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Planning an Environmentally Sound Drainage System (Eco-Drainage) Using Infiltration Wells in Pasteur Village, Bandung City

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ABSTRACT

A sustainable drainage system is essential in urban management to optimize runoff utilization and enhance rainwater infiltration. Pasteur Village, a densely populated area, often experiences inundation during the rainy season and drought during the dry season, with an average of 10 flood events annually over the past five years. This study aims to reduce the frequency and duration of flooding while increasing water infiltration through an eco-drainage approach. One proposed solution is the construction of infiltration wells. The methodology involves hydrological analysis using the Rational Method to calculate peak discharge and hydraulic analysis of the existing drainage channels to assess their capacity. The analysis shows a runoff discharge of 0.0910 m³/second that needs to be managed. Infiltration wells are designed with a depth of 2 meters and a surface area of 4 m², providing an infiltration rate of 0.0022 m³/second per well. A total of 41 wells are required, each capable of storing 8 m³ of water during heavy rain. This implementation is expected to reduce runoff volume by up to 75%. The total estimated cost for channel normalization and well construction is IDR 553,000,000. The study contributes to sustainable urban water management and serves as a model for other areas with similar characteristics.

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1. INTRODUCTION

1.1. Background

In sustainable urban management, it is essential to maintain a balance between economic growth, social welfare, and environmental sustainability (Djojosumarto, 2020). An effective drainage system is a key factor in managing sanitation and the environmental quality of an area. Currently, drainage systems in Indonesia are still largely dominated by conventional approaches, where rainwater is immediately discharged into rivers through drainage channels without sufficient time to infiltrate the soil (Suripin, 2004). This reduces the rate of rainwater infiltration and increases the risk of inundation and urban flooding. The rise in surface runoff contributes significantly to these issues (Tjahjanto et al., 2008). Flooding in urban areas can generally be categorized into three types: flooding caused by intense local rainfall, river overflow, and flash floods (Tingsanchali, 2012).

One type of eco-drainage widely implemented in Indonesia is the infiltration well. Infiltration wells are structures designed similarly to dug wells with a certain depth, functioning to collect rainwater from rooftops or impermeable surfaces and allow it to infiltrate into the soil (Suhardjono, 2013). They are commonly used to address surface inundation that cannot be managed by existing drainage systems. Numerous studies have examined the effectiveness of infiltration wells in mitigating inundation across various regions in Indonesia. In Kampong Cicayur, their implementation was found to reduce runoff discharge by up to 45% (Aurice et al., 2023). Similarly, a study by Kusumastuti et al. (2019) demonstrated that infiltration wells reduced up to 70% of runoff in Mojokerto.

Pasteur Village, located in Sukajadi District, Bandung City, is a densely populated area. According to data from BMKG (2022), the village experiences an average of 120 rainy days per year, with an average rainfall intensity of 50 mm/hour. Consequently, approximately 30% of the area is frequently affected by flooding, with water depths reaching up to 20 cm (BPBD Kota Bandung, 2023). The urgency of this research lies in the need to address recurrent inundation in Pasteur Village through the implementation of eco-drainage systems, particularly by utilizing infiltration wells. This study aims to fill a gap in existing research, as there is a lack of studies that specifically address inundation management in this region using hydrological and hydraulic approaches in the design of infiltration wells. The findings of this study are expected to contribute significantly to inundation mitigation and rainwater conservation efforts in Pasteur Village and serve as a reference for other areas with similar characteristics.

1.2. Objectives

Based on the previously stated problem formulation, the objectives of this research are as follows:

1) To analyze the existing condition of the drainage system in Pasteur Village
2) To design an eco-drainage system using infiltration wells in Pasteur Village
3) To Calculate the cost budget plan (RAB) for the development of infiltration wells in Pasteur Village

1.3. Problem Formulation

The formulation of the problem in this study includes:

1) What is the existing condition of the drainage system in Pasteur Village?
2) How is the design plan for the eco-drainage system usinh infiltration wells Pasteur Village?
3) What is the estimated cost budget (RAB) for the planning of infiltration wells in Pasteur Village?

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2. LITERATURE REVIEW

Urbanization has accelerated the expansion of impervious urban areas—such as roads, buildings, and rooftops—which significantly increases stormwater runoff and contributes to flooding problems (Mentens et al., 2006). Conventional stormwater management, known as grey infrastructure, typically directs runoff into nearby water bodies through storm drains, channels, and subsurface drainage systems. In response to these challenges, several alternative strategies have been adopted, including sustainable drainage systems (SuDS), which aim to reduce runoff volumes while enhancing retention and infiltration capacity(Fletcher et al., 2015; Prudencio & Null, 2018). In Indonesia, the term "sustainable drainage system" often draws from practices in developed countries. For example, the United Kingdom refers to it as Sustainable Urban Drainage Systems (SuDS), the United States uses Low Impact Development (LID) or Best Management Practices (BMP), while Australia adopts Water Sensitive Urban Design (WSUD). Other terms used globally include integrated catchment planning and ecological stormwater management (Yudianto & Roy, 2009). Eco-drainage offers a solution to restore the disrupted relationship between land use and the natural hydrological cycle caused by urbanization. (Butler et al., 2024) emphasize the need to integrate eco-drainage strategies into urban planning to maintain water balance in urban areas. A recent study by Muchtar et al. (2024) shows that many sub-districts in Bandung City still fall within the moderate to low urban sustainability category, particularly concerning disaster risks such as flooding. The implementation of infiltration wells is one of the key policy strategies for groundwater conservation efforts in Bandung (Harmila et al., 2021).

Effective surface runoff management can be achieved by constructing facilities designed to control or retain runoff. These facilities are generally classified into two types based on their function: storage types and infiltration types. Storage facilities can be further categorized by location into off-site storage and on-site storage. On-site storage is typically utilized when rainwater falling on a given area cannot be discharged into external drainage systems due to their insufficient capacity or uncertain performance. Examples of on-site storage facilities include detention ponds, flood parking reservoirs (retarding ponds), and regulation ponds (Suripin, 2004).

Infiltration wells are one of the key components in sustainable urban development. They function to collect and absorb rainwater into the ground, thereby reducing surface runoff that can lead to flooding. Additionally, infiltration wells help address water scarcity by maintaining groundwater availability (Kurnianingsih & Deni, 2024). This type of infiltration facility is particularly suitable for areas with high soil permeability, where groundwater recharge does not interfere with geological stability. Infiltration wells represent a practical example of such facilities. Their working principle involves channeling and storing rainwater into a well or pit, allowing water to remain on the surface longer, so that it gradually infiltrates into the soil. Moreover, the construction of infiltration wells must meet specific technical requirements as outlined by the (Badan Standarisasi Nasional, 2002) in SNI No. 03-2453-2002, which include the following criteria:

The technical requirements for infiltration well construction, as stated in SNI No. 03-2453-2002 (National Standardization Agency, 2002), include the following criteria:

1) Infiltration wells should be located on relatively flat land with a maximum slope of 3%;
2) Water entering the infiltration well must be uncontaminated rainwater;
3) The groundwater level must be at least 1.5 meters below the surface during the rainy season;
4) Soil permeability must be ≥ 2.0 cm/hour;

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5) The minimum distance from the infiltration well to other structures must be maintained as follows: 3 meters from clean water wells, 1 meter from building foundations, and 5 meters from septic tanks.

Studies on the implementation of infiltration wells have been conducted in several areas of Bandung City. Research by (Asdak, 2023) showed that the application of biopore infiltration holes and infiltration wells was able to reduce runoff discharge by up to 23.70% in Astana Anyar District. In addition, the implementation of 1,713 infiltration wells in Lembang Village succeeded in reducing runoff discharge by 24% (Firdaus et al., 2023). Similarly, the application of infiltration wells in Margaasih Sub-district resulted in a runoff reduction of up to 11.03% (Hapsa & Juwana, 2023). This present study focuses on the case area of Pasteur Village and is expected to contribute valuable insights into inundation mitigation and groundwater conservation efforts in the region.

3. RESEARCH METHODOLOGY

In this planning, a hydrological analysis was conducted to calculate the runoff discharge, followed by a hydraulic analysis to assess the capacity of the existing drainage channels. Additionally, the dimensions and number of infiltration wells required to address inundation in Pasteur Village were determined.

3.1 Data Collection Technique

In this planning, a hydrological analysis was conducted to calculate the runoff discharge, followed by a hydraulic analysis to assess the capacity of the existing drainage channels. Additionally, the dimensions and number of infiltration wells required to address inundation in Pasteur Village were determined.

3.1.1 Data Analysis Technique

Several data analysis techniques were employed in this study, as described below:

A. Analysis of Existing Drainage System Conditions

This analysis consists of two main components:

1) Hydrological Analysis

The objective of the hydrological analysis is to determine the volume of stormwater runoff flowing into the drainage channels in Pasteur Village. The steps involved include calculating the rainfall frequency using probability distribution methods, followed by the determination of rainfall intensity and runoff discharge. The probability distribution methods used in this study include the Normal, Log-Normal, Log-Pearson Type III, and Gumbel distributions. The most suitable distribution was determined using the Chi-Square and Kolmogorov–Smirnov goodness-of-fit tests. Runoff discharge was then calculated using the Rational Method.

2) Hydraulic Analysis

The purpose of the hydraulic analysis is determine the capacity of the existing drainage channels. After obtaining the design flood discharge and the capacity of the current drainage system, a comparative analysis was conducted to assess whether the existing system is sufficient to accommodate the projected runoff.

B. Infiltration Well Planning Analysis

The infiltration well planning analysis involves calculations to determine the number of infiltration wells required for the study area.

C. Cost Budget Plan (RAB) for Infiltration Well Planning

This planning also includes the calculation of the Bill of Quantities (BOQ) and the Cost Budget Plan (RAB) required for the construction of infiltration wells.

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4. RESULT AND DISCUSSION

This study shows that there are four drainage channels whose existing discharge capacities are insufficient to accommodate the design discharge. Based on field observations, these four drainage channels were found to be obstructed by grass and waste. A comparison between the design discharge and the existing discharge capacity of the drainage channels is presented in Table 1.

Table 1. Comparison Between Design Discharge and Existing Discharge

Channel Name	Q Plan (m^3/sec)	Q Existing (m^3/sec)
AE-Z	0,0584	0,0238
H-S2	0,0951	0,0565
J-S3	0,1128	0,0660
M-S4	0,1771	0,0421

Source: Author, 2023

4.1. Analysis of the Existing Condition of Drainage Channels in Pasteur Village

This existing condition analysis aims to the assess the actual state of the drainage channels in Pasteur Village. In addition to identifying the current conditions, the design rainfall discharge for a specific return period is also calculated. The existing discharge capacity is then compared with the design discharge.

4.1.1 Hydrological Analysis

The map of Pasteur Village and the drainage channels is shown in Figure 1.

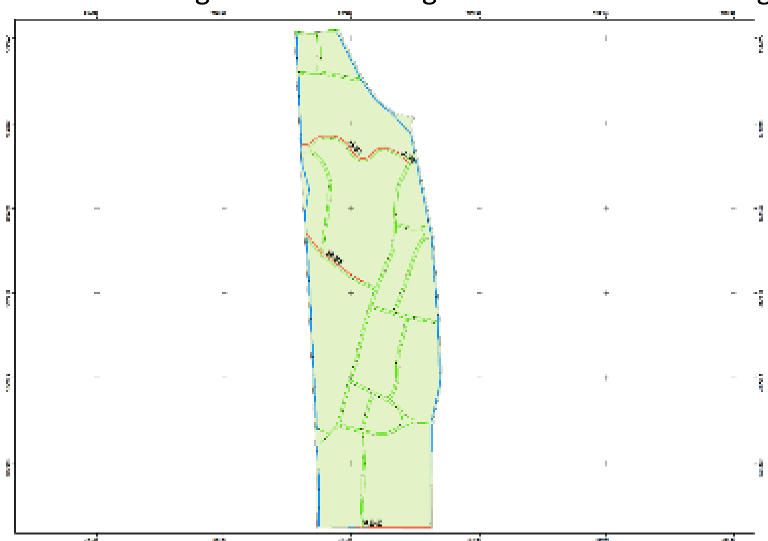

Figure 1 Drainage Channel Map of Pasteur Village
(Source: Author, 2023)

The rainfall station used for this analysis is the Dago Pakar station, which represents the study area. It provides 19 years of rainfall observation data, from 2004 to 2022, obtained from the Department of Water Resources and Highways of Bandung City. The rainfall data used in the calculation are presented in the following table.

Table 2 Maximum Rainfall Data of Dago Pakar Station

No	Year	Rainfall (mm)	No	Year	Rainfall (mm)
1	2004	80	11	2014	79
2	2005	55	12	2015	85
3	2006	70	13	2016	86
4	2007	113	14	2017	187
5	2008	80	15	2018	58
6	2009	73	16	2019	55
7	2010	104	17	2020	85

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No	Year	Rainfall (mm)	No	Year	Rainfall (mm)
8	2011	45	18	2021	75
9	2012	70	19	2022	44
10	2013	95			

Source: DSDABM Bandung City, 2023

A. Frequency Analysis of Design Rainfall

The design rainfall frequency in this study was analyzed using the Normal, Gumbel, Log-Normal, and Log-Pearson Type III methods. The results of the maximum daily rainfall calculations for each distribution method are presented in Table 3.

Table 3 Frequency of Design Rainfall

PUH (Year)	Design Rainfall (mm)			
	Normal	Gumbel	Log Normal	Log Pearson III
2	81	76	76	74
5	108	110	96	95
10	121	133	117	110
20	133	154	120	111
50	146	182	135	147
100	155	203	146	164

Source: Author, 2023

B. Probability Test

The probability test is intended to determine the probability distribution equation that best represents the statistical distribution of the analyzed sample data. Two types of probability tests were used: the Chi-Square test and the Kolmogorov–Smirnov test. The results of the probability tests indicated that the Log-Normal distribution was the most appropriate and acceptable method to represent the selected frequency distribution.

C. Design Rainfall Intensity

This design rainfall analysis aims to determine the maximum rainfall for a specific return period, which will be used to calculate the design flood discharge. Based on the study area, which falls under a major urban category with a catchment area ranging from 101 to 500 hectares, a 10-year return period was selected. The maximum daily rainfall value for the 10-year return period, using the Log-Normal method, is 117 mm. The results of the time of concentration and design rainfall intensity calculations are presented in Table 4.

Table 4 Design Rainfall Intensity

Channel Section	L (m)	S (m)	Tc (hour)	HHM (mm)	I (mm/hour)
AE-Z	539,4755	0,00446	67,6668	117	2,4427
H-S2	558,2400	0,02519	35,6684	117	3,7433
J-S3	37,4906	0,09052	2,7245	117	20,7934
M-S4	356,3441	0,04038	21,0511	117	5,3203

Source: Author, 2023

D. Runoff Discharge

Runoff discharge analysis refers to the rate of surface water flow under peak conditions. To obtain the runoff discharge, it is necessary to determine the runoff coefficient and the surface area contributing to the drainage system. The calculation of the runoff coefficient, surface area, and design flood discharge is presented in Table 5.

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Table 5 Runoff Water Discharge

Channel Section	C	A (Ha)	I (mm/hours)	Q (m^3/second)
AE-Z	0,75	11,4238	2,4427	0,0584
H-S2	0,75	12,1746	3,7433	0,0951
J-S3	0,75	2,6013	20,7934	0,1128
M-S4	0,75	15,9673	5,3203	0,1771

Source: Author, 2023

4.1.1. Hydraulic Analysis

The calculation of existing channel capacity aims to determine the volume that the drainage channels can accommodate under current physical conditions in the study area. The water surface height (h) used in the calculation reflects actual conditions, including sediment accumulation in each channel. The calculation of the existing drainage channel capacities is presented in table 6.

Tabel 6 Existing Drainage Channel Capacity

Channel Section	n	S	A (m^2)	P (m)	R	Q (m^3/second)
AE-Z	0,030	0,0045	0,060	0,80	0,075	0,0238
H-S2	0,030	0,0252	0,060	0,80	0,075	0,0565
J-S3	0,030	0,0905	0,040	0,60	0,067	0,0660
M-S4	0,030	0,0404	0,050	1,12	0,045	0,0421

Source: Author, 2023

The results of the existing channel capacity and design discharge calculations were used to analyze the ability of the drainage channels to convey the calculated design discharge. If the design discharge exceeds the existing channel capacity, the channel is considered incapable of handling the runoff. Therefore, it is recommended to normalize the drainage channel. Based on field observations, the four channels showed the presence of grass and waste accumulation. The comparison between the design discharge and the existing channel discharge, as well as the recalculated discharge after normalization (by adjusting the Manning's roughness coefficient), is presented in Table 7.

Tabel 7 Comparison of Design Discharge, Existing Discharge, and Post-Normalization Discharge

Channel Name	Q Design Discharge(m^3/second)	Q Existing Discharge(m^3/second)	Q Post-Normalization Discharge (m^3/second)
AE-Z	0,0584	0,0238	0,0331
H-S2	0,0951	0,0565	0,0786
J-S3	0,1128	0,0660	0,1070
M-S4	0,1771	0,0421	0,1338

Source: Author, 2023

The existing condition shows that four drainage channels have insufficient capacity to accommodate the design discharge. After normalization efforts—such as cleaning the drainage channels, adjusting the Manning's roughness coefficient, and modifying channel depth—these channels still could not accommodate the design discharge. The excess rainfall runoff that cannot be handled by the drainage system in Pasteur Village is 0.0909 m^3/second.

4.2. Infiltration Well Construction Planning

Infiltration wells are designed as an alternative to replace the lost function of natural infiltration areas due to land conversion into built-up zones, which hinders the direct infiltration of rainwater into the soil. The implementation of infiltration wells is planned around the drainage channels within the respective catchment areas, in order to minimize the potential for inundation.

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In Pasteur Village, the groundwater table is approximately 15 meters below the ground surface, as observed from existing community wells. For the application of infiltration wells, it is essential to determine the soil type and its permeability in the inundated areas. The soil type in Pasteur Village is clay, with a permeability coefficient of 3×10^{-6} m/s. The infiltration wells are designed in a square shape with dimensions of 2 × 2 meters and a depth of 2 meters, selected to facilitate easier construction. The calculation of the required number of infiltration wells in Pasteur Village is presented in Table 8.

Tabel 8 Analysis of the Number of Infiltration Wells in Pasteur Village

Channel Name	**Q Flooding (m^3/second)**	**Q Infiltration Well (m^3/second)**	**Number of Infiltration Wells**
AE-Z	0,0253	0,0022	11
H-S2	0,0165		7
J-S3	0,0058		3
M-S4	0,0433		19
Quantity	0,0909	-	41

Source: Author, 2023

The construction of the infiltration well consists of two main components: the water storage section and the filtering media. The filtering media is composed of coral stones and ijuk fibers with a total layer thickness of 40 cm. The well walls are designed using concrete to prevent soil erosion caused by water flow. At the top, the well is equipped with a 10 cm thick concrete cover, which contains openings that serve as inlets for water to enter the infiltration well.

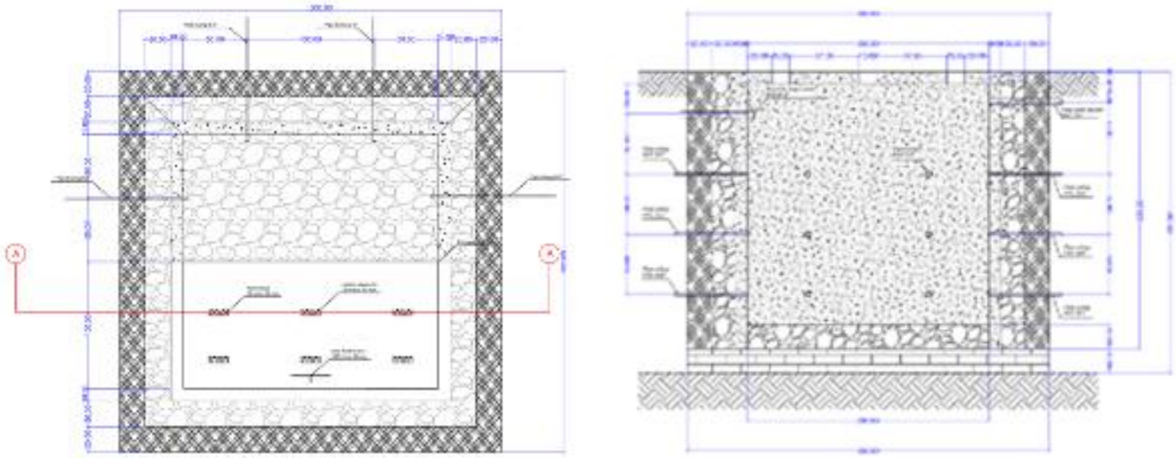

Figure 1 Infiltration Well Planning Layout
Source: Author, 2023

4.3. Bill of Quantity (BOQ) Calculation and Cost Budget Plan (RAB)

The Bill of Quantity (BOQ) calculation is prepared to identify the equipment and materials needed for the normalization of drainage channels and the construction of infiltration wells, thereby facilitating the cost estimation process. The total cost required for the construction of infiltration wells in Pasteur Village is IDR 553,000,000. Detailed BOQ and Cost Budget Plan (RAB) calculations designed for the drainage channel normalization and infiltration well construction activities are presented in Tables 9 and 10.

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Table 9 *Bill of Quantity* (BOQ) Drainage Normalization and Infiltration Wells

No	Description	Dimensions	Volume	Total Volume (m3)
		Job description		
I	**Drainage Normalization (Cleaning and Removal)**			
	Excavation of Channel AE-Z	0,1 m x 0,3 m x 539,48 m	16,1844	53,0152
	Excavation of Channel H-S2	0,15 m x 0,3 m x 558,24 m	25,1208	
	Excavation of Channel J-S3	0,1 m x 0,2 m x 37,49 m	0,7498	
	Excavation of Channel M-S4	0,1 m x 0,3 m x 356,34 m	10,9602	
II	**Pra-Construction**			
1	Earth Excavation	3m x 3m x 2,5m	22,5 m3	22,5
III	**Construction**			
1	Installation of Concrete Slab	2,2m x 2,2m x 0,1m	0,484 m3	22,324
2	Installation of Reinforced Concrete wall	4 x (2m x 2.2 m x 0.1 m)	1,76 m3	
3	Installation of Hollow Brick Wall	3 m x 3 m x 0.2 m	1,8 m3	
4	Installation of Coral Stone	5 (2 m x 2.3 m x 0.2 m)	4,6 m3	
5	Installation of Ijuk Fiber	4 (2 m x 2.3 m x 0.2 m)	3,68 m3	
IV	**After Construction**			
1	Infiltration Well Maintenance	2m x 2m x 2m	8 m3	8

Source: Author, 2023

Table 10 Cost Budget Plan (RAB) for Drainage Normalization and Infiltration Wells

No	Description	Volume (m3)	Unit Price	Total price
I	Drainage Channel Normalization	53,0152	Rp250.000	Rp13.253.800
II	Pre-Construction	22,5	Rp125.000	Rp2.812.500
III	Construction	22,324	Rp350.000	Rp7.813.400
IV	After Construction	8	Rp150.000	Rp1.200.000
Total 1 Infiltration Well				Rp11.825.900
Total 41 Infiltration Well				Rp484.861.900
Total for Drainage Normalization				Rp498.115.700
VAT (11%)				Rp54.792.727
Rounded Total				Rp553.000.000

Source: Author, 2023

5. CONCLUSION

Based on the planning results, the following conclusions can be drawn:

1. The existing condition indicates that four drainage channels have insufficient capacity to accommodate the design discharge. The excess rainfall runoff that cannot be handled by the drainage system in Pasteur Village is 0.0909 m^3/second
2. The infiltration wells are designed with a typical dimension of 2 meters in depth and a surface area of 4 m^2. To address the inundation issue in Pasteur Village, a total of 41 infiltration wells are required.
3. The Cost Budget Plan (RAB) required for the drainage channel normalization and the construction of infiltration wells is estimated at IDR 550,000,000,00

REFERENCE

Asdak, C. (2023). *Hidrologi dan pengelolaan daerah aliran sungai*. Ugm Press.

Aurice, P. A., Yureana, W., & Ayu, K. R. (2023). Study of inundation and eco drainage system approach in Cicayur Kampong area. *E3S Web of Conferences*, *429*, 02009.

Badan Standarisasi Nasional. (2002). *sni2003-2453-2002-perenc-sumur-resapan*.

BPBD Kota Bandung. (2023). *badan-penanggulangan-bencana-daerah-laporan-tahunan-bpbd-kabupaten-bandung-tahun-2023*.

DOI: http://doi.org/10.17509/jaz.v8i2.87681
p- ISSN 2621-1610 e- ISSN 2620-9934

Butler, D., Digman, C., Makropoulos, C., & Davies, J. W. (2024). *Urban drainage*. Crc Press.

Djojosumarto, P. (2020). *Pengetahuan Dasar Pestisida Pertanian dan Penggunaannya*. AgroMedia.

Firdaus, M. R., Asri, D., & Taroepratjeka, H. (2023). EVALUASI DAN PERENCANAAN SISTEM DRAINASE BERWAWASAN LINGKUNGAN DI KAWASAN PASAR PANORAMA DESA LEMBANG KECAMATAN LEMBANG KABUPATEN BANDUNG BARAT. In *FTSP Series*.

Fletcher, T. D., Shuster, W., Hunt, W. F., Ashley, R., Butler, D., Arthur, S., Trowsdale, S., Barraud, S., Semadeni-Davies, A., & Bertrand-Krajewski, J.-L. (2015). SUDS, LID, BMPs, WSUD and more–The evolution and application of terminology surrounding urban drainage. *Urban Water Journal*, *12*(7), 525–542.

HAPSA, H. K., & JUWANA, I. (2023). Perencanaan Pembangunan Sumur Resapan Di Kelurahan Margaasih Sebagai Upaya Mengurangi Debit Limpasan. *Prosiding FTSP Series*, 2197–2202.

Harmila, S., Djumara, N., & Pratiwi, A. D. R. (2021). Strategi Implementasi Kebijakan Penyelenggaraan Konservasi Air Tanah di Kota Bandung. *Jurnal Media Administrasi Terapan*, *2*(1), 53–60.

Kusumastuti, C., Chandra, H. P., Wibisono, K., & Hartono, A. C. (2019). Eco drainage system for surface runoff reduction in Indonesia. *Civil Engineering Dimension*, *21*(1), 29–35.

Mentens, J., Raes, D., & Hermy, M. (2006). Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? *Landscape and Urban Planning*, *77*(3), 217–226.

Muchtar, H. S., Wijaya, I. N. S., & Setyono, D. A. (2024). Pembangunan Berkelanjutan Perkotaan Dalam Aspek Ekologi Kota Bandung. *Planning for Urban Region and Environment Journal (PURE)*, *13*(3), 193–204.

Prudencio, L., & Null, S. E. (2018). Stormwater management and ecosystem services: a review. *Environmental Research Letters*, *13*(3), 033002.

Suripin. (2004). *Sistem drainase perkotaan yang berkelanjutan*. Andi.

Tingsanchali, T. (2012). Urban flood disaster management. *Procedia Engineering*, *32*, 25–37.

Tjahjanto, D., Musa, S., & Ridzuan, M. B. (2008). A study on artificial recharge well as a part of drainage system and water supply in UTHM. *Proceedings 1st National Seminar on Environment, Development and Sustainability (PSISenviro2008)*, 106–111.

Yudianto, D., & Roy, A. F. V. (2009). Pemanfaatan kolam retensi dan sumur resapan pada sistem drainase kawasan padat penduduk. *Jurnal Teknik Sipil*, *5*(2), 103–121.

DOI: http://doi.org/10.17509/jaz.v8i2.87681
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