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## **Mitigating the Effects of Flooding in the Khlong Toei Slum of Bangkok, Thailand**

An Interactive Qualifying Project Report  
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This report represents the work of four WPI and three Chula undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its website without editorial or peer review. For more information about the projects program at WPI, please see <http://www.wpi.edu/Academics/Projects>

# Abstract

This project focused on mitigating flooding in the Khlong Toei slum in Bangkok, Thailand. Flooding in Khlong Toei is caused by the torrential downpours from monsoons in the rainy season and leads to many health and sanitation concerns. The key contributors to flooding that we identified were failing drainage systems, inadequate waste management practices, and poor relations between residents and stakeholders. We created a collection of geographical maps based on our interviews and first-hand observations and measurements in order to convey the susceptibility of certain areas within the slum to external stakeholders. Additionally, we formulated a series of recommendations to improve the waste management practices and the drainage infrastructure within the slum.

# Executive Summary

## Introduction and Background

One quarter of the world's urban population lives in slums, the most deprived and isolated form of informal settlement, where occupants have no right to the land. These people are referred to as “squatters” and they typically experience extremely harsh living conditions due to their socioeconomic status and lack of support from government and local authorities (Habitat iii, 2016). Often, slum residents suffer disproportionately from natural disasters because the only affordable land is located in highly undesirable areas. This relationship between poverty, location, and the environment is referred to as “environmental justice” (Habitat iii, 2016). Residents of these informal settlements are vulnerable to a variety of threats as a result. The most common and pervasive problems in slum communities often include improper sanitation, lack of infrastructure for drainage and waste removal, lack of adequate housing, and increased exposure to environmental threats such as flooding, monsoons, and volatile weather (Informal Settlements, 2015).

Our project focused specifically on the slum in the Khlong Toei District of Bangkok, Thailand. The sponsor we worked with during our project was the Duang Prateep Foundation (DPF), a non-profit organization which aims to address five overarching issues in the slum: education, health, social services, human development, and emergency funding (Murray, 2007). Located on a plot of land owned by the Port Authority of Thailand, the community is built over swampland and thus experiences frequent floods, especially during the Southwest and Northeast monsoons (Drakakis-Smith, 2012). Standing water resulting from such flooding acts as a breeding ground for mosquitoes and causes many health problems for the community (Fai, personal communication, 12 January 2017). One of the best ways to help the DPF and the Khlong Toei community is to provide tangible information regarding their flooding problem which can be used to explain their current situation to key stakeholders.

## Goal, Objectives, and Methodology

The goal of our project was to convey vulnerabilities to flooding within the Khlong Toei slum of Bangkok, Thailand in order to enable the DPF to bring about change which will ultimately mitigate the effects of flooding within the community. In order to accomplish this goal, we divided our research into four objectives:

1. Analyze the physical attributes of the slum in order to understand the vulnerability to flooding faced by the residents of Khlong Toei.
2. Investigate the social factors that are inhibiting progress towards flooding solutions.
3. Develop visualization tools showcasing both notable contributors to flooding and areas most vulnerable to flooding in order to assist the DPF in explaining the current state of susceptibility to flooding in Khlong Toei to policy makers.
4. Identify feasible solutions to be implemented by the DPF for long-term flooding mitigation in the Khlong Toei slum.

To accomplish our first objective, we traversed every soi in the slum of Khlong Toei making first-hand observations and measuring different attributes of the slum such as width of walkways, water quality, depth of drains, height of visible water damage, direction of water flow, locations of trash buildup both on land and in standing water, and elevation. Conducted simultaneously along

with the actions towards our first objective, we interviewed slum residents, community leaders, and DPF officials in order to understand the social factors which are holding back progress towards solving the flooding problem in Khlong Toei. Additionally, we interviewed Dr. Sopon Pornchokchai, a local researcher of slums and Pavaris Meebangsai of the Thailand Department of Drainage and Sewage in order to gain a third-party perspective on Khlong Toei's flooding issues.

After gathering substantial data about the physical infrastructure in the slum, we began to analyze our data through the use of graphical information systems in order to get a better idea of the meaning behind all of our measurements. By visualizing our data, we were able to identify certain trends, pinpoint the most susceptible areas to flooding within the slum, and locate the most promising areas of focus in terms of devoting resources for possible solutions such as installation of additional drainage pipes and establishment of waste management services.

Finally, the actions toward our last objective primarily consisted of interviews with more slum residents, DPF officials, and Kru Prateep herself. Through these interviews we were able to inform ourselves about programs and solutions devised to solve flooding that had been attempted in the past. We learned which programs were effective, which were not, why certain programs had failed, and the characteristics of successful initiatives.

## Results/Findings

After analyzing the data we collected, we were able to organize our findings into three different categories: the current state of drainage in Khlong Toei, the major contributors to flooding, and the relationships between key stakeholders.

### Current State of Drainage System in Khlong Toei

Finding 1: Failing drainage systems lead to flooding in Khlong Toei.

From our interviews and first-hand inspection, we found that water located in the drainage trenches situated along the sides of the walkways is predominantly stagnant and is pooling due to clogging. During periods of intense rainfall, rainwater adds to the volume of this standing water and flooding occurs.

### Major Contributors to Flooding

Finding 2: The water from Khlong Toei cannot be released to the Chao Phraya River due to the water quality

We collected water from 70 Rai and submitted it to the Environmental Research Institute at Chulalongkorn University. We compared the results with the acceptable water quality based on the Pollution Control Department of Thailand and found the water quality in the southeast corner of 70 Rai does not meet the standard, and therefore cannot be released directly into the Chao Phraya River.

Finding 3: Lower lying areas in Khlong Toei are more susceptible to flooding.

The lowest lying areas of the slum are the western majority of Lock 4 and the south of 70 Rai. As water naturally flows to lower elevations, we determined that the lower lying areas of Khlong Toei would be especially susceptible to floods. Our interviews with the residents of Khlong Toei confirmed our findings.

Finding 4: The congregation of trash and sediment exacerbates vulnerability to flooding.

We observed a strong correlation between areas of prominent trash buildup (Appendix E) and areas reported to be most flood-prone by residents. Water flows to areas of lowest elevation, bringing with it trash and sediment, which contributes to clogging, which exacerbates flooding.

## Relationships Between Key Stakeholders

Finding 5: The Port Authority of Thailand (PAT) closed pipes due to security and water quality concerns.

Around 10 years ago, a series of underground drains were built by the PAT to allow the water from Khlong Toei to drain into the Chao Phraya River from the southeast corner of 70 Rai. Recently the pipes were closed by the PAT. Through interviews with the DPF, Kru Prateep, the PAT, and Dr. Sapon Pornchokchai, an expert on slum development, we found that the most likely reason for this sealing of the drains was a combination of security concern on the part of the PAT, as they reported incidences of residents sneaking through the pipes to steal from the PAT, and the water from Khlong Toei failing to pass environmental regulations necessary for entering the Chao Phraya River.

Finding 6: Many residents of Khlong Toei lack motivation to improve their quality of living.

The residents believe they will be evicted in the near future and thus have very little motivation to improve their current living situation. Additionally, they don't own the land and believe action should be taken not by themselves, but by the landowner (the PAT). This attitude makes it very difficult for programs to gain traction and be sustained, as the residents have trouble committing to community efforts.

Finding 7: The Khlong Toei District Government has only recently signed on the help clean the drainage in Khlong Toei.

There exists a stark disconnect in the way that the Khlong Toei District Government and the Duang Prateep Foundation view the residents of Khlong Toei. The District Office believes "the residents do not want to clean the pipes because in the past they have gone to the Khlong Toei slum to try and help clean the pipes but only a few of the residents helped" (Natsurang Pongchakran, General Staff of Drainage in Khlong Toei District, 1/31/2017). The District wants to see a self-started effort showing promise before they devote time and resources to assisting the residents. In contrast, the residents, along with the DPF, view themselves as the foundation of business in Thailand justifying an entitlement to the services of the government (Kru Prateep, 1/5/2017).

Only recently, on February 13, 2017 did the District visit the Khlong Toei slum to help clean the drainage system. This day was a national Buddhist holiday so many residents were able to stay home from work and help clean the drainage system. Apparently one of the reasons this help had not come earlier was because the leader of Lock 4-5 had not filled out the proper paperwork which the District requires (Non, 2/15/2017).

Finding 8: The goal of the PAT is to eventually get the residents to leave so they can use the land the residents are currently living on for business expansion.

Through interviews with both the Port Authority of Thailand and the Duang Prateep Foundation, we determined the most likely goal of the Port Authority is to eventually evict the residents, or slowly pressure them to leave on their own, so that the Port Authority can use the land

to expand their business. Deachar Nuchpoom, the Director of the Asset Management Division of the Port Authority of Thailand, says “The port wants to drive out the residents to create more space for storage for the Port Authority” (Deachar Nuchpoom, 2/9/2017). Additionally, representatives from the Duang Prateep Foundation say they believe the port does not care about the residents in the slum. The port just wants to reclaim the area that the residents live on because of its prime location within Bangkok. (Kru Prateep, 1/5/2017).

## Recommendations

From our findings, we outlined ten recommendations for key stakeholders in the Khlong Toei community to begin mitigating flooding. Included in Appendix N, is a timeline we designed for the suggested sequence of implementation for these recommendations.

Recommendation 1: Community leaders organize a community effort to clear obstructions in the drainage system.

In Lock 4-5-6 as well as 70 Rai there are many obstructed drainage paths preventing water flow. We recommend community leaders to organize an initiative to remove all blockages from drains including cement covers, trees, arisen vegetation, and anything else preventing water flow. It would be best if community leaders recruit the support of property owners where clogging is present to ensure cooperation. Additionally, we recommend conducting these types of community pickup days at least once every few months if possible.

Recommendation 2: Residents add new drainage outflow pipes to the slum.

The residents of Khlong Toei installed a new pipe in the northern part of Lock 1-2-3 underneath the railroad which connected to the Bangkok Metropolitan Drainage System and allowed water to flow directly into the Hualampong Canal instead of all the way down through 70 Rai. We recommend the residents install similar additional drainage infrastructure in certain locations in Lock 4-5-6.

Recommendation 3: The DPF and community leaders establish waste management initiatives with the residents.

After finding that areas of trash buildup are strongly correlated with the most flood-prone areas, we recommend the DPF and community leaders initiate and lead the formation of internal waste management programs that incentivize the residents to clean using some sort of exchange reward. Successful programs in the past included “Garbage for Eggs” and “Trash for Toothpaste” where residents traded garbage for either eggs or toothpaste.

Recommendation 4: Residents raise walkways in front of their homes.

Residents in the past have used concrete to raise the walkways in front of their homes, causing the water to flow towards different areas of lower elevation. We recommend this individual solution for households that are particularly susceptible to the negative effects of flooding.

Recommendation 5: The DPF record data regarding flooding events whenever they occur.

We recommend the DPF take note of certain data when flooding does occur in order to aid future projects. Taking note of affected areas, dates of flooding, duration of rainfall, and the height of standing water will help future projects understand flooding and possibly allow them to connect

more rainfall and environmental trends which we did not possess adequate information to accomplish.

Recommendation 6: Khlong Toei District to add more trash bins in Locks 4-5.

Additional trash bins will only help the waste management problem in Khlong Toei. As the situation exists currently, there are just not enough places to put trash, which leads to residents openly dumping waste which ends up in the drainage system.

Recommendation 7: Installing fences surrounding communal waste dumps to contain waste in the event of flooding.

As another possible route to alleviating the waste management problem, we recommend building basic fences around areas that have already been deemed and established dumping areas to prevent trash from overflowing into the drainage system.

Recommendation 8: The DPF establish a recurring cleanup day of existing drainage outflow infrastructure.

As was discovered in Finding 7, the Khlong Toei District does work to clean drainage outflow pipes in the slum, provided the proper paperwork for request of cleaning has been completed. We recommend the Duang Prateep Foundation help community leaders to complete their respective paperworks and establish a schedule of dates when the responsible parties would be available and the District Office would be willing to clean these drains.

Recommendation 9: Khlong Toei District Office work with the DPF to build a water treatment station.

One of the key reasons the Port Authority refuses to open the drainage at the southeast corner of 70 Rai is because the water is well below required standards for discharge into the Chao Phraya River. We suggest the Khlong Toei District and the DPF work together to investigate building a water treatment station capable of improving the water quality to acceptable standards in hopes of persuading the Port Authority to reopen the drain.

Recommendation 10: The DPF organize regular meetings with all relevant stakeholders to go over progress made on the agenda we supply to the DPF.

We recommend the DPF foster the scheduling and conducting of meetings with stakeholders at regular intervals. The key stakeholders are the DPF, the community leaders of the slum, the Khlong Toei District Government, and the Khlong Toei Housing Cooperative. Getting the relevant parties at the table, in-person, will give them the chance to voice concerns, intentions, and share progress and direction. Keeping everyone on the same page allows the DPF to most effectively achieve the goal of flooding mitigation in the Khlong Toei slum

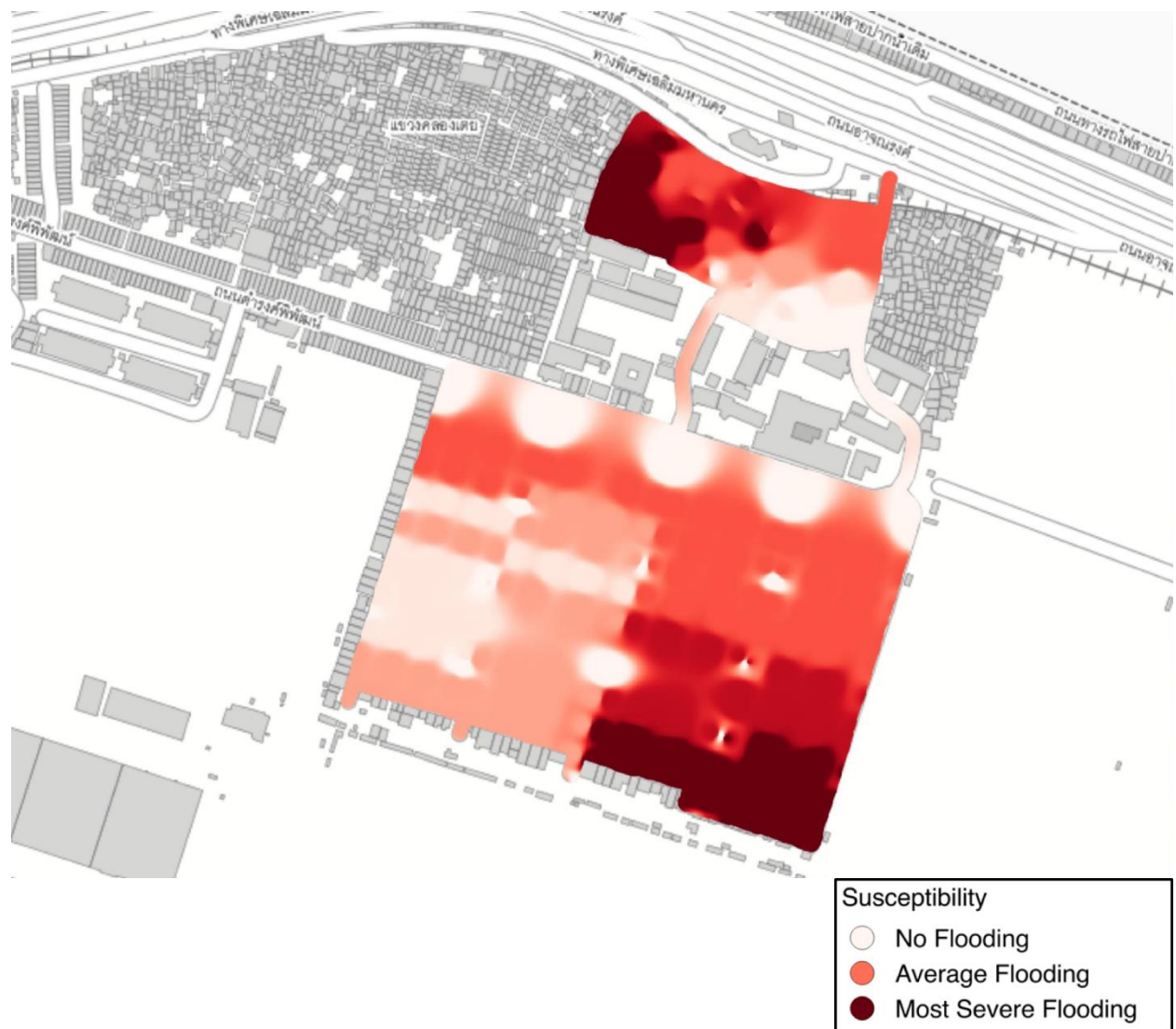
## Conclusion

During the course of our project we determined several major contributors to flooding in our focus area of Lock 4-5-6 and 70 Rai in the Khlong Toei slum. A lack of planned drainage, lower relative elevation in the southeastern corner of 70 Rai and the western section of Lock 4-5-6, and poor waste management practices together lead to clogged drainage systems which exacerbate flooding. Additionally, the quality of the water that pools at the southeast of 70 Rai is not up to the

necessary standards for drainage into the Chao Phraya River which leads to inefficient drainage patterns. Furthermore, most residents lack motivation to act on this problem because they are currently nearing the end of a 30 year lease on the land and believe they will be evicted soon. This makes it difficult for community programs and initiatives to gain traction. We constructed a collection of maps depicting many factors surrounding the state of flooding in Khlong Toei in order to help the DPF advocate for the slum to external stakeholders. Additionally, we devised an action plan consisting of a series of recommendations for the DPF to begin implementing. We hope our recommendations, along with our deliverables, will help the DPF begin to mitigate flooding in the Khlong Toei slum.

## Appendix M: Maps for the Duang Prateep Foundation

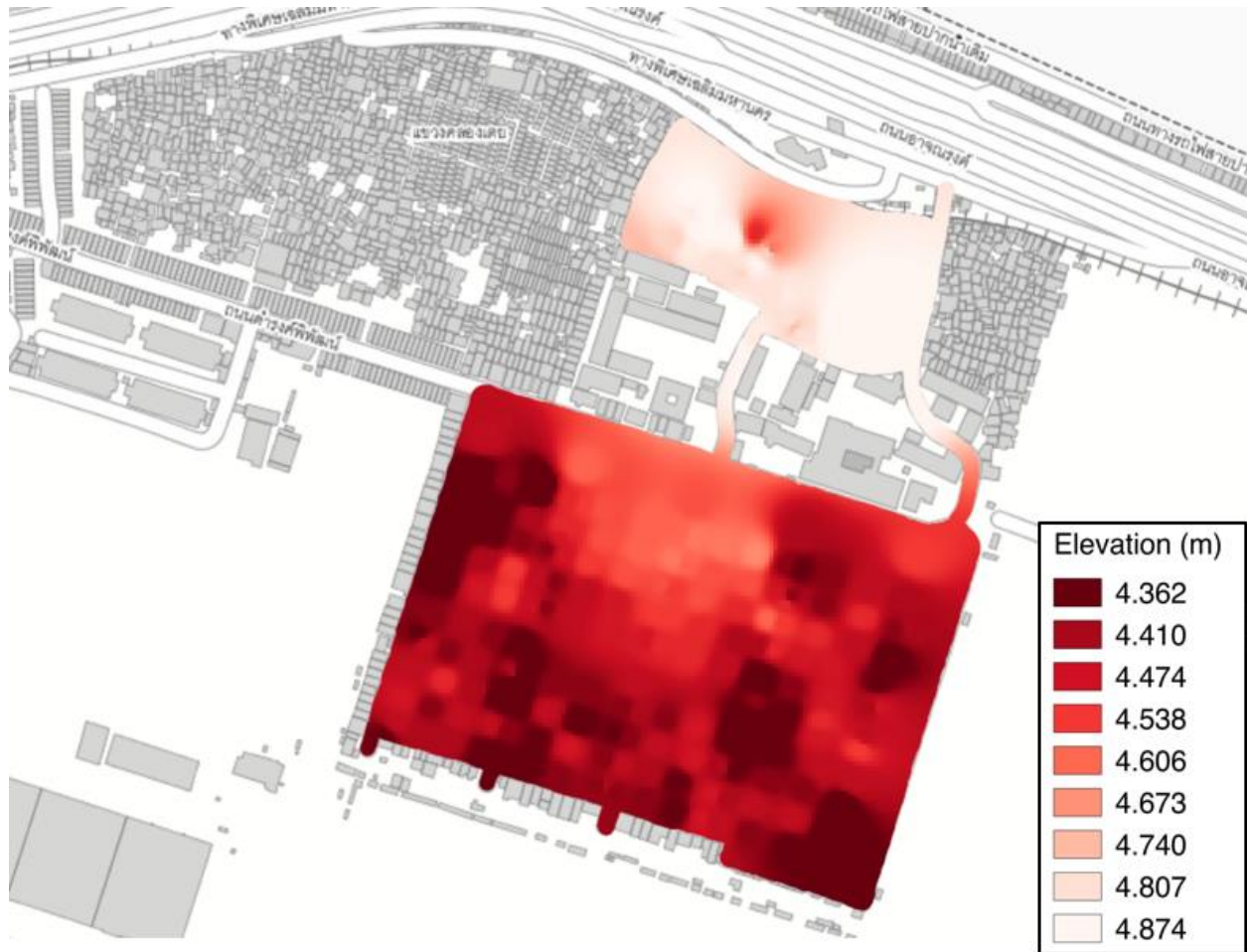
Map 1: Susceptibility





This map depicts locations that residents and community leaders have stated are more susceptible to flooding. The darker red represents the areas that are prone to the most severe flooding, while white shows the areas that do not flood. The areas that residents have said are the most vulnerable are the lower right area of 70 Rai, the left side of Lock 4, and the center of Lock 5.

Map 2: Elevation of Lock 4-5-6 and 70 Rai



This map depicts the elevation of Khlong Toei. Elevation data points were gathered at multiple locations along the Sois using the Google Maps Elevation API. Lower lying areas are shown in darker red while the lighter areas are slightly higher. Lock 4-5-6 sits at a higher elevation than 70 Rai. Within 70 Rai, the elevation is higher in the North and lower in the South. The lowest elevation being in the canal located to the south of 70 Rai, towards the Southeast corner of 70 Rai. The areas that are lower is consistent with where the residents say the flooding is more severe. However, some other areas are low yet do not experience flooding. These reasons will be explained further in the report.

Map 3: Elevation of Lock 4-5-6



Map 4: Elevation of 70 Rai





Map 5: Designed Water Flow



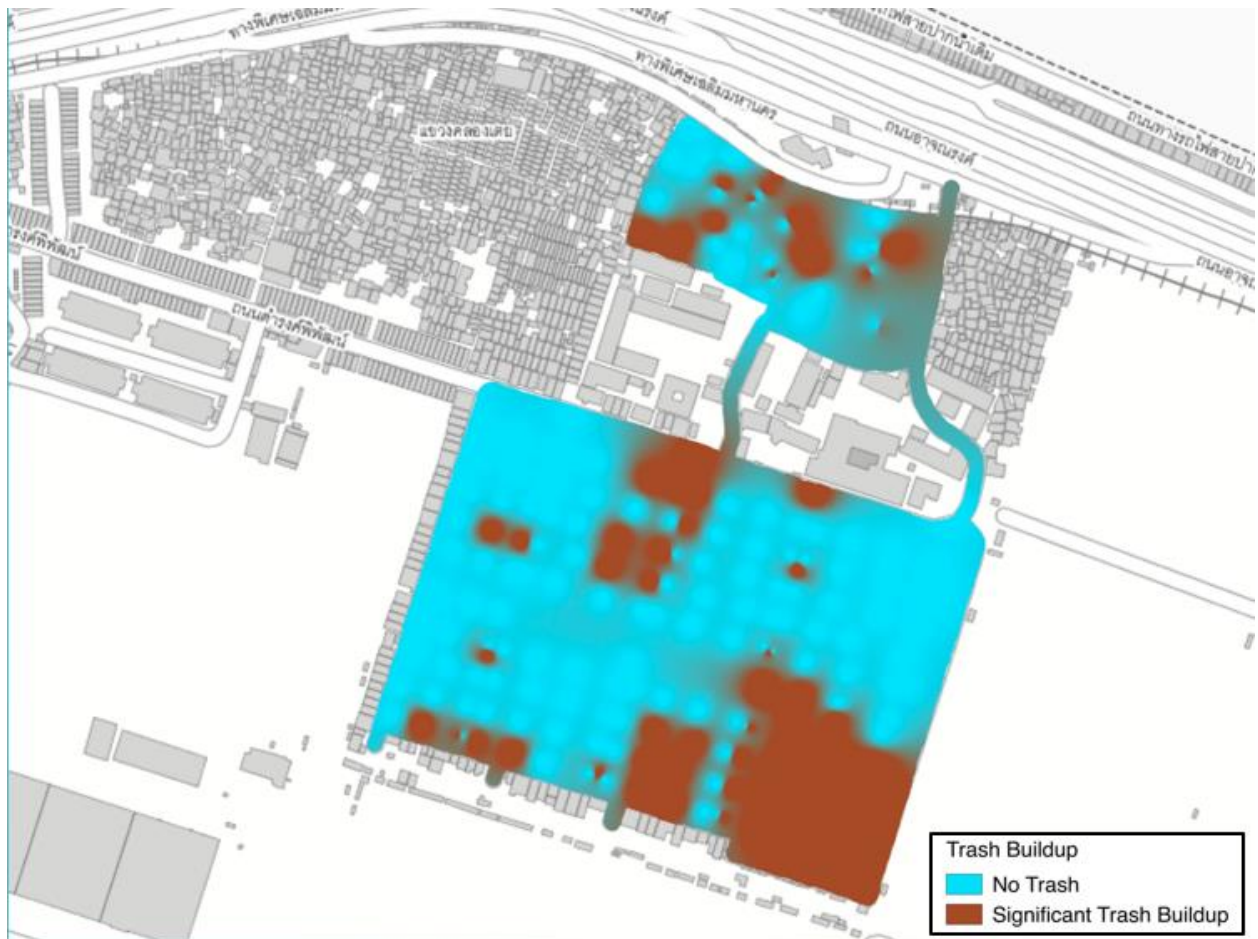
This map depicts the flow of water in the drainage system as it was designed. When we compare it to the elevation, it is clear that the system was designed for the water to flow downhill, from the top of 70 Rai to the canal at the bottom where the water is lead to the Chao Phraya River through pipes that go underneath the Port Authority.

Map 6: Actual Water Flow



This map depicts the current state of water flow of the drainage system of Khlong Toei. Notice the majority of the drains are stagnant and some portions are flowing in the wrong direction represents in red arrows. This is the direction of water flow because the canal at the bottom of 70 Rai has nowhere to go, as the pipes leading to the Chao Phraya river that go underneath the Port Authority have been closed off with concrete. Because of this, the community made the drain on the right side of 70 Rai angled so that the water would naturally flow up 70 Rai. This is because the community must pump the water out of the drain to the Hua Lampong Canal, which is at a higher elevation.

Map 7: Trash Buildup



This map depicts locations with excessive trash build up. The area in brown shows where trash has built up in the drains. Notable locations are the bottom right of 70 Rai, the canal in the center of 70 Rai, and the majority of Lock 4-5.



Map 8: Locations of Trash Bins



This is the location of the district trash bins we observed. The Khlong Toei District is responsible for emptying these trash bins, which are intended to be picked up daily. There are almost no formal trash bins in Lock 4-5 compared to 70 Rai, where the district trash bins are placed in front of most Sois. The only trash can in lock 4 is at the lower left area where all of the community trash is collected in a big wasteland.

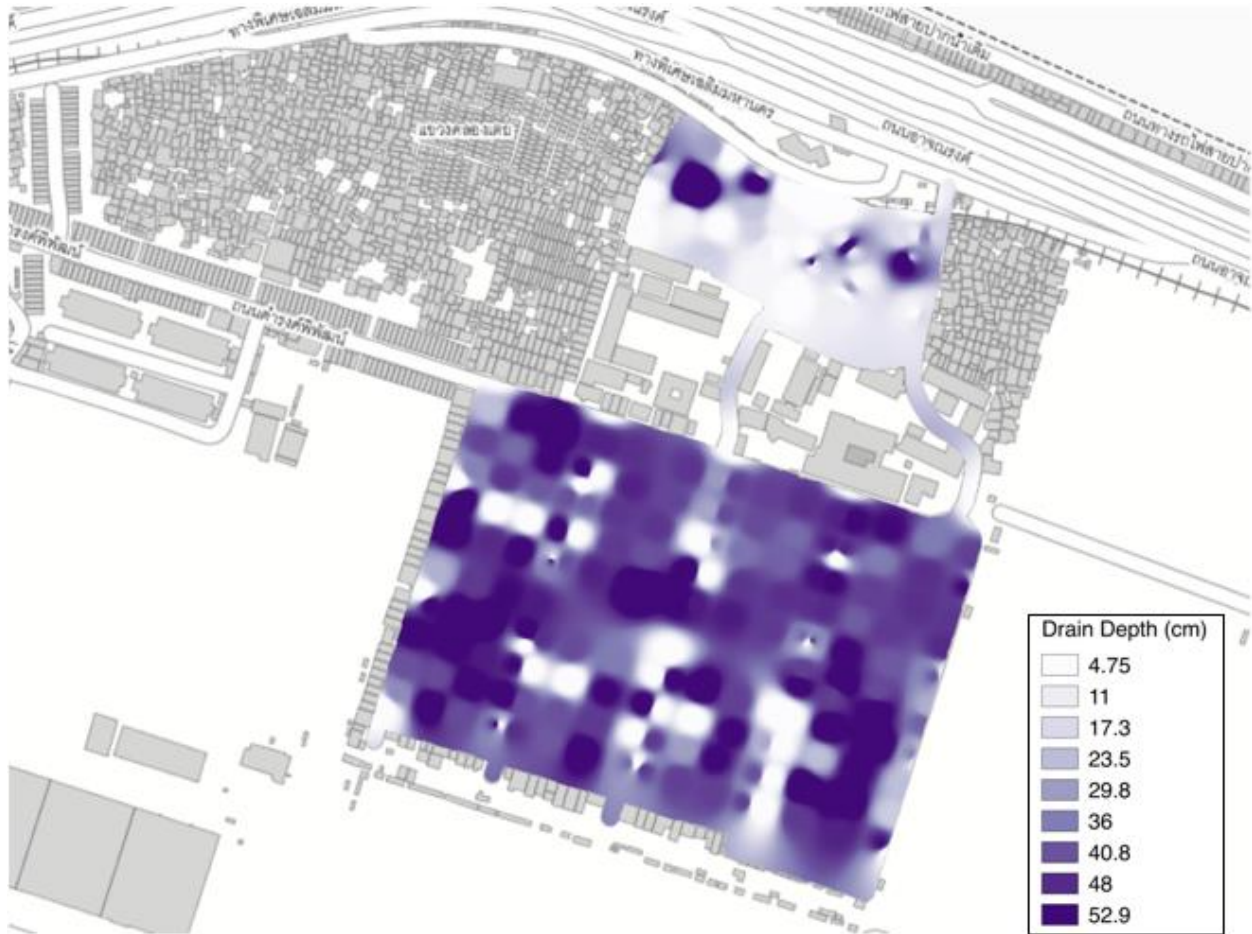


## Map 9: Trash Bins on Trash Buildup



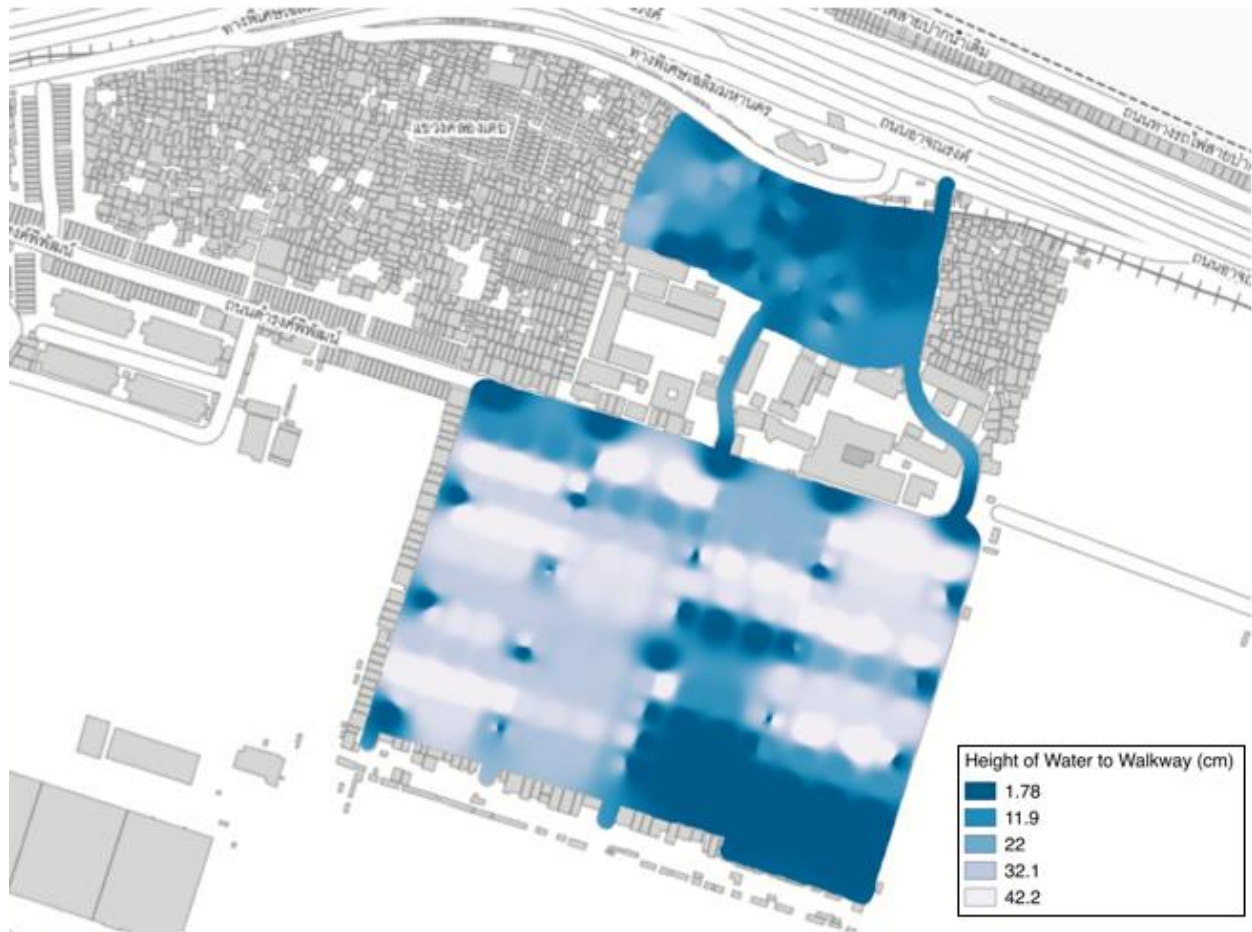
In this map, the locations of the trash bins are overlaid on the areas of trash buildup. The green dots represent the locations of the trash buildup. When we compared this map to the areas of significant trash buildup, we found that the areas that have trash bins are more prone to trash buildup. This is because residents throw their trash into the drain next to the trash can if the can is full. This simply becomes a trash area, and the waste ends up blocking the drains.

Map 10: Drain Depth



This map shows the depth of the drains in Lock 4-5-6 and 70 Rai. The dark purple represents the deeper drain, while the lighter colors show the shallower drains. When there is no drain then the value for the depth is marked as 0. Locks 4-5 do not have a formal drainage system while 70 Rai does. Any drainage system previously in Lock 4-5 has been covered and blocked by residents filling their land with concrete.

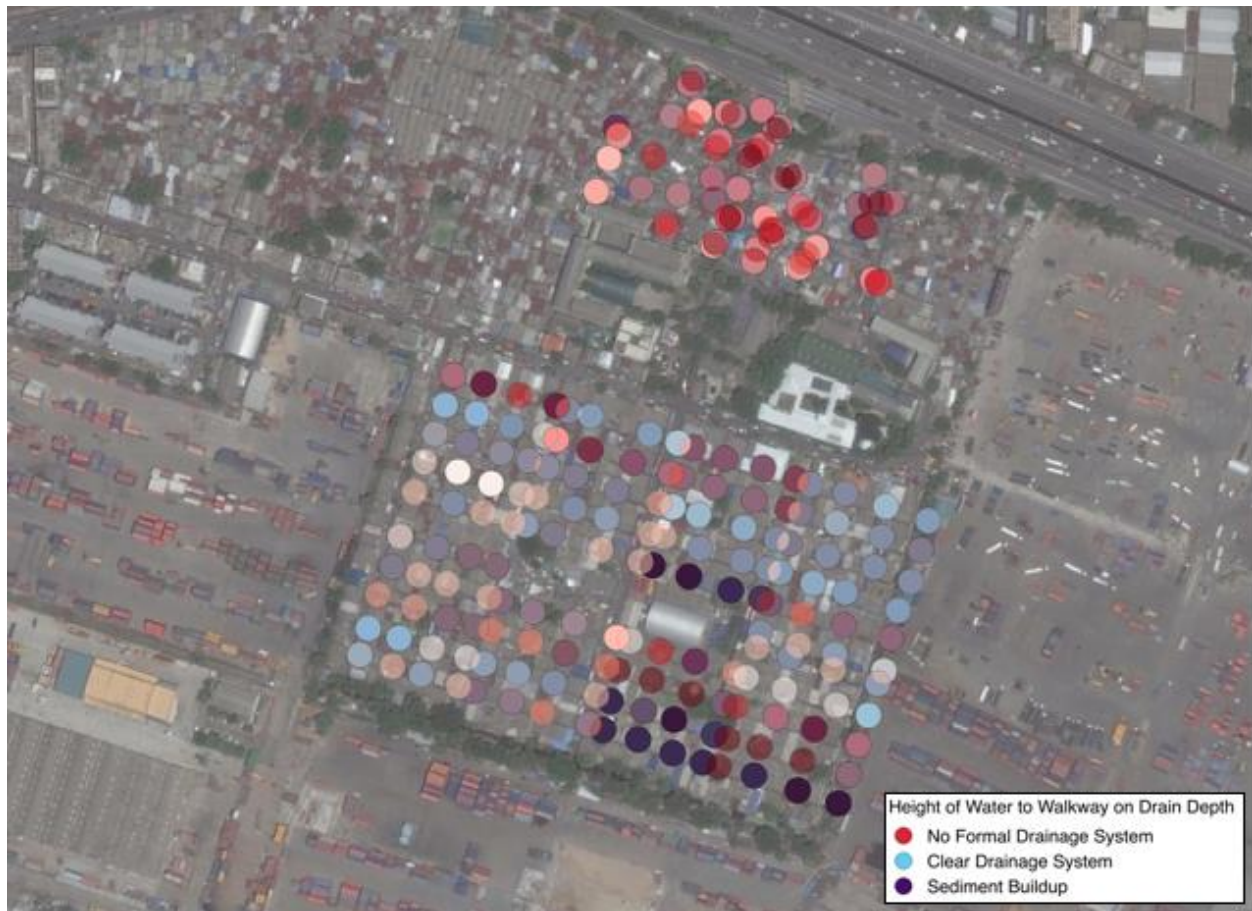
Map 11: Height from the Top of the Water to the Walkway



This map depicts the height of the water in the drains to the walkway on Jan. 26. Lower heights indicate locations that would flood first, as it shows the minimal amount of rainfall before the walkway would be covered in water. There are other factors that go into this, such as the water flowing from different areas due to elevation, and how effective the drains are for getting the water to flow out of the area. Lower heights may also indicate locations that may have high sediment or trash buildup, potentially going up all the way to the walkway.



Map 12: Height of Water to Walkway on Drain Depth



This map shows the height from the water to the walkway overlaid on the depth of the drainage. By making the Height of the water to walkway red and partially transparent on top of the drain depth (blue), we can analyze the trends more easily. From this map we can determine two important findings. First, where there is purple it means that the drain is deep but the water is higher, indicating where there is sediment built up in the drain preventing water from flowing out of the Soi. We can also determine that where there is red means that there is no drainage system, as the drain depth is low, or zero, and the height to walkway is also low.