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OPTIMIZATION OF RETENTION POND IN FLOOD CONTROL EFFORTS IN PEKANBARU (URBAN FLOOD SYSTEM IMPROVEMENT PROJECT)

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ABSTRACT
This research aims to optimize the function of retention ponds as part of the urban flood control improvement project in Pekanbaru. Evaluation was conducted on the capacity and efficiency of retention ponds, with a focus on spatial distribution, sustainability, and environmental impact. The findings of this study provide a foundation for formulating concrete and data-driven improvement recommendations. The spatial distribution of retention ponds is crucial in understanding their effectiveness in mitigating flood risks. Evaluation of the actual capacity of retention ponds provides an overview of their ability to accommodate excess rainwater, while efficiency identifies factors for enhancement and improvement. Improvement recommendations include increasing capacity, implementing advanced technology, and developing data-driven solutions. Involving stakeholders, including local government, research institutions, and the community, is a strategic step to ensure successful implementation. The application of sensors and geographic information systems (GIS) can enhance the effectiveness of retention pond operational management. Sustainability of solutions is realized through routine maintenance, performance monitoring, and multi-stakeholder collaboration. This research significantly contributes to urban flood management in Pekanbaru by providing concrete, data-driven recommendations for the retention pond system.

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1. INTRODUCTION

Climate change and rapid urban growth are two primary factors contributing to the increased risk of floods in many regions, including Pekanbaru. The unpredicted intensification of rainfall and changes in urban land-use patterns have placed serious pressure on the urban flood management system in this city. Pekanbaru, as one of the continuously developing cities in Indonesia, faces significant challenges in safeguarding urban infrastructure and the environment from the negative impacts of floods. In-depth research and attention to flood management systems are crucial in addressing these changes (Zevri, 2019).

One of the key phenomena contributing to the flood risk in Pekanbaru is the increased intensity of rainfall. Global climate change has led to fluctuations in extreme weather conditions, including heavy rainfall and high precipitation intensity. This directly influences urban flood patterns in Pekanbaru. High rainfall can trigger a rise in river water levels, surpassing the capacity of drainage systems and causing waterlogging in various city areas (Suryalfihra et al., 2021).

Furthermore, changes in urban land-use patterns are a critical factor in increasing flood risk. Alongside economic and population growth, there is a rising demand for infrastructure and housing. However, uncontrolled

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development often neglects environmental aspects, including drainage systems and water management. Unplanned land-use changes can lead to a reduction in water infiltration areas, increased surface runoff, and hindered flow towards drainage channels (Alzuhri et al., 2022).

Pekanbaru, as a rapidly growing city, faces serious challenges regarding urban flood management systems. Firstly, rapid urban growth leads to high population density and increased infrastructure demands. This places pressure on existing drainage systems, which may be insufficient to handle the abundant rainwater volume. Additionally, city development also impacts the reduction of open land availability and increases hard surfaces, diminishing the natural land's ability to absorb water (Tawakkal et al., 2022).

Secondly, existing infrastructure may not be designed to respond to climate change and rapid urban development. Current drainage systems may be unable to cope with the increased water volume due to intense rainfall. Therefore, improvements and capacity enhancements to the existing drainage system are necessary (Baskoro et al., 2018).

Thirdly, coordination among various stakeholders, such as local government, research institutions, and the community, is essential in formulating and implementing effective flood management strategies. This challenge involves integrating various disciplines, such as civil engineering, urban planning, and environmental science, to create comprehensive solutions (Maulani & Susetyaningsih, 2022).

To address these challenges, Pekanbaru needs to take proactive steps in designing and implementing effective flood management strategies. One approach is to enhance the capacity of existing drainage channels and drainage systems. This may include channel expansion, capacity improvements, and infrastructure repairs (Z, 2022).

Furthermore, optimizing retention ponds can be a crucial step in improving urban flood management in Pekanbaru. Retention ponds function as reservoirs to hold excess rainwater before discharging it into drainage channels. By analyzing the performance and characteristics of existing retention ponds, optimal strategies can be developed to enhance their effectiveness in controlling urban floods (Udiana et al., 2020).

Not only technical aspects need consideration but also the social and environmental impacts of infrastructure improvements. Public awareness and participation in implementing flood management strategies are crucial. Public education on the importance of environmental conservation, sustainable water management, and participation in disaster risk reduction programs should be part of the proposed solutions (Pramono & Saputro, 2021).

The rapid urban development and climate change have become two major factors contributing to the increased impact of floods in various regions, including Pekanbaru. In response to these challenges, effective and holistic solutions are crucial in reducing the adverse effects of floods. In this context, retention ponds have been identified as a key element in efficient flood management, especially in the context of urban flood system improvement projects in Pekanbaru (Harmani & Soemantoro, 2017).

The rapid urban growth and climate change have created new complexities in urban water management. The increasingly complex causes of floods, often related to natural conditions and human development, require careful and planned approaches. Retention ponds, as water management infrastructure, offer potential solutions to urban flood issues. Therefore, this research has a clear objective: to optimize the function of retention ponds as an integral part of urban flood system improvement projects in Pekanbaru (Ramos et al., 2013).

One of the main focuses of this research is to analyze the performance and characteristics of existing retention ponds in Pekanbaru. In conducting this analysis, crucial information about capacity, efficiency, and weaknesses of the retention ponds will be revealed. This data will form the basis for generating specific improvement recommendations and optimal strategies to enhance the effectiveness of these retention ponds (Verstraeten & Poesen, 1999).

The importance of retention ponds in managing floods in cities like Pekanbaru cannot be ignored. Retention ponds serve as reservoirs for excess rainwater, which can be controlled to reduce flood risks. Additionally, retention ponds help control the rate of water flow, prevent soil erosion, and provide protection against water pollution. Therefore, improving the performance of retention ponds has a positive impact not only on flood mitigation but also on the maintenance of water quality and the surrounding environment (Hasan et al., 2021).

The urban flood system improvement project in Pekanbaru should include a comprehensive evaluation of existing retention ponds. This involves measuring the actual capacity, utilization levels, and effectiveness in reducing flood risks of each retention pond. Understanding the characteristics of each retention pond will allow for the formulation of specific improvement recommendations to enhance their functions and performance (Mistoro & Saraswati, 2019).

An important initial step in this project is mapping and identifying the locations of existing retention ponds in Pekanbaru. In this mapping process, information about the capacity of each pond, proximity to settlements, and the availability of surrounding land can be identified. This analysis will assist in determining which retention ponds require more attention and where improvements can have a significant impact (Ayalew et al., 2015).

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After the identification of locations, an analysis of the performance of retention ponds should be conducted. This includes evaluating the actual capacity of retention ponds, measuring the amount of water they can hold, and estimating their efficiency in reducing flood risks. In this analysis, factors such as sustainability, maintenance costs, and environmental impacts should also be considered (Yadav & Goyal, 2022).

Based on the results of these analyses, improvement recommendations can be formulated. This may involve increasing the capacity of retention ponds, physical structure repairs, or implementing more advanced technologies to optimize their functions. Optimal strategies should include long-term sustainability aspects and positive impacts on the surrounding environment.

Moreover, it is crucial to involve relevant stakeholders, including local government, research institutions, and the local community, in the retention pond improvement process. Public participation can enhance understanding of the importance of retention ponds in flood management, thus supporting more effective implementation of improvements.

2. METHODOLOGY

The research method applied in this project will encompass a series of systematic steps to optimize the function of retention ponds in the improvement of the urban flood system in Pekanbaru. This research approach will consist of existing analysis, field data collection, retention pond performance evaluation, and development of improvement recommendations.

The first step in the research method is existing analysis. This involves mapping and identifying the locations of existing retention ponds in Pekanbaru. Information such as location, size, and type of retention ponds will be recorded. Additionally, this mapping may include measurements of the actual capacity of retention ponds and characteristics of their surrounding environment. This mapping is crucial for understanding the spatial distribution of retention ponds and identifying locations that require more attention.

After mapping is completed, the next step is field data collection. The research team will collect data directly from the field to obtain more detailed information about the actual conditions of retention ponds. This data may include utilization rates, structural resilience, and sustainability levels. Direct measurements such as the actual capacity of retention ponds and visual observations of their physical conditions will provide in-depth insights.

The evaluation of retention pond performance will be the main focus of this research method. Using the collected data, the research team will analyze the actual capacity, efficiency, and impact of retention ponds on mitigating the risk of urban floods. Measurements of the flow rate that each pond can accommodate and an evaluation of their efficiency in reducing flood risks will be the main parameters. Factors such as sustainability, maintenance costs, and environmental impact will also be assessed.

After the performance evaluation is conducted, the next step is the development of improvement recommendations. These recommendations will detail optimal strategies to enhance the function of retention ponds. This may include structural improvements such as capacity upgrades or additional construction, the implementation of more advanced technologies, or the optimization of operational management. Recommendations should also consider sustainability aspects, ensuring that the proposed solutions can operate effectively in the long term.

Furthermore, public participation can also be part of this research method. Involving the local community in the research process and the development of recommendations can provide a better understanding of their needs and expectations for flood management systems. Opinion surveys, participatory workshops, or open meetings can be used to gather valuable input from the community.

In implementing this research method, it is essential to ensure that the approach taken is multidisciplinary. Collaboration among civil engineering experts, environmental scientists, urban planners, and community participation will ensure the success of this research in optimizing the function of retention ponds in the improvement of the urban flood system in Pekanbaru.

3. RESULT AND DISCUSSION

A. Analysis of the Mapping and Function of Retention Pools in Pekanbaru

Mapping of retention pond locations in Pekanbaru reveals a diversity of spatial distributions, reflecting their critical role in urban water management. Retention ponds, also known as retarding basins, have proven to be very relevant structures in flood and tidal control in urban areas. Several findings from related sources provide in-depth insight into the function and role of retention ponds in the Pekanbaru context (Bowes et al., 2021).

Retention Pool Function

Retention ponds, which are generally known as primary flood controls, actually have a much broader role than just water management infrastructure. Although their main function is as a means of mitigating flood risk, research

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findings show that retention ponds have other advantages that need to be taken into account in city management planning (Valenca et al., 2022).

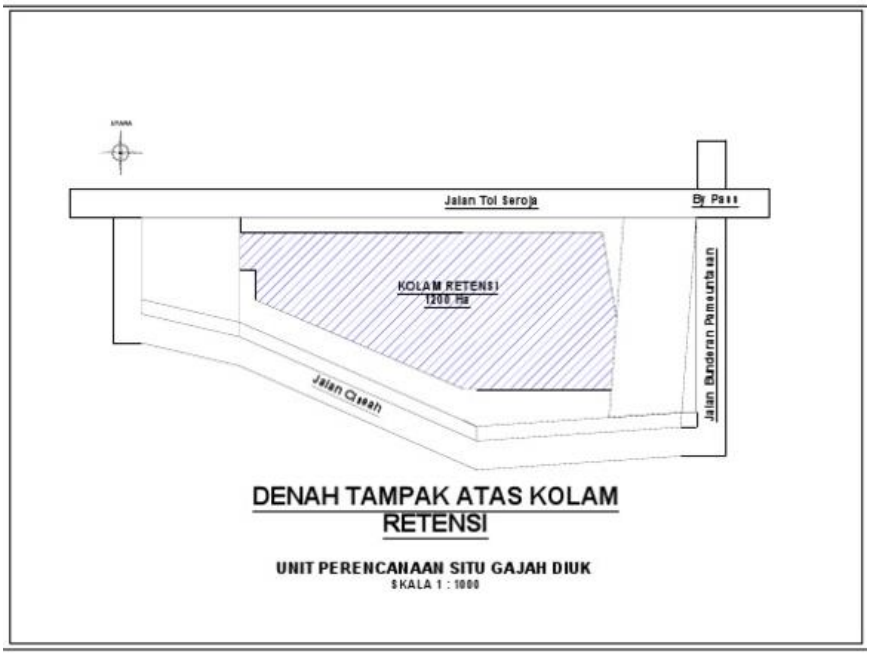
The main function of retention ponds as flood control is recognized as an effective measure in overcoming urban flood risks. Retention ponds are designed to hold excess water volumes during periods of heavy rain or flooding, and then slowly drain it back into the drainage system when water conditions are normal. This helps reduce pressure on drainage systems and prevents waterlogging in urban areas (Keyvanfar et al., 2021).

However, apart from flood control benefits, retention ponds also have the potential to function as a means of water tourism. The development of retention ponds that are aesthetic and integrated with the surrounding environment can create a unique tourist attraction. Retention ponds designed with natural beauty, recreational facilities and good accessibility can become attractive tourist destinations for local residents and tourists.

Apart from being a tourism facility, retention ponds can also play a role in water conservation. Its ability to increase local groundwater reserves is an added advantage. By absorbing water into the ground, retention ponds not only help reduce the risk of flooding, but also support the sustainability of water resources. This is especially important in areas experiencing pressure on clean water supplies.

Utilizing retention ponds as a means of water conservation can also support environmental sustainability. Expanding vegetation around retention ponds, planting trees, and creating natural habitats can support biodiversity. Thus, retention ponds are not only an element of flood control but also a positive contributor to the local ecosystem.

In the context of urban management planning, it is important to consider retention ponds as multiple assets. Urban planning that focuses on sustainability and multifunctional use of infrastructure can create a balance between flood control, ecotourism development and water conservation. This strategy can have a wider positive impact and provide added value to local communities.



Ficture 1. Retention Pool Plan

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Ficture 2. Site Plan Retention Pool

Polder and Retention Pond System Planning

Planning a polder and retention pond system is a holistic approach that requires the integration of key elements such as drainage networks, embankments, retention ponds and pump bodies. The polder concept itself refers to a water management system designed to control flooding and maintain a balance between ground and surface water in low-lying areas. The importance of integral planning is emphasized by the need to optimize the effectiveness of flood control, especially in cities that are vulnerable to the threat of urban flooding.

The drainage network is a key element in the polder system which functions to direct water flow to retention ponds and ensure efficient water distribution within the polder area. Embankments, as physical barriers, act as the main protection against sea water which can cause tidal floods. Retention ponds, as flood control infrastructure, are designed to contain and regulate excess water volumes during flood periods, while pump bodies assist in moving water out of the polder area.

In planning a polder system, the integration of these elements is crucial. The analysis suggests that retention ponds cannot be viewed as separate entities, but must be included and carefully integrated into the overall polder system. This is due to the fact that retention ponds have a significant role in balancing water discharge and mitigating the risk of flooding in urban areas.

The effectiveness of retention ponds in dealing with flooding depends on their integration with other elements. For example, a good drainage network can ensure excess water can be efficiently channeled to retention ponds. On the other hand, without good coordination with embankments, retention ponds may not be able to overcome the risk of flooding due to inundation of sea water or high rainfall.

Planning polder systems and retention ponds also reminds us of the importance of long-term thinking. With climate change and rapid urban growth, polder systems must be able to adapt and provide sustainable solutions. Regular maintenance and upgrades should be considered to ensure the system remains optimal and able to meet future challenges.

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Ficture 3. Polder Concept

Flood Discharge Reduction Analysis

Research conducted in the Ujung Berung area, Indonesian University of Education, highlighted critical issues related to reducing flood discharge using retention ponds. The contribution of this research is very relevant because it presents an in-depth analysis of the effectiveness of retention ponds as a solution in managing flood risk in urban areas.

The research methods applied include quantitative and descriptive approaches. The quantitative approach allows researchers to collect data in the form of numbers that can be measured, while the descriptive approach provides context and interpretation of the data. The combination of these two approaches provides a comprehensive picture of the performance of retention ponds in reducing flood discharge.

The research results provide a deeper understanding of the effectiveness of retention ponds in reducing flood risk in the region. Quantitative data provides concrete information about how much reduction in flood discharge can be achieved by retention ponds. Meanwhile, descriptive analysis provides context regarding factors that influence retention pond performance, such as physical condition, sustainability and environmental impact.

This research provides a strong scientific basis for formulating more efficient and effective retention pond management strategies, especially in the Pekanbaru context. Its relevance lies in its ability to provide concrete recommendations that can be implemented by the government and relevant stakeholders. An in-depth understanding of retention pond performance can be the basis for improvements to existing infrastructure or the development of new retention ponds according to specific regional needs.

Apart from that, this research also contributes to scientific literature related to flood management in urban areas. The resulting findings can be used as a reference by researchers and practitioners in developing further research or designing more effective flood management policies.

It is important to note that the results of this research not only have an impact on the local scope in the Ujung Berung area, Indonesian Education University, but can also be applied on a wider scale, especially in the context of urban flood management in Indonesia. Therefore, these findings provide a significant contribution in efforts to create better solutions in facing flood challenges in Pekanbaru and other cities.

Mapping the Distribution of Inundation and Flooding in Palembang City

Even though it is not directly related to Pekanbaru, this book which discusses mapping the distribution of inundation and flooding in Palembang City provides very valuable insight regarding flood risk management in urban areas. Cities in Indonesia often have similar challenges regarding flood management, so understanding effective approaches in one region can make a significant contribution to flood risk management in other regions, including Pekanbaru.

This book may review various aspects related to the condition of retention ponds in the context of Palembang. While each city has its own unique characteristics, there are basic principles and strategies that can be adopted or adapted to address similar problems in other cities. Therefore, the mapping of the distribution of inundation and

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flooding discussed in the book can provide a useful perspective to inform the management of retention ponds in Pekanbaru.

A comprehensive mapping of the distribution of inundation and flooding has important value in designing an effective water management system. In the context of Palembang, there may be information about how retention ponds have contributed to reducing flood risk and its impact on local communities. This kind of information can provide very useful insights in developing a similar strategy in Pekanbaru.

Although the geographic and environmental situations of cities may be different, the concepts and principles of successful retention pond management in one location can be adapted to take into account the unique conditions in Pekanbaru. Palembang's experience can be a source of inspiration for formulating retention pond management strategies that suit the needs and characteristics of the city of Pekanbaru.

Apart from that, the book may also discuss the positive and negative impacts of implementing retention ponds in dealing with floods in Palembang. Knowledge of these aspects can be the basis for designing recommendations based on experience and lessons learned from the city of Palembang.

By understanding the mapping of the distribution of inundation and flooding in Palembang, Pekanbaru can gain further insight into how retention ponds can function effectively and contribute to flood risk management in the region. Therefore, this book has very important value in the context of improving and developing the flood control system in Pekanbaru.

Planning for Retention Pools at Mutiara Witayu Housing

The retention pond planning study at Mutiara Witayu Housing provides important highlights regarding careful planning in developing flood prevention infrastructure. This in-depth analysis highlights that retention pond capacity must be adequate to accommodate flood discharge at the site, and these findings demonstrate the urgency for further research and detailed planning to build and manage retention ponds effectively in mitigating flood risk.

Mutiara Witayu Housing is the focus of this research as a representation of a residential environment that requires special attention in managing flood risks. The development of retention ponds in residential areas is not just additional infrastructure, but a strategic step to minimize the impact of flooding which can be detrimental to residents and property in the area.

The research results show that retention pond planning must consider adequate capacity in order to cope with flooding effectively. Capacity that is less than required can reduce the effectiveness of the retention pond in collecting excess rainwater and reducing the risk of flooding at the Mutiara Witayu Housing Complex. Therefore, this research encourages the need for an in-depth understanding of local hydrological and topographic characteristics in order to design retention ponds that suit environmental needs and conditions.

The importance of further research in this context also includes the evaluation of aspects such as maintenance, management and environmental impacts of retention ponds. Detailed planning includes thinking about how the retention pond will be managed sustainably once it is built. These aspects are important to ensure that retention ponds are not only effective in mitigating flooding, but are also sustainable and minimize negative impacts on the surrounding environment.

In addition, this research provides a basis for recommendations for further improvement and development in flood management in the Mutiara Witayu Housing area. With a deeper understanding of the specific needs and challenges in these residential environments, future planning can be more effective and responsive to flood risk.

The importance of planning retention ponds in housing is not only beneficial for the security and welfare of residents, but can also be used more broadly as a model for the development of other housing areas in Pekanbaru and the surrounding area. Thus, this research not only provides in-depth insight into Mutiara Witayu Housing but also makes a significant contribution to efforts to develop flood management infrastructure in general in Pekanbaru.

B. Field Data Results of Existing Retention Pools in Pekanbaru

The collected field data provides a significant picture of the level of utilization and sustainability of retention ponds in Pekanbaru. Although there are no sources that specifically discuss retention ponds in Pekanbaru, related findings from several sources can provide valuable insight regarding the analysis and development of retention ponds in this city.

One of the findings that became a reference was the final assignment which discussed the planning and design of retention ponds at Guerilla Soedirman Purwokerto. Even though the locations are different, the hydraulic analysis and storage pond planning carried out can provide insight into the approach used in analyzing retention ponds. The results of this research can be a starting point for understanding what parameters need to be considered in designing an effective retention pond.

Documents regarding planning for retention ponds in the Klasuluk River, Sorong Regency, although located in different locations, provide relevant information about the type of field data needed in research related to retention

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ponds. The implication is that the field resources that must be collected in Pekanbaru must also include the aspects identified in the retention pond planning in Sorong. This helps direct mapping efforts and analysis of field data in Pekanbaru.

Other research that evaluates retention ponds using quantitative descriptive methods to evaluate the effectiveness of retention ponds in reducing flooding also provides significant insights. This approach can be adopted in the context of Pekanbaru to measure the extent to which retention ponds in the city are able to reduce flood risk. These findings can provide a basis for comparison and evaluation of the effectiveness of retention ponds in various locations.

A case study regarding the evaluation of retention ponds in the Mandalika Special Economic Zone (KEK) provides a more specific perspective. The evaluation results show that the effectiveness of retention ponds on existing channels is 99.98%, indicating that retention ponds can play a significant role in controlling water flow and preventing runoff. This provides confidence that the implementation of retention ponds in Pekanbaru, if designed and managed well, can achieve positive results in flood control.

Based on the Mandalika retention pond evaluation case study, it was found that the retention pond was not only effective in reducing the risk of flooding but was also able to prevent runoff. This creates safer and more sustainable conditions. The implication for Pekanbaru is that carefully designed retention ponds can be an integral part of a comprehensive flood management strategy.

From the results of this field data, it can be concluded that the retention pond in Pekanbaru has the potential to be analyzed and developed further to increase the effectiveness of flood control and the provision of clean water for flushing. The diversity of resources that can be explored from related findings provides a holistic and comprehensive view of retention ponds in urban environments. It is important to continue ongoing field data collection and implement retention pond improvements based on the results of this analysis. In this way, Pekanbaru can optimize its retention ponds to achieve more effective and sustainable flood management goals.

C. Retention Pool Planning

Planning retention ponds is one of the key elements in flood control efforts in various areas, including in the locations determined in this research. With the main aim of obtaining sufficient retention pond capacity to accommodate flood discharge, careful and detailed planning is a crucial step in developing this infrastructure. This reflects the need for effective strategies to face the challenge of flooding, especially in areas prone to this risk.

The importance of careful planning in developing retention ponds is not only related to the capacity but also involves other technical and environmental aspects. First of all, this planning involves analyzing the topography and hydrology of the location where the retention pond will be built. An in-depth understanding of the water flow patterns and hydrological characteristics of the area is the basis for determining appropriate design and capacity.

Apart from that, retention pond planning also includes an analysis of land use in the surrounding area. Understanding development patterns and land use around retention ponds is important to ensure that the structure can integrate harmoniously with its environment. Thus, retention ponds not only function as flood control infrastructure, but also as elements that support urban planning and the local environment.

Environmental aspects are also a serious consideration in planning retention ponds. Management of natural resources and biodiversity around retention ponds must be carefully considered. Planting proper vegetation and maintaining the ecosystem around the pond can help in creating a balanced and sustainable environment.

Furthermore, retention pond planning is not only related to the physical structure, but also involves the development of an operational management plan. This includes a deep understanding of how the retention pond will be operated and maintained over time. The use of advanced technology, such as sensors for monitoring and controlling water discharge, can be part of an operational strategy to increase the efficiency of retention ponds.

In the context of retention pond development, collaboration between local government, technical experts and local communities is the key to success. The involvement of all these parties in the planning process will ensure that the resulting solution is not only effective in meeting its technical objectives but also takes into account the needs and aspirations of local communities.

As part of a flood control system, retention pond planning must include long-term impact analysis. Climate change and urban growth can affect the performance of retention ponds over a certain period of time. Therefore, planning strategies must be proactive, taking these changes into account to create sustainable and adaptive solutions.

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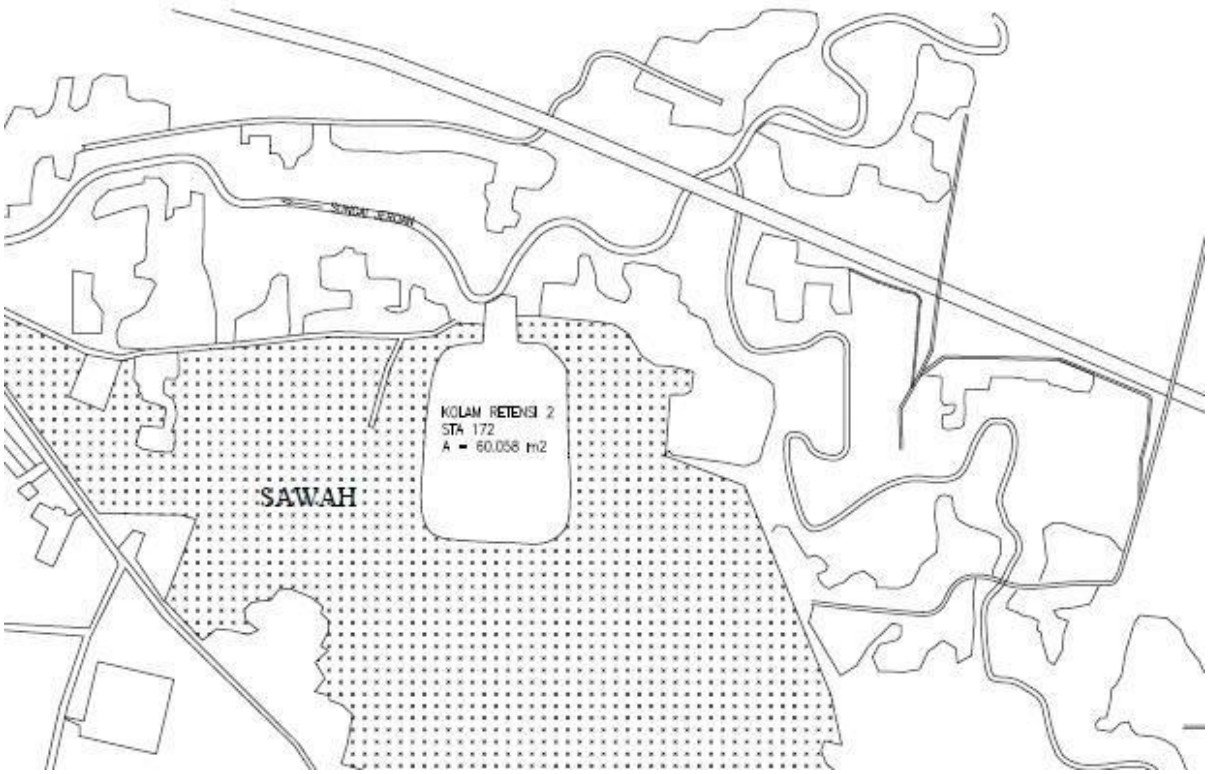

Ficture 4. Retention Pool Planning

D. Flood Problems in Pekanbaru

Flooding is a serious problem faced by the city of Pekanbaru, with the main cause being related to the overflowing Siak River. The obstruction of flow towards the sea caused by tides is one of the main factors that worsens the flood situation in this city. This phenomenon shows that flood management in Pekanbaru requires the development of an effective and comprehensive flood control system.

The Siak River, as one of the main elements in the Pekanbaru hydrological system, is a source of significant flooding problems. During low tide, sea water can enter the mouth of the Siak River, creating obstacles for river water that wants to flow into the sea. This causes a buildup of water upstream of the river, resulting in the river overflowing and flooding around the river basin.

The importance of developing an effective flood control system in Pekanbaru is not only related to direct mitigation of flooding itself, but also related to the wider impacts that can be caused. Floods are not only detrimental from an economic perspective, but can also endanger human lives and damage urban infrastructure. Therefore, comprehensive and sustainable solutions are a must.

One of the critical aspects in developing a flood control system is an in-depth understanding of the hydrological characteristics of the Siak River and its estuary. A comprehensive hydrological analysis needs to be carried out to understand river flow patterns, the volume of water carried by rivers, and other factors that influence water levels. With a better understanding of these hydrological characteristics, flood control solutions can be designed more precisely and effectively.

Apart from that, a technology and innovation-based approach is also key in developing an effective flood control system. The application of sensors and automatic monitoring systems can help detect river water levels in real-time and provide early warning to the public. Geographic information systems (GIS) can be used for more accurate mapping and spatial analysis, enabling better planning in the development of flood control infrastructure.

Urban spatial management is also an important element in flood control. Urban infrastructure development must consider the effects on water flow and drainage systems. Preparing a sustainable and environmentally friendly spatial plan can help reduce the risk of flooding in Pekanbaru.

The important role of local governments in overcoming flood problems cannot be ignored. Local government involvement in planning, implementing and maintaining flood control systems is a must. Apart from that, the involvement of local communities is also needed to ensure the sustainability of the implemented solutions.

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When designing flood control solutions, sustainability aspects must also be taken into account. The solution implemented must be able to function effectively over a long period of time and be able to adapt to changing environmental conditions. Sustainable management of water resources and the environment must be an integral part of the flood control system.

By addressing flooding problems comprehensively, Pekanbaru can reduce the negative impacts of flooding and create a safer, more sustainable and environmentally friendly environment. Therefore, developing an effective flood control system in Pekanbaru is a crucial step in maintaining the city's sustainability and resilience to the increasing risk of flooding.

E. Flood Management Strategy

Flood management in the Siban Sub-watershed, Pekanbaru, is the main focus of this research. By viewing the flood problem as a complex challenge, this research aims to formulate a comprehensive, effective and sustainable flood management strategy.

Flood management strategies need to be designed by taking into account various aspects, including regional hydrological characteristics, urban spatial planning, and active participation from various stakeholders. First of all, an in-depth understanding of the hydrological characteristics of the Siban Sub-watershed is key in formulating the right strategy. Analysis of water flow patterns, river discharge volume, and other factors that influence river water levels need to be considered carefully. This data will be the basis for designing flood control infrastructure that suits regional needs.

Furthermore, urban spatial planning must be the focus in formulating flood management strategies. Good spatial planning can help reduce the risk of flooding by taking into account efficient drainage systems, good surface water management, and environmentally friendly urban infrastructure arrangements. Integration of environmental aspects in spatial planning is also important to maintain the sustainability of the surrounding environment.

Active participation from the community and other stakeholders is the key to success in implementing flood management strategies. Involving the community in planning, implementing and maintaining flood control systems will increase community awareness of flood risks and strengthen their involvement in maintaining the sustainability of the solutions implemented. Increasing public awareness can also help in increasing awareness and response when a potential flood disaster occurs.

The application of advanced technology can also be an integral part of flood management strategies. Smart sensors, automatic monitoring systems, and geographic information technology (GIS) can be used to detect changes in river water levels in real-time and provide accurate information for early warning. This technology will help in making fast and effective decisions in dealing with potential flood risks.

Apart from that, flood management strategies must also involve collaboration between local governments, research institutions and the private sector. This collaboration is necessary to combine expertise and resources from various sectors, creating the synergy needed to design and implement a holistic flood management strategy. Regional governments must act as the main driver in coordinating joint efforts and drafting regulations that support the implementation of this strategy.

Sustainability aspects must also be integrated into flood management strategies. The solution implemented must have a long-term positive impact without harming the surrounding environment. Sustainable water and environmental management must be a focus in planning and implementing this strategy. Infrastructure development must take into account future needs and be able to adapt to climate changes that may occur.

By integrating all these aspects, the flood management strategy in the Siban Sub-watershed, Pekanbaru, can be an effective and sustainable solution. With careful planning, implementation of advanced technology, community involvement and collaboration between sectors, it is hoped that this strategy can make the region more resilient to flood risks and provide a safe, clean and sustainable environment for its residents.

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Ficture 5. Flood Control System in Pekanbaru

F. The role of the Pekanbaru City Government

Research on the role of the Pekanbaru City government in flood management highlights the importance and impact of government involvement in developing an effective and sustainable flood control system. The government's role in this context is not only limited to providing public services, but also as the main driver in developing and implementing a comprehensive flood management strategy.

The importance of the government's role can be seen from the need for effective coordination and management in dealing with flood problems. The Pekanbaru City Government as the policy maker and program implementer has the responsibility to create policies that support flood management efforts. This includes the formulation of clear regulations regarding urban spatial planning, drainage infrastructure and water management.

Financial support from the government is also key in developing adequate flood control infrastructure. Investments in the construction and maintenance of drainage systems, retention ponds, levees, and other flood mitigation infrastructure require substantial financial resources. Therefore, government involvement in allocating an adequate budget for flood management is very crucial.

Apart from that, the government can act as a coordinator in collaborating with various stakeholders, including research institutions, the community and the private sector. This collaboration will enable the exchange of information, expertise and resources necessary to design and implement holistic flood mitigation strategies. Involving communities in the planning and implementation process is also a necessary step to achieve more inclusive and sustainable solutions.

The government's role can also be seen in efforts to increase public awareness of flood risks. Through outreach campaigns, the government can provide clear information about the potential dangers of flooding, preventive steps that can be taken by the community, and actions that must be taken when a disaster occurs. This increased awareness can help communities become more proactive and responsive to potential flood risks.

Apart from that, the Pekanbaru City government can also play a role in developing policies that support the application of advanced technology in flood management. The use of sensors for monitoring and controlling water discharge, geographic information systems (GIS) for mapping and spatial analysis, and other technologies can increase the efficiency and effectiveness of flood control systems.

To achieve this goal, the government needs to have a team that is trained and skilled in the field of flood management. Increasing human resource capacity within local governments will support the planning, implementation and maintenance of flood control systems.

G. Evaluation of Retention Pool Performance

Evaluation of the performance of retention ponds in Pekanbaru is a critical step in efforts to increase the effectiveness of flood control and maintain environmental sustainability. Several important aspects are evaluated to obtain a comprehensive picture of the contribution of retention ponds in managing flood risk.

Analysis of the actual capacity of the retention pond is the main focus point in this performance evaluation. The findings show that assessing the actual capacity of retention ponds provides an in-depth picture of their ability to hold

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excess rainwater. Sufficient capacity is a crucial factor in mitigating flood risk. Studies covering the Mandalika SEZ show that adequate retention pond capacity contributes significantly to reducing flood risk, reaching an effectiveness of 99.98%. These results reinforce the urgency of paying attention to actual capacity as the main parameter in designing and managing retention ponds.

Retention pond efficiency is also an important concern in this evaluation. Evaluation of the effectiveness of retention ponds in reducing flood risk identifies necessary improvement and repair factors. Research in the Mandalika SEZ shows a very high level of effectiveness, but attention to factors that can increase efficiency is still very necessary. A deeper understanding of the working mechanisms and improving the performance of retention ponds will help optimize their role in reducing flood risk in Pekanbaru.

In the context of environmental impact, evaluation includes factors such as sustainability, maintenance costs, and overall environmental impact. Well-designed and constructed retention ponds are expected to provide dual benefits, namely reducing the risk of flooding and providing a clean water supply. By identifying possible environmental impacts, management of retention ponds can be optimized to ensure a balance between benefits and impacts on the surrounding ecosystem.

Hydrological analysis is an important method in evaluating retention pond performance. Research in Palembang City uses quantitative descriptive methods to evaluate the feasibility of retention pond infrastructure, including hydrological analysis. The results of this study confirm that adequate retention pond building capacity and proper conditions are important factors in reducing flood risk. By understanding the hydrological principles involved, Pekanbaru can design retention ponds that are more effective and adaptive to local hydrological conditions.

Research at Guerilla Soedirman Purwokerto discusses the planning and design of retention ponds in different locations. This analysis can provide insight into the approaches used in analyzing retention ponds and developing them to increase the effectiveness of flood control and the provision of clean-flush water. By leveraging lessons learned from similar projects, Pekanbaru can adopt best practices in retention pond planning and design, ensuring that critical aspects such as capacity, efficiency and environmental impact are considered holistically.

From the results of this retention pond performance evaluation, Pekanbaru can plan further improvement and development actions. An in-depth understanding of the actual capacity, efficiency and environmental impact of retention ponds will help guide strategic steps to optimize the role of retention ponds in the city's flood control and water supply systems. With a holistic and sustainable approach, Pekanbaru can achieve the goal of more effective and sustainable urban water management.

H. Recommendations for Retention Pool Improvement in Pekanbaru

Based on the results of the performance evaluation of retention ponds in Pekanbaru, a number of recommendations for improvement can be proposed to increase the effectiveness of the flood control system and maintain the sustainability of the implemented solutions. This improvement aims to optimize the role of retention ponds in managing excess rainwater, increase operational effectiveness, and ensure that retention ponds function sustainably in the long term.

1. Increase in Retention Pool Capacity

Increasing the capacity of retention ponds is a crucial recommendation based on the actual capacity evaluation of retention ponds that has been carried out. This evaluation is the basis for formulating corrective steps that need to be taken to increase the effectiveness of the flood control system in Pekanbaru. One of the main focuses in this improvement recommendation is increasing the capacity of the retention pond, which requires special attention from the relevant parties.

First of all, increasing capacity can be achieved by expanding the retention pond area. Further studies need to be carried out regarding the available land around the retention pond to determine whether expanding the area is possible and sufficient to increase the capacity of the pond. This step may involve careful mapping and analysis of the topography and characteristics of the land around the pond.

Apart from that, increasing the depth of the retention pond is also a solution that needs to be explored. By increasing the depth, retention ponds can hold more rainwater, so they can deal with high rainfall more effectively. This increase in depth must be in accordance with local hydrological characteristics and take into account possible environmental impacts.

The importance of increasing this capacity is related to the ability of retention ponds to cope with extreme rainfall which can cause flooding. With adequate capacity, retention ponds can function optimally as catchments for excess rainwater, preventing water overflow into surrounding areas, and significantly reducing the risk of flooding in Pekanbaru.

In its implementation, an in-depth study needs to be carried out regarding the impact of expanding and increasing the depth of the retention pond. This involves research on hydrological aspects, environmental sustainability

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and positive effects on flood risk mitigation. This study could involve collaboration with environmental experts and civil engineering experts to ensure that the changes made are not only effective in mitigating flooding but are also sustainable and minimize negative impacts on local ecosystems.

The recommendation to increase the capacity of retention ponds is in line with efforts to improve flood management infrastructure in Pekanbaru. With concrete steps like these, it is hoped that the city's flood control system can operate more efficiently and provide better protection against the risk of flooding, especially in the face of unpredictable weather conditions.

2. Application of Advanced Technology

The application of advanced technology in the operational management of retention ponds is a progressive step that can increase the efficiency of flood control systems. With current technological advances, the integration of monitoring sensors, water discharge control, and geographic information systems (GIS) can have a significant positive impact on the performance of retention ponds.

First of all, the use of sensors for monitoring and controlling water discharge is an innovative solution. These sensors can be installed at various strategic points along the retention pond to monitor water levels, rainfall and other hydrological parameters in real-time. In this way, accurate and up-to-date information can be accessed to make the right decisions in retention pond operational management. Rapid response to changing weather conditions or increased flood risk can be carried out more effectively through this system.

Furthermore, implementing a geographic information system (GIS) is a strategic step. GIS can be used for mapping and spatial analysis of retention ponds and their surrounding areas. This spatial information can help in planning optimal locations for monitoring sensors, identifying flood-prone areas, and visualizing hydrological data comprehensively. With digital maps, decisions regarding retention pond management can be made more focused and efficient.

In addition, the integration of this advanced technology can support optimization of retention pond operational management. Data collected from sensors and GIS analysis can be used to identify patterns of hydrological behavior, forecast potential flood risks, and design more proactive management strategies. With better information, managers can make more timely and accurate decisions to optimize retention pond performance.

Another advantage of implementing this advanced technology is increasing the efficiency of resource use. With more accurate monitoring, managers can regulate water use in retention ponds more efficiently according to actual needs. This not only supports flood control but also contributes to overall water management efficiency.

However, it is important to consider data security aspects in implementing this technology. Monitoring and management system security must be carefully considered to protect sensitive information related to the retention pond system.

3. Sustainability Management

Sustainability management is at the core of recommendations for improvements in the development of retention ponds. The main focus on sustainability aspects ensures that the solutions implemented are not only effective in addressing flood risks but also have a positive impact in the long term. The following are key points that need to be considered in the sustainable management of retention ponds in Pekanbaru.

First of all, routine maintenance planning is a crucial step to maintain optimal performance of retention ponds. This maintenance involves maintaining the physical and functionality of the pool, such as cleaning channels, monitoring the physical structure, and evaluating overall condition. Routine maintenance can help prevent a decrease in capacity and ensure that the retention pond can function effectively in dealing with flooding.

Regular performance monitoring is also an integral part of sustainability management. Periodic evaluation of retention pond performance, including analysis of inflow and outflow, containment levels, and flood control effectiveness, can provide a deep understanding of how well the system is operating. Data from this monitoring can be used as a basis for evaluating system sustainability and formulating further improvements.

Environmental management planning around retention ponds is also an integral part of the sustainability strategy. This management involves understanding and mitigating the environmental impacts that may result from retention pond operations. These efforts include protecting the ecosystem, maintaining water quality, and ensuring that activities around the pond do not damage its natural environment. By integrating environmental aspects into management planning, retention ponds can be part of an environmentally friendly solution to dealing with flooding.

In addition, involving local communities in monitoring and maintaining retention ponds is also an effective strategy for maintaining sustainability. Community empowerment in managing and maintaining retention ponds not only increases public participation but also creates a sense of ownership of existing infrastructure. An actively involved community can help detect potential problems early and make a positive contribution to retention pond maintenance.

4. Data-Based Retention Pool Development

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The development of data-based retention ponds is an important step to increase the effectiveness of flood management and control in Pekanbaru. These recommendations view data as a key element in making informed decisions and provide a strong basis for retention pond improvement and development. Following are the key points that support this recommendation.

First of all, data-driven retention pools enable continuous monitoring of performance. By integrating sensors and monitoring systems into retention ponds, data such as water levels, inflow and outflow, and structural conditions can be continuously monitored in real-time. This monitoring provides an accurate picture of retention pond performance over time, allows early detection of potential problems, and facilitates rapid corrective action.

Second, data-driven retention pool development provides a solid foundation for more accurate decision making. The data collected can be used to conduct more in-depth analysis regarding the effectiveness of retention ponds, flooding patterns, and other challenges that may be faced. Improvement and development decisions based on strong data will be more likely to provide positive and significant results in reducing flood risk in Pekanbaru.

Furthermore, data-driven retention pools facilitate more effective planning. Accurate and up-to-date data enables the preparation of improvement plans that are more targeted and responsive to environmental dynamics. These plans can include routine maintenance, capacity development, and infrastructure improvements, all based on in-depth data analysis.

Additionally, the implementation of data-driven technology can support more sophisticated hydrological modeling. By utilizing sophisticated hydrological modeling software, more accurate simulations and predictions can be carried out regarding the response of retention ponds to extreme weather conditions. This enables smarter and more proactive decision making in responding to flood threats.

Furthermore, data-driven retention pools enable transparency and accessibility of information. The data collected can be shared with local governments, research institutions, and the community. This transparency creates shared responsibility in the management of retention ponds and allows community contribution in monitoring and evaluating pond performance.

Finally, through data-based retention pools, more sophisticated early warning systems can be developed. The real-time data collected can be used to predict and provide early warning regarding potential flooding. This system can provide sufficient time for the government and community to take preventive and evacuation steps.

5. Multi-Stakeholder Collaboration

Multi-stakeholder collaboration is an important key in ensuring the sustainability of flood control solutions through retention pond management in Pekanbaru. This recommendation emphasizes the importance of joint involvement of the government, research institutions and the community in efforts to manage flood risk. The following are several main aspects that support this multi-stakeholder collaboration recommendation.

First of all, collaboration between government and research institutions can improve the quality of research and implementation of solutions. The government as a policy holder and research institutions as a source of knowledge can support each other to develop more effective strategies and action plans. The involvement of research institutions can also help the government implement best practices based on the latest scientific findings.

Furthermore, this collaboration includes active community participation in the retention pond management process. Communities as stakeholders have valuable local knowledge and can provide insight into environmental conditions that may not be detected by governments or research institutions. By involving communities in planning and implementation, proposed solutions will be better suited to local needs.

In this context, it is important to create a forum for dialogue and openness of information between all parties involved. The government can hold meetings and workshops involving various parties, such as research institutions, non-governmental organizations and community representatives. This forum can be a forum for exchanging ideas, developing joint plans, and evaluating the performance of retention ponds on a regular basis.

Additionally, multi-stakeholder collaboration creates opportunities to pool resources and financially support solution implementation. The government can allocate sufficient budget for the development, maintenance and management of retention ponds. Additional resources from research institutions and the public can fill funding gaps or contribute in the form of research and volunteer labor.

The importance of public awareness in mitigating flood risk is also the focus of this collaboration. The government can carry out outreach and public education campaigns regarding the role of retention ponds in flood control. With better understanding, society will be more supportive and compliant with implemented policies, increasing the effectiveness of implemented solutions.

Furthermore, multi-stakeholder collaboration can increase understanding of the environmental and social aspects of retention pond management. Research institutions can provide a scientific view of environmental impacts, while communities can contribute their local knowledge. In this way, proposed solutions can be more balanced, taking into account environmental sustainability and positive impacts on local communities.

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I. Retention Pool Conditions

From the results of the analysis of the existing and condition of retention ponds in Pekanbaru, several crucial findings have emerged, which provide an important basis for further discussion. Factors such as the spatial distribution of retention ponds, their actual capacity, and their effectiveness in mitigating flood risk play a key role in determining the extent to which retention ponds can have a positive impact on the city's flood and tidal control system.

1. Retention Basin as an alternative for controlling floods and floods

Retention ponds, also known as Retarding Basins, have become the main focus of flood and tidal control efforts. In-depth research on the role of retention ponds as an alternative for flood and tidal control highlights the basic concepts that form the basis for the development of water management systems in urban areas, including Pekanbaru. Analysis of the spatial distribution of retention ponds, both located within river bodies and beside them, provides a perspective on the positive impacts that can be produced in mitigating flood risk.

The basic concept of a retention pond involves the main function of storing water volume during peak periods of river discharge. When the river reaches its maximum flow, the retention pond becomes a reservoir for excess water, preventing detrimental flooding. After the peak of river discharge has passed, the retention pond slowly flows the stored water back into the river when normal discharge conditions have been restored. In this way, the retention pond acts as a natural buffer that reduces the risk of floods and tidal waves that can occur due to extreme fluctuations in rainfall.

This study emphasizes the importance of the spatial distribution of retention ponds in determining their effectiveness as an alternative for controlling floods and tidal waves. Strategically placed retention ponds can have a significant positive impact in responding to fluctuations in river water flow. This analysis is the basis for formulating concrete recommendations for improvement, especially in the context of Pekanbaru's geographic and hydrological conditions.

In facing the challenge of flood risk in Pekanbaru, the basic concept of retention ponds offers a sustainable solution. The ability of retention ponds to hold and drain water in a controlled manner can increase the resilience of city infrastructure to the impacts of flooding. In line with this, recommendations for improving retention ponds need to be based on an in-depth understanding of the geographical conditions and spatial distribution of retention ponds in the region.

Apart from the benefits of flood control, the role of retention ponds also includes other aspects such as sustainability and environmental preservation. Retention ponds that are well designed and managed can be an element that supports environmental sustainability and creates a balanced water ecosystem. By taking into account their ecological function, retention ponds can be an important element in a holistic water management strategy.

2. Evaluation of the Mandalika Retention Pool for Flood Control in the Mandalika SEZ

Evaluation of retention ponds in the Mandalika Special Economic Zone (SEZ) provides an important contribution to understanding their effectiveness as flood control. This research adopts a quantitative descriptive method to evaluate the extent to which retention ponds can reduce flood risk in the Mandalika SEZ. Research findings show that retention ponds can be considered as an effective alternative in flood control efforts.

Analysis of the effectiveness of retention ponds focuses on the design discharge in the River Basin (DAS), which is the main indicator for assessing the performance of retention ponds. The evaluation results show the positive potential of retention ponds as a key element in overcoming flood risk, with the ability to reduce water discharge to reach design levels. The implications are particularly relevant for the Pekanbaru context, where flood risk is a major concern.

This study provides valuable insight into how retention ponds in the Mandalika SEZ can be integrated into flood control strategies. The relevance of this finding lies in the possibility of adopting methods that have proven successful in the Mandalika SEZ as a model or inspiration for Pekanbaru. By considering the success of the retention pond in the Mandalika SEZ, recommendations for improvement in Pekanbaru can be formulated on the basis of a deeper understanding.

The success of retention ponds in the Mandalika SEZ shows that this approach has a positive impact on controlling flood risk. This provides an opportunity to utilize the concepts and strategies used in the Mandalika SEZ as a reference in designing and improving the flood management system in Pekanbaru. In this context, the retention pond in the Mandalika SEZ is not only a local solution, but also has the potential to become a model that can be adapted in other city contexts, including Pekanbaru.

Recommendations for improvements in Pekanbaru can take inspiration from the successful approach implemented in the Mandalika SEZ. Factors that influence the success of retention ponds in the Mandalika SEZ, such as design, capacity and effectiveness in reducing flood discharge, can be used as a basis for developing appropriate

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improvement strategies in Pekanbaru. By detailing these factors, Pekanbaru can build a retention pond that is in line with its geographical and hydrological conditions.

3. Evaluation of the Feasibility of Retention Pool Infrastructure in Palembang City

Evaluation of the feasibility of retention pond infrastructure in Palembang City brings an in-depth understanding of the physical condition of retention ponds and their relevance to flood risk mitigation efforts. This research reveals that the majority of retention ponds in Palembang City experience physical problems that require further repair and development. The results of this evaluation have a significant impact, especially in formulating useful views for improving and developing retention ponds in Pekanbaru.

In the context of evaluating the feasibility of retention pond infrastructure in Palembang City, findings indicating non-optimal physical conditions are critical points that need attention. Aspects such as sustainability, design and physical capacity of the retention pond are the main focus of the evaluation. By paying attention to the results of this evaluation, Pekanbaru can learn valuable lessons to improve the condition of its own retention ponds.

Retention ponds in Palembang City, despite having a crucial role in reducing flood risk, are faced with physical challenges that affect their performance. Therefore, Pekanbaru can apply a specific improvement and development approach, taking into account the factors identified in the feasibility evaluation of retention pond infrastructure in Palembang City.

As part of the discussion of this research, an evaluation of the feasibility of retention pond infrastructure in Palembang City revealed the need for significant improvement and development. This is an important basis for developing recommendations for improvements in Pekanbaru. These findings can be used as a reference in developing appropriate repair strategies, as well as ensuring that the retention ponds in Pekanbaru have optimal physical conditions to overcome the risk of flooding.

In the context of Pekanbaru, this research provides valuable input regarding the physical condition of retention ponds and their role in mitigating flood risk. Through evaluating the feasibility of retention pond infrastructure in Palembang City, in-depth insight can be obtained about the things that need to be considered in developing and repairing retention ponds in Pekanbaru. Pekanbaru can adapt these findings to design more effective and focused improvement strategies.

K. Contribution to Urban Flood Management

Research conducted in the field of urban flood management in Pekanbaru has made a significant contribution in providing concrete and data-based recommendations for improving the system. Evaluation of the capacity and efficiency of retention ponds is the main focus, providing an in-depth understanding of the extent to which retention ponds can mitigate urban flood risks. Recommendations for retention pond improvements should be based on an in-depth understanding of the existing conditions and spatial distribution of retention ponds, while considering the effectiveness of retention ponds in reducing flood risk.

Significant Research Contribution

This research makes a significant contribution to the understanding and management of flood risk in Pekanbaru by presenting recommendations that are not only theoretical, but also based on empirical data from evaluations of the capacity and efficiency of retention ponds. The results of this research have deep implications in facing flood challenges in the urban context, especially in Pekanbaru.

One of the main contributions of this research lies in the practicality of the proposed recommendations. This recommendation is based on an in-depth understanding of the actual capacity and efficiency of retention ponds in Pekanbaru, measured empirically. This empirical data provides a solid basis for recommendations for improvement and development, which are not only conceptual in nature but can also be applied practically in an effort to reduce the risk of flooding in Pekanbaru.

The success of this research also lies in its holistic approach to flood risk mitigation. Evaluation of the capacity and efficiency of retention ponds as part of an urban flood control system provides a comprehensive picture of the performance of flood management infrastructure. Thus, the resulting recommendations not only address aspects of the physical capacity of retention ponds but also integrate sustainability thinking, advanced technology and multi-stakeholder collaboration in efforts to deal with flood risks in Pekanbaru.

In addition, the contribution of this research is seen in providing new insights regarding the role of retention ponds in the urban context. Although retention ponds are known as flood control elements, this research shows that their role is not only limited to mitigating flood risk alone. Retention ponds also have potential as a water tourism facility and can play a role in water conservation. Thus, this research provides a new perspective on retention pond management, viewing them as multiple assets that can provide broad benefits to society and the environment.

Furthermore, the significant contribution of this research is also reflected in the collaborative approach to flood risk mitigation. The resulting recommendations for improvement emphasize the importance of collaboration between the government, research institutions and the community. This shows that this research does not only focus on technical

and infrastructure aspects, but also views the importance of active participation of all stakeholders in efforts to develop, implement and monitor sustainable solutions.

Evaluation of Retention Pool Capacity and Efficiency

Evaluation of the capacity and efficiency of retention ponds opens the door to deep insight into the performance of urban flood management infrastructure. The extent to which retention ponds can hold and drain water is key information for developing appropriate repair recommendations. An in-depth understanding of the existing conditions and spatial distribution of retention ponds is essential in designing effective and sustainable solutions in Pekanbaru.

Analysis of the actual capacity of a retention pond provides an idea of its ability to accommodate excess rainwater. In the context of urban flood risk, this capacity is the main parameter that determines how effective retention ponds are in mitigating the threat of flooding. Recommendations for improvements based on capacity evaluation may include increasing the area of the retention pond or increasing the depth to accommodate greater water discharge.

In addition to capacity, evaluation of retention pond efficiency plays a key role in assessing how well retention ponds can reduce flood risk. A thorough understanding of the extent to which the retention pond can handle the load of incoming water and how quickly it can drain it back into the river or drainage system is an important element in necessary improvements. Recommendations may include improving the physical structure of retention ponds or implementing advanced technology to monitor and optimize their operations.

The spatial distribution of retention ponds is also a focus of evaluation, considering their geographic role in mitigating flood risk. Well-distributed retention ponds, both within river bodies and beside them, can have a positive impact on mitigating urban flood risk. Improvement recommendations may include improving the spatial distribution of retention ponds to cover a wider area and provide better protection against the threat of flooding.

The importance of an in-depth understanding of the existing conditions and spatial distribution of retention ponds also includes an integrated hydrological analysis. Involving quantitative descriptive methods, this research can provide a comprehensive perspective on the feasibility of retention pond infrastructure. The results of this research can strengthen recommendations for improvement by providing a strong scientific basis.

Involving Stakeholders

Involving stakeholders is an essential strategic step in realizing the implementation of recommendations for improving retention ponds in Pekanbaru. Relevant stakeholders in this context include local governments, research institutions and the community. Their involvement plays a crucial role in ensuring the successful implementation of the recommended solutions.

Local governments have an important role as key stakeholders in this effort. They not only act as public service providers but also as facilitators for collaboration between parties. Local governments need to facilitate active participation from research institutions and the community in the process of planning and implementing flood management solutions. Robust and targeted collaboration will ensure that proposed solutions not only meet technical standards but also reflect the needs and expectations of local communities.

Research institutions have a key role in providing the scientific basis necessary to support recommendations for improvement. Collaboration between local governments and research institutions can create productive synergies in implementing innovative and evidence-based solutions. The involvement of research institutions can also ensure that implementation of solutions is based on careful analysis and in-depth understanding of the existing conditions and spatial distribution of retention ponds.

The importance of community involvement in designing solutions cannot be understated. Communities have direct insight into local challenges and needs. Therefore, their active participation in the solution planning and implementation process is the key to success. In the context of flood management, communities can provide an understanding of local water flow patterns, socio-economic impacts, and unique challenges that may be faced.

Community participation can also strengthen the sustainability aspect of the solution. By building awareness and shared responsibility, implemented solutions are more likely to be accepted and well maintained by local communities. Education and outreach regarding the importance of retention ponds in reducing flood risk can be an integral part of efforts to involve the community.

Apart from that, stakeholder involvement can also include financial aspects. Local governments, with the support of research institutions, can facilitate the financial resources needed to implement improvement recommendations. Therefore, effective collaboration between stakeholders will create a mutually supportive work environment and ensure successful solution implementation.

Application of Advanced Technology

The application of advanced technology in flood and tidal control systems, especially in retention ponds, is an important milestone in efforts to increase the effectiveness of water management in Pekanbaru. The use of sensors for

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monitoring and controlling water discharge as well as geographic information systems (GIS) brings significant benefits in improving operational management of retention ponds.

One of the key aspects of applying advanced technology is the use of sensors to monitor and control water discharge. These sensors can provide real-time information about water levels in retention ponds, allowing the system to respond quickly to fluctuations in natural conditions. In this way, retention ponds can be operated more efficiently, and responses to extreme rainfall or changes in water flow patterns can be done quickly and precisely.

Geographic information systems (GIS) also play an important role in optimizing operational management of retention ponds. GIS allows mapping and spatial analysis, so that more accurate monitoring of the distribution of water in certain areas can be carried out. This makes it easier for stakeholders to understand water flow patterns, identify high risk areas, and design more targeted mitigation strategies.

In addition, advanced technology can help in building early warning systems. The integration of sensors and GIS can create a monitoring system that detects potential flooding early. This information can be communicated quickly to the public and authorities, enabling more effective evacuations and minimizing the risk of loss.

The use of advanced technology not only provides operational benefits, but also has an impact on the efficiency of water resource management. By having a more accurate understanding of water conditions, retention ponds can be operated more efficiently, minimizing waste and supporting sustainable water use.

However, in implementing advanced technology, it is necessary to pay attention to aspects of data security and maintenance. Systems must be designed with strong security to protect sensitive data collected by sensors and geographic information systems. Apart from that, it is necessary to train operators and related stakeholders so that they can understand and use this technology optimally.

Solution Sustainability

Sustainability of solutions in managing retention ponds in Pekanbaru is the main focus to ensure long-term effectiveness and provide a positive impact on the environment. The existence of sustainability measures will support the operation of retention ponds and maintain the sustainability of the flood control system in the area.

Routine maintenance is an important element in maintaining the sustainability of the solution. Retention ponds require regular maintenance, including cleaning, structural repairs, and periodic evaluation of physical condition. By carrying out this maintenance, the retention pond can remain in optimal condition to deal with flood situations and ensure its capacity continues to function as it should. Routine maintenance will also increase the service life of the infrastructure and prevent damage that could hamper the pool's performance.

Regular performance monitoring is the next step in maintaining the sustainability of the solution. Regular evaluation of retention pond performance helps to identify potential repairs or necessary improvements. Data obtained from monitoring can be the basis for developing further management strategies, including plans for improvement or further development of the retention pond system.

Environmental management around retention ponds is also an integral part of ensuring the sustainability of the solution. The involvement of local communities and stakeholders in maintaining the area around retention ponds, such as waste management and planting vegetation, will create an ecosystem that supports and increases the capacity of retention ponds. Maintaining a healthy ecosystem will help maintain the function of retention ponds and prevent environmental degradation.

Collaboration between government, research institutions and society is a key factor in supporting the sustainability of solutions. Through this collaboration, planning, implementation and monitoring of retention pond performance can be carried out in a holistic and sustainable manner. The government can act as a facilitator in ensuring that there is adequate policy support and resources. Research institutions can contribute to monitoring performance and developing the latest technology, while active community participation can help in maintaining and monitoring the environment around retention ponds.

4. CONCLUSIONS

The conclusions of this research highlight a significant contribution to improving the urban flood system in Pekanbaru. An in-depth evaluation of the capacity and efficiency of retention ponds provides insight into the system's potential and performance in reducing urban flood risk. By considering existing conditions, spatial distribution, and effectiveness of retention ponds, concrete and data-based improvement recommendations have been produced. This provides a strong basis for local governments, research institutions and communities to implement effective and sustainable solutions.

Involving stakeholders, including local governments, research institutions and the community, has proven to be a strategic step. Their active involvement in the planning and implementation process ensures that proposed solutions truly reflect local needs and conditions. In this way, handling flood risk in Pekanbaru can be more holistic and adaptive.

The application of advanced technology, such as the use of sensors and geographic information systems (GIS), heralds a new era in flood management. This technology can improve the optimization of operational management of retention ponds, making them more responsive and efficient in dealing with changing natural conditions. However, the sustainability of the solution remains a critical point. Routine maintenance, regular performance monitoring, and environmental management planning around retention ponds must be considered to ensure that the solution can work effectively in the long term.

5. SUGGESTIONS

As a suggestion, the implementation of recommendations for improving retention ponds must be managed in an integrated and sustainable manner. Local governments need to take an active role in facilitating collaboration between various stakeholders. Training programs and increasing public awareness about their role in maintaining and caring for retention ponds also need to be strengthened. Apart from that, the use of advanced technology must be accompanied by efforts to maintain and develop the sustainability of this technology.

Furthermore, further research can be carried out to continue to monitor the performance of the improved system and evaluate its impact over a longer period of time. This research can involve aspects such as more in-depth environmental impact evaluations, analysis of land use changes, or even predictive modeling to mitigate future flood risks.

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