Sebagai Upaya Pengendalian Banjir. *Jurnal Sumber Daya Alam dan Lingkungan*, 9(2), 46–57.
- Aryani, S., Hidayah, E., & Halik, G. (2025). Exploring Hydraulic Behavior of Barrage Using HEC-RAS at Semangir River Jember Regency. *Journal of the Civil Engineering Forum*, 11(02), 167–180.
- Awang Sharicee, A. M. S., Mohamad, I. N., & Lee, W. K. (2020). Backwater Effect of Tidal Water Level Fluctuation and Riverine Discharge in An Idealized River. *IOP Conference Series: Earth and Environmental Science*, 498, 012055. <https://doi.org/10.1088/1755-1315/498/1/012055>
- Bc, A. Y., & Mutia, E. (2013). Peningkatan Kinerja Saluran Drainase Kota Langsa Berdasarkan Penataan Ruang. *Jurnal Teknik Sipil*, 3(1), 1–8.

- BSNI. (2016). Tata Cara Perhitungan Debit Banjir Rencana (SNI 2415:2016). Standar Nasional Indonesia.
- Chanson, H. (2004). *The Hydraulic of Open Channel Flow: And Introduction*. Elsevier Butterworth-Heinemann.
- Chaudry, M. H. (2008). *Open Channel Flow (Second Edition)*. Springer.
- Chow, V. T. (1985). *Hidrolika Saluran Terbuka*. Penerbit Airlangga.
- Cunha, M. C., Zeferino, J. A., Simões, N. E., & Saldarriaga, J. G. (2016). Optimal location and sizing of storage units in a drainage system. *Environmental Modelling & Software*, 83, 155–166. <https://doi.org/10.1016/j.envsoft.2016.05.015>
- Damayanti, L. D., Syafarini, H., Darsono, S., & Soedarto, J. (2017). Perencanaan Sistem Drainase Wilayah Tawang Sari Dan Tawang Mas Semarang Barat. 6.
- Desromi, F., Putri, Y. E., Wijaya, O. E., & Hermawati, H. (2022). Penggunaan Program Hec-Ras Dalam Pengendalian Banjir Sungai. *Jurnal Deformasi*, 7(2), 117–126. <https://doi.org/10.31851/deformasi.v7i2.9646>
- Elli Senjawati, E. S., Sumiadi, & Very Dermawan. (2025). Studi Pengendalian Banjir menggunakan Pemodelan HEC-RAS 1D di Sungai Likupang Bagian Hilir Kabupaten Minahasa Utara Provinsi Sulawesi Utara. *Jurnal Teknologi dan Rekayasa Sumber Daya Air*, 5(2), 1274–1287. <https://doi.org/10.21776/ub.jtresda.2025.005.02.121>
- Fathurrahman, F., Adawiyah, R., Perdana, M. G., & Surya, A. (2023). Perencanaan Long Storage Pada Dir Sei Tunjang-Sei Rasau Kabupaten Barito Kuala Untuk Pengaturan Kebutuhan Air. *Jurnal Kacapuri : Jurnal Keilmuan Teknik Sipil*, 6(2), 283.
- Haribowo, R., & Suhardjono. (2022). *Drainase Perkotaan*. UB Press.
- Harto, S. (1993). *Analisis Hidrologi*. Gramedia Pustaka Utama.
- Ignes, J., & Arbaningrum, R. (2021). Analisis Debit Maksimum Pada Long Storage Sungai Serua Di Lingkungan Universitas Pembangunan Jaya. *Jurnal Proyek Teknik Sipil*, 4(2), 43–48. <https://doi.org/10.14710/potensi.2021.11540>
- Kartikaningrum, D. F. F., Hadiani, R., & Suryandari, E. S. (2022). Analisis Backwater Dengan Hec-Ras Di Kelurahan Sewu Kota Surakarta. *Jurnal Riset Rekayasa Sipil*, 5(2), 133. <https://doi.org/10.20961/jrrs.v5i2.54730>
- Moglen, G. E. (2015). *Fundamental of Open Channel Flow*. CRC Press.
- Monica, L., Hendratta, L. A., & Supit, C. J. (2020). Analisis Pengaruh Backwater Di Muara Sungai Talawaan-Bajo Kabupaten Minahasa Utara. *Jurnal Ilmiah Media Engineering*, 10(2), 125–134.
- Muhammad, N. F., & Nugroho, B. J. (2024). Analisis Drainase Pada Lahan Yang Mengalami Perubahan Fungsi (Studi Kasus Di Kawasan Kampus Politeknik PU). *Rang Teknik Journal*, 7(1).
- Nuannukul, W., Phumiphan, A., & Kangrang, A. (2021). CROSS-DRAINAGE CULVERT DESIGN UNDER GLOBAL CLIMATE AND LAND USE CHANGES. 16(10).
- Nugrahanto, B. A., Limantara, L. M., & Wahyuni, S. (2022). Evaluasi Rasionalisasi Pos Hujan dengan Metode Stepwise dan Standar WMO pada DAS Telomoyo Kabupaten Kebumen. *Jurnal Teknologi Dan Rekayasa Sumber Daya Air*, 02(02), 188–196.
- Nurhayati, D. E., Kusumaningrum, D., & Syafiarti, A. I. D. (2024). Analisis Potensi Banjir Pada Avour Jambon Kabupaten Tuban.

- Nurhayati, D. E., & Teguh, N. A. (2023). Analisis Pengaruh Pembagian Daerah Aliran Sungai Dalam Analisis Debit Banjir Rencana (Studi Kasus DAS Menengan Kabupaten Tuban). *Jurnal Aplikasi Teknik Sipil*, 21.
- PERMEN PUPR. (2014). Peraturan Menteri Pekerjaan Umum Republik Indonesia Tentang Penyelenggaraan Sistem Drainase Perkotaan No. 12.
- Ritaka Wangsa, A. A. R., Suryatmaja, I. B., & Puja Andini, A. A. M. (2023). Analisis Daya Tampung Air Pada Saluran Drainase Di Lingkungan Art Centre Kota Denpasar. *JMTS: Jurnal Mitra Teknik Sipil*, 755–764. <https://doi.org/10.24912/jmts.v6i3.23609>
- Saraswati, Y., & Mojopahit, J. (2020). Analisis Design Long Storage Pada Embung Sumber Pule Dengan Metode Pasten Modifikasi. *Jurnal Qua Teknika*, 10(1), 12–25.
- SNI. (2006). Pedoman Perencanaan Drainase Jalan. Departemen Pekerjaan Umum.
- Sturm, T. W. (2001). *Open Channel Hydraulics*. McGraw-Hill.
- Subramanya, K. (2009). *Flow in Open Channel (Third Edition)*. Tata McGraw-Hill.
- Suripin. (2004). *Sistem Drainase Perkotaan yang Berkelanjutan*. Penerbit Andi.
- Suripin. (2019). *Mekanika Fluida dan Hidraulika Saluran Terbuka untuk Teknik Sipil*. Penerbit Andi.
- Suryatmaja, I. B., Ritaka Wangsa, A. A. R., Kurniari, K., & Prasetya, I. P. (2024). Pemodelan Kapasitas Air Pada Saluran Drainase dengan Program HEC-RAS: (Studi Kasus: Jalan Cekomaria dan Jalan Padma Denpasar Timur). *Jurnal Ilmiah Kurva Teknik*, 13(2), 127–136. <https://doi.org/10.36733/jikt.v13i2.10182>
- Syahranie, F. A., & Andayani, S. (2024). The Evaluation Of Drainage System At Bank Indonesia Housing Complex Pancoran, Jakarta. *International Journal on Livable Space*, 7(2), 44–52.
- Triatmodjo, B. (2019). *Hidrologi Terapan (7th ed.)*. Beta Offset.
- Trisdiana, F., Arifaini, N., & Zakaria, A. (2021). Studi Long Storage Sebagai Upaya Mengatasi Kekeringan Di Daerah Cinta Manis Sumatera Selatan. *Journal Rekayasa Sipil Dan Desain*, 9(1), 1–12.
- Udom, N., Istiarto, I., & Rahardjo, A. P. (2018). Evaluation of Flood Risk Reduction Project at Tenggang River, Semarang City, Central Java Province, Indonesia. *Journal of the Civil Engineering Forum*, 4(2), 159. <https://doi.org/10.22146/jcef.34035>
- WIdianto, G. L., & Wibisono, R. E. (2023). Analisis Kapasitas Saluran Drainase Dukuh Kupang Dengan Optimalisasi Kolam Penampungan (Bozem) Pada Catchment Area Gunung Sari Surabaya. 3(1).
- Zhang, X., Bi, Z., Sun, X., Wang, P., Xu, Z., & Jia, B. (2023). Backwater Effects in Rivers and Lakes: Case Study of Dongping Lake in China. *Water*, 15(21), 3850. <https://doi.org/10.3390/w15213850>
- Zhou, W., Yang, Z., Liu, P., Bai, F., & Zheng, C. (2019). Estimation of reservoir inflow with significant lateral inflow by using the adjoint equation method. *Journal of Hydrology*, 574, 360–372. <https://doi.org/10.1016/j.jhydrol.2019.04.047>