DRAINAGE & WASTEWATER

MASTER PLAN OF MSU-IIT

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1 INTRODUCTION

1.1 General

This research is prepared and submitted to the Mindanao Center for Resiliency in accordance with the terms of reference and technical proposal provided by the researchers. It outlines the current flooding conditions in MSU-Iligan Institute of Technology, proposes both structural and non-structural solutions to address the issue, provides cost estimates, and outlines the proposed implementation plan for these solutions. The goal of the report is to address the ongoing problem of flooding in MSU-Iligan Institute of Technology.

1.2 Overview

Linde et al. (2010) claimed that flooding resulting in damages to property and human lives is anticipated to soar high in the coming years. The article discussed broadly the expected increase in flood probability due to climate change but did not focus on flood prevention measures. Moreover, urbanization contributes significantly to generating floods caused by excessive quantities of stormwater (Gupta, 2016) when permanent structures replace natural landscapes with impervious surfaces which are attributed to decreased infiltration capacity of local soil (Patel et al., 2020). On the other hand, Hooijer et al. (2004) suggested that to effectively manage flood risk, a combination of structural and non-structural measures may be necessary to achieve long-term results.

Consequently, a broad research question “can drainage systems be reliable and effective” was developed based on the initial claim. This was furtherly refined to specifically consider stormwater and wastewater drainage systems.

In general, drainage systems are implemented to manage the extremes of rainfall because of their capacity to reduce the force and treat rainwater (Cotteril & Bracken, 2020). In a study by Boogaard et al. (2016), most cities in Asia use drainage systems adjacent to wastewater treatment systems in flood run-off mitigation, and water quality improvement to minimize pollution on receiving bodies of water. Aside from pollution, urban areas can face the challenge of disease outbreaks once drainage systems fail and flooding starts (Gupta, 2016). In the same study, it is stated that the consequences of negligence to an effective stormwater and wastewater drainage system are severe and the management of the system carries a huge impact on people's health and resources.

In relation, straightforward approaches have been presented to study stormwater and wastewater drainage systems as main urban flood control structures (Balsells et al. 2013) and one of them is the quantification of thereof (Valizadeh et al., 2019). As highlighted by Beheshti & Sægrov (2018), the accurate quantification of rainfall volume served an important task in the assessment of the management system. Equally, drainage systems were key to preventing floods (Binesh et al., 2016) making it important that such infrastructures be assessed after quantification of rainfall volume for most of them suffers from declining functionality caused by degradation and deterioration. The result of the study by Binesh et al., 2016 showed that functionality of drainage systems can be improved using effective management practices as thereof provides means on how to reduce flood risks. Subsequently, Huljenic et al. (2018) illustrated that research projects that present comprehensive management plans demonstrated good performance for development with emphasis that goals of research projects can be abstract and subject to changes in the future.

Drainage system consists of two major components namely the storm water drainage and wastewater drainage. The function of the storm water drainage is to prevent flooding; to prevent rain water from accumulating that might result in flooding. While the waste water drainage is to ensure that waste from the campus specifically human and laboratory waste will not be deposited directly on any bodies of water.

Unfortunately, the storm water drainage system of Iligan City is insufficient in preventing flooding. Even at a brief intense rainfall, flooding had occurred at the OC IDS area, hostel, Between CSM and COET, PRISM and IPDM, CASS, CBAA, BTRC, Ceramics, ICTC and MSU-IIT Gymnasium

Likewise, the current waste water drainage system is not sufficient to prevent human and laboratory waste from directly depositing to the bodies of water for the reason that not all buildings are not connected to the waste water treatment plan of MSU-IIT. Specifically these buildings are CASS, CBAA, CSS, KTTO, Main Library, IDS and admin building. Furthermore, it is to be determined if all the chemicals from the laboratory neutralized prior to release to the environment.

1.3 Goals

The goal of this research is to accurately determine the volume of stormwater and wastewater in order to design a drainage system that prevents flooding by properly channeling rainwater and connecting all campus buildings to a wastewater treatment plant. This will ensure that the waste water produced by the university is properly treated before being released into the environment.

1.4 Objectives

This study has the following objectives.

1. To come up with a hydrological analysis for flood model for Mindanao State University – Iligan Institute of technology;
2. To assess the existing storm water drainage system and Waste water drainage system in Mindanao State University – Iligan Institute of technology;

3. To come up with a Culvert and catchment basin design;
4. To come up with a septic network system design;
5. Evaluate the design for the culvert and catchment basin design and Septic network system design;
6. Management plan for the storm water and waste water drainage design;
7. Formulate an implementation plan for the storm water and waste water drainage design; and
8. Formulate an investment plan for the storm water and waste water drainage design.

1.6 Planning and Approach

A. ***Hydrological analysis*** will allow us to determine the spatial distribution of flood depth whether which area is deeply flooded and which area is relatively least affected by the flood inside the campus.

B.1. ***Assessment of the existing drainage system*** is to determine the connectivity of the drainage system network, the size of the drainage culvert, the density of the storm water drainage and the outlet of the drainage system network towards the sea.

B.2. ***Assessment of existing wastewater drainage Sub system***

The following components of the sub wastewater drainage system will be assessed:

Buildings that are not connected to the wastewater treatment plant.

The daily volume of wastewater that is deposited to the wastewater treatment plant.

The sufficiency of the parameters to check whether the treated water is safe for release to the environment.

The sufficiency of the wastewater treatment plant to cater all the waste water of MSU-IIT.

C.1. ***Culvert and Catchment basin design*** based on the hydrological analysis and the assessment of the existing drainage system we will be able to:

Appropriately design the size of the culvert and the dimensions of the catchment basins

Install hydrants and faucets on the catchment basins so as to make use of the water in said basins to water the plants, to control fire and for general sanitation purposes

Install filter systems to minimize siltation rate inside the basins

Appropriate man-holes for easy maintenance

Will serve as parking areas

Use pavers for pavement of parking areas to allow infiltration of water into the catch basins

C.2. ***Septic Network Design***

Will be designed to ensure that all waste from all buildings of the MSU-IIT will be connected to the wastewater treatment plant.

That the wastewater treatment plant is sufficient to cater all the waste water of MSU-IIT

That the parameters to examine the treated water is safe to release treated water to the environment

D. ***Design evaluation*** will enable us to determine by simulation the effectiveness of the culvert and catchment basin design to mitigate flooding inside the campus.

E. ***Management of the stormwater and wastewater drainage system*** consists of the following:

Manuals for the Stormwater and Wastewater drainage system

Operations and maintenance of the Stormwater and Wastewater drainage system

Public and agency involvement (Duties and Responsibilities)

Stormwater and Wastewater drainage system network model

F. ***Implementation plan*** allows us which component of the Stormwater and Wastewater drainage system to prioritize

G. *Investment plan* allows us to determine the total amount of funds needed for the establishment of the Stormwater and Wastewater drainage system, the periodic disbursement of funds and the maintenance needed for the optimal performance of the Stormwater and Wastewater drainage system.

1.6 Scopes of Work

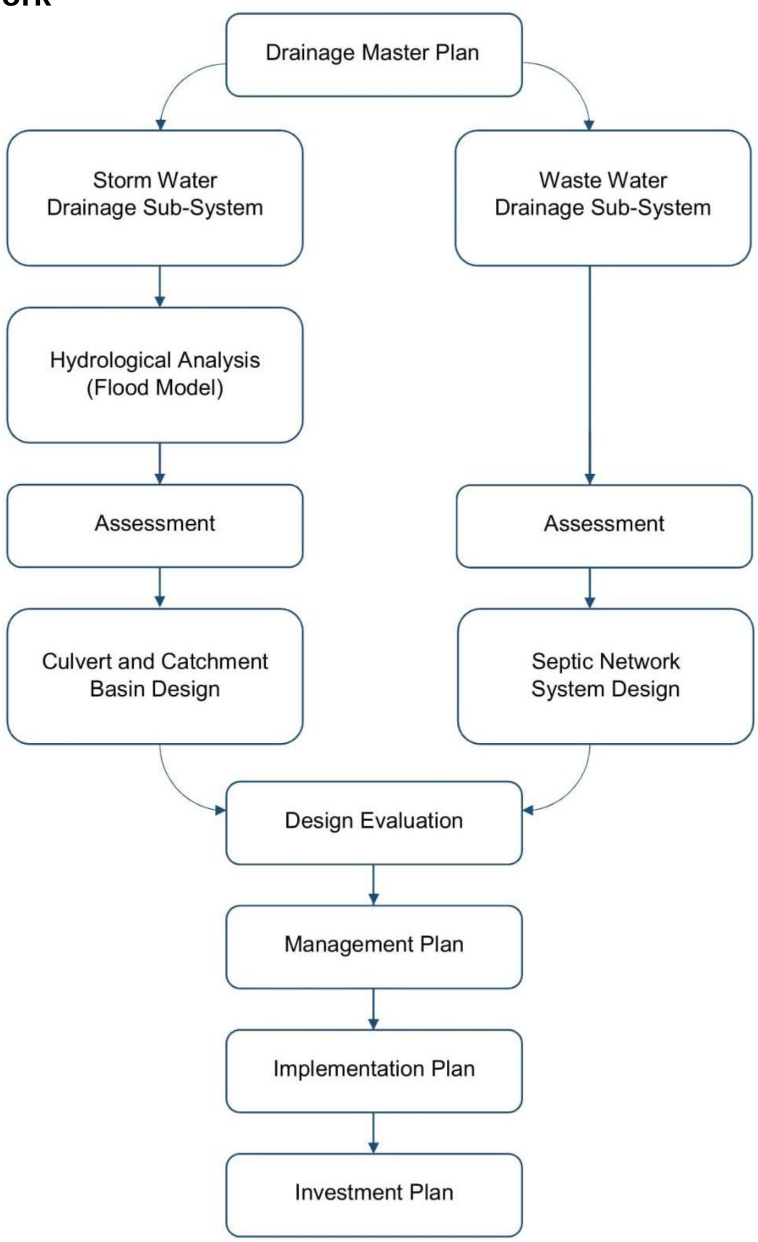


Figure 1.1 Conceptual Framework

This study aims to produce an output of the two subsystems: storm water drainage subsystem and waste water drainage subsystem in the campus scale. The storm water drainage sub-system will conduct a hydrological analysis while the waste water drainage sub-system will not. A hydrological analysis will help us identify which areas within the campus are more heavily flooded and which areas are less affected by the flood by determining the distribution of flood depth in different locations. Both subsystems will be assessed and the purpose of evaluating the current subsystems is to examine its connectivity, culvert size, storm water drainage density, and the locations where the drainage system empties into the ocean in order to determine its effectiveness. The management of the stormwater and wastewater drainage system involves the following tasks:

1. Creating manuals for the system,
2. Operating and maintaining the system,
3. Involving the public and relevant agencies in the process, and
4. Developing a model of the drainage system network.

Furthermore, an implementation plan helps us prioritize which components of the stormwater and wastewater drainage system to focus on. Lastly, an investment plan helps us determine the total cost of establishing and maintaining the stormwater and wastewater drainage system, as well as the schedule for disbursing funds. This enables us to ensure that the system is able to operate optimally

2 DESCRIPTION OF THE STUDY AREA

2.1 The Study Area

The campus of Mindanao State University - Iligan Institute of Technology (MSU-IIT), located in Andres Bonifacio Avenue, Tibanga, Iligan City, Lanao del Norte, Philippines. MSU-IIT has an approximate area of 90,000 m^2 with more than 29 facilities.

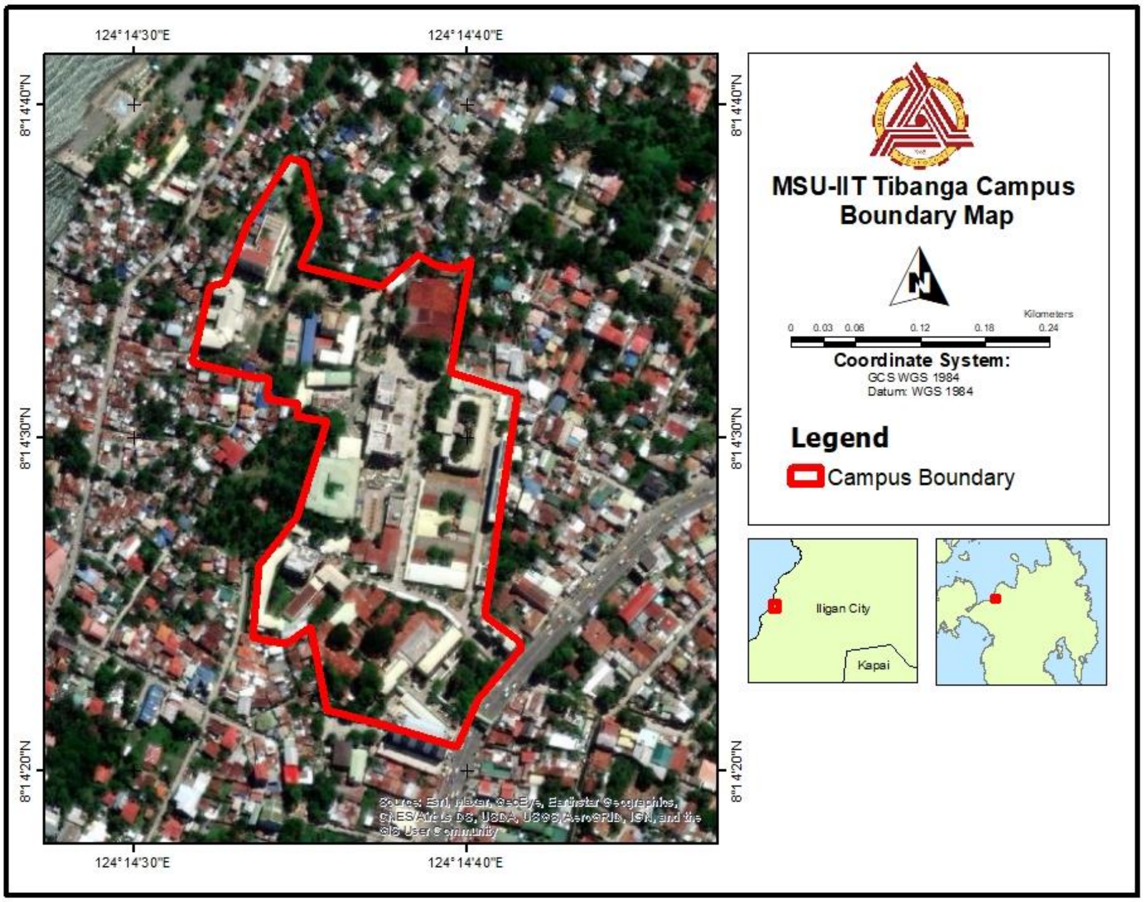


Figure 2.1: Boundary Map of MSU-IIT

2.2 Terrain and Topography

It is located approximately 150-200 meters from the shoreline of the Barangay Canaway and has an elevation of 5 meters above sea level. The campus is situated in a plain with slightly sloping to rolling terrain by about 0 - 18% towards the sea.

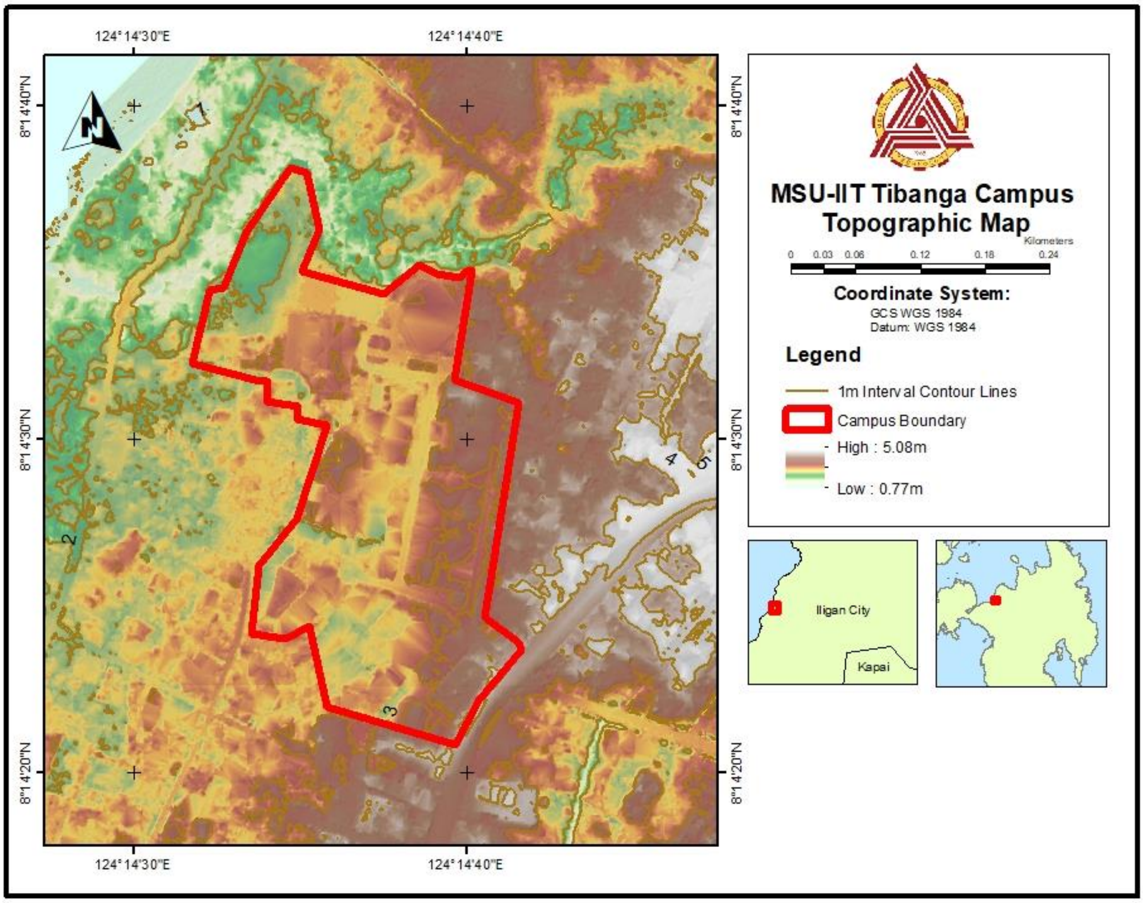


Figure 2.2: Topographic Map of MSU-IIT

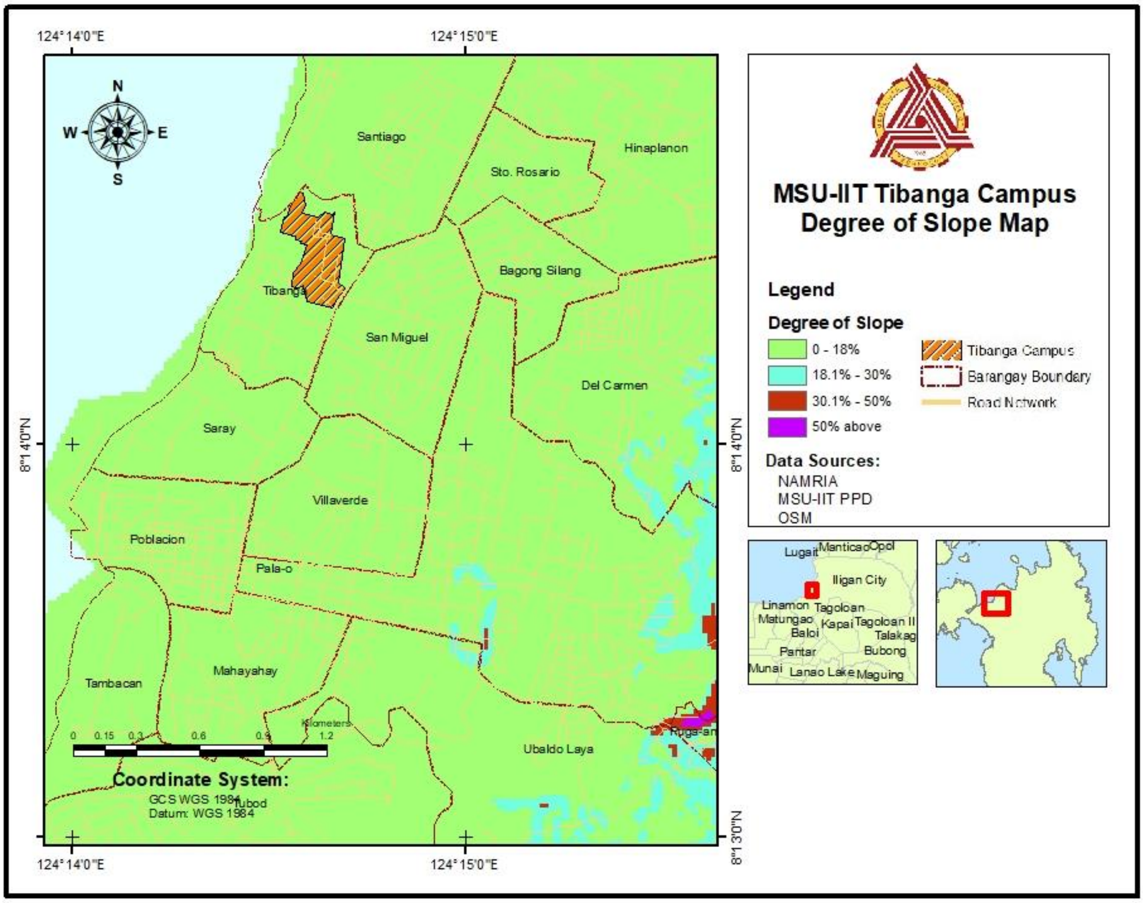


Figure 2.3: Slope Map of MSU-IIT

2.3 Meteorological Information

2.3.1 Climate

MSU-IIT, Iligan City, falls under Type III of the Modified Coronas Classification of Philippine Climate. It is characterized by a "not very pronounced or distinct season". It is relatively dry from November to April and wet during the rest of the year.

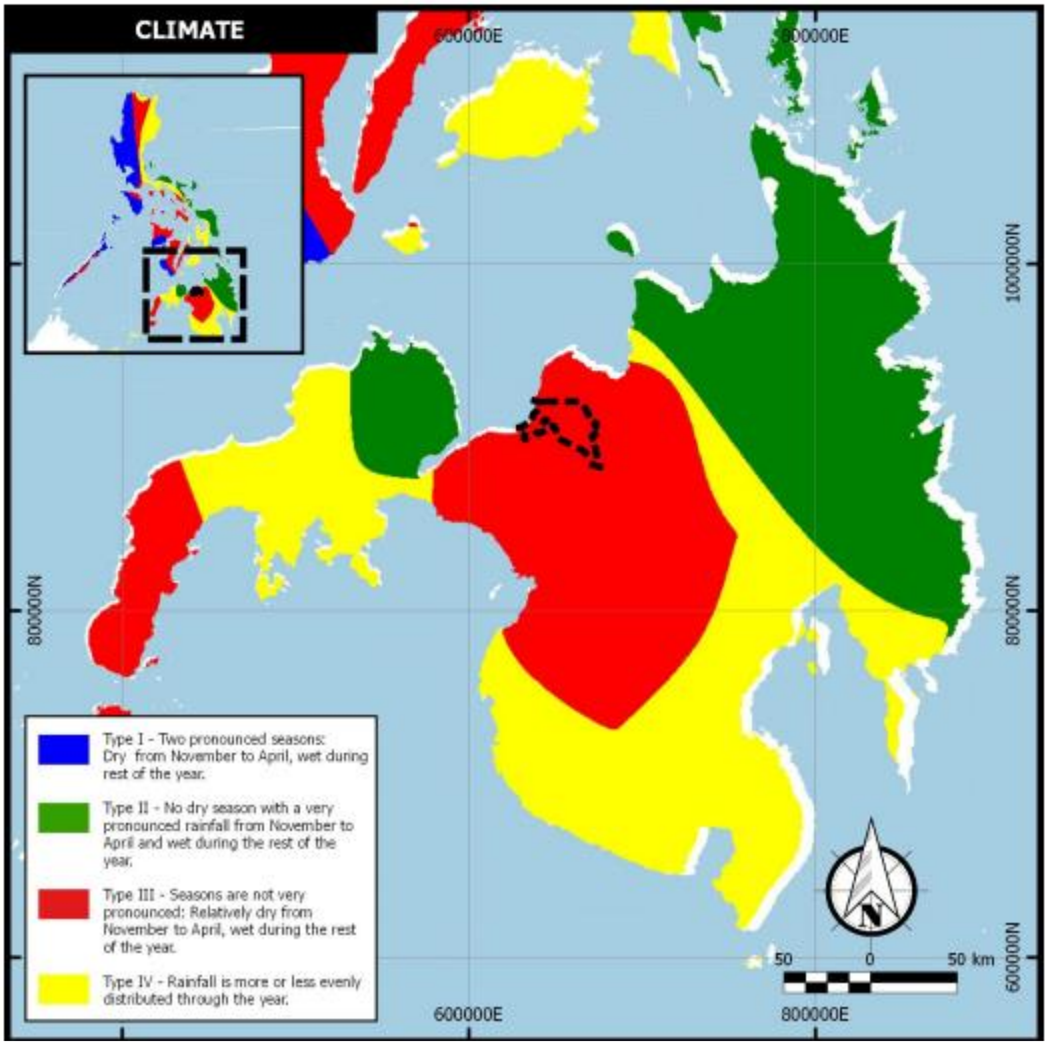


Figure 2.4: Climate Map of Philippines Highlighting Northern Mindanao Region

2.3.2 Annual Rainfall

The historical rainfall data was obtained from the Mindanao Engineering Resource and Services Department, NPC. These sets of data were recorded for more than 25 years from year 1983 to 2014. The average annual rainfall is 229.32 mm.

Based on the rainfall data analysis, the maximum annual rainfall recorded in Iligan City is 815.10mm. The analysis noted the substantial annual, monthly and daily fluctuation of rainfall heights. Figure 2.1 shows the annual fluctuation of rainfall in the study area.

2.3.3 Monthly Rainfall

The rainy season starts in the middle of May. Monthly rainfall is relatively higher during the months of June and July and persists until October. The area received very little rainfall from the months of March to May, with less than 75mm per month. Figure 2.2 shows the monthly fluctuation of rainfall in Iligan City.

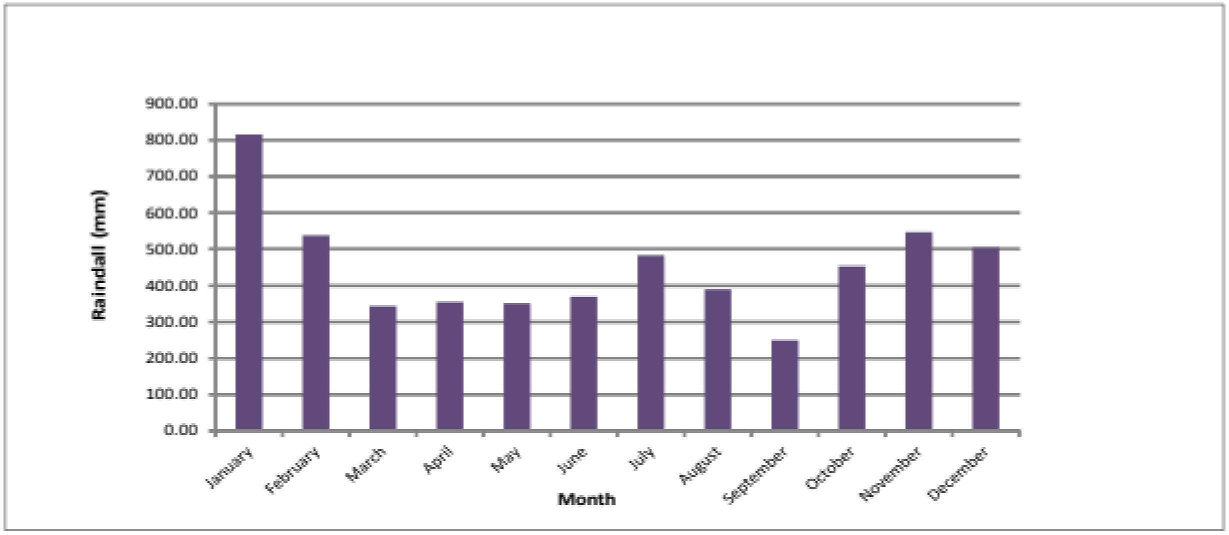


Figure 2.5: Average Monthly Maximum Rainfall

2.3.4 Maximum 24-hr Rainfall

A thirteen-year period was observed to see the maximum 24-hour rainfall as shown in the table below. It yielded a maximum 24-hour rainfall of 457.0mm in January 2009. Table 2.3 presents the generated daily rainfall data which are essential in establishing the design rainfall intensity.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2000	68.0	126.9	97.7	154.2	90.4	377.0	202.5	258.6	114.3	346.8	189.0	69.3
2001	19.9	84.2	121.8	26.5	227.4	158.2	315.2	238.4	243.1	128.0	300.6	137.3
2002	71.9	104.0	65.0	23.7	131.4	381.2	161.5	178.0	358.5	158.7	55.3	29.1
2003	35.4	13.5	3.1	0.1	127.0	254.2	285.3	235.2	337.6	157.4	81.6	401.7
2004	39.5	102.3	48.3	25.4	118.9	178.2	152.2	120.4	119.3	140.7	17.9	81.5
2005	28.8	9.7	68.5	3.0	186.2	204.0	217.8	241.2	288.9	167.7	32.7	160.8
2006	72.6	87.3	42.2	36.8	62.9	253.9	221.2	142.3	169.4	211.0	42.8	44.3
2007	85.6	47.4	2.8	24.2	135.2	248.0	212.5	233.1	181.6	209.8	160.8	99.2
2008	183.8	90.1	93.4	165.8	170.7	228.2	240.7	193.2	279.1	253.2	101.4	143.4
2009	457.0	207.1	1.0	136.8	233.7	189.9	307.8	138.7	209.7	105.1	329.3	36.0
2010	152.2	0.4	23.3	16.4	153.5	155.3	353.2	212.0	258.8	280.1	62.8	131.9
2011	180.8	199.2	131.3	34.9	118.3	231.8	182.5	226.8	232.3	209.5	115.8	333.6
2012	24.2	122.9	67.4	75.1	152.7	144.9	273.7	174.6	200.3	185.2	42.3	207.0
2013	211.1	91.3	61.2	89.3	201.1	310.4	268.2	211.4	162.0	0.0	0.0	0.0

Source: PAG-ASA (Philippine Atmospheric Geophysical Astronomical Services Administration) Cagayan De Oro City Station

Table 2.1: Maximum 24-hr Rainfall

2.4 Environmental Setting of MSU-IIT

2.4.1 Assessment of Land Resources

The Bureau of Soil and Water Management (BSWM) made the Soil & Land Evaluation in 2003 and revealed that Iligan City has largest area with forest/woodland (62%) which is currently experiencing degradation. The city also has about 27% of its total land area classified as agricultural but was said not being fully utilized for agriculture.

As per the 2013 Comprehensive Land Use Plan (CLUP) of Iligan City, urbanized regions encompass 4.5% of the entire land expanse within the city limits. Among these urbanized regions, MSU-IIT contributes to this proportion. Within the premises of MSU-IIT, a collective count of 54 structures and 322 trees has been documented.

2.4.2 Assessment of Coastal & Marine Environment

Iligan City has 24.5 kilometers of coastline covering 14 coastal barangays namely; Dalipuga, Kiwalan, Acmac, Sta. Filomena, Hinaplanon, Santiago, Tibanga, Saray, Poblacion, Tambacan, Tomas Cabili, Suarez, Ma. Cristina and Buru-un.

Coastal water in Iligan is turbid especially near river mouth and in shallow areas. Coastal erosion and siltation in Iligan Bay compounded by squatting/illegal settlements along the coast, improper waste disposal and lack of enforcement of the marine protection ordinances lead to the fast degradation of the coastal and marine resources, which have an impact on the food security situation of the city.

An initial evaluation by the Marine Geological Survey Division of the Mines and Geohazard Bureau (MGB)-Region 10 has identified Iligan City's vulnerability to coastal erosion as ranging from low to moderate. Within the vicinity of Barangay Tibanga, where MSU-IIT is situated, observable evidence of coastal erosion is apparent, warranting a susceptibility rating of low to moderate.

2.5 Demographic Profile of the Study Area

MSU-IIT is one of the top state universities in the Philippines. The university has a population of 14,395 including student, faculty, and staff based on the 2022 census and a total area of 9.11 hectares as well as a population density of 1,579 persons per hectare. The gender distribution of MSU-IIT is 61 female to 39 male students and the age range of students falls within 18–24 years old.

The university was founded on July 12, 1968 and has since provided excellent education to thousands of students in the country. As part of the MSU System, MSU-IIT continues to integrate the cultural communities in Mindanao specially the Muslims into socio-cultural and political life.

The university population dropped due to the implementation of the K to 12 Program back in 2012 resulting in students spending a total of 6 years in High School which impacted the annual growth in 2016 and 2017. MSU-IIT recorded a high annual growth in 2013 reaching up to 5.6%.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population	24,390	25,160	26,135	26,170	27,525	29,070	29,778	30,342	24,259	19,009
Growth Rate		+3.2%	+3.9%	+0.1%	+5.2%	+5.6%	+2.4%	+1.9%	-20%	-21%

Table 2.2: Average Annual Growth Rate in Population, MSU-IIT 2008-2018

Figure 2.6: Average Annual Growth Rate in Population, MSU-IIT 2008-18

2.6 Population

MSU-IIT has a total of 58 buildings and offices with 7 colleges and 1 Integrated Development School. The total student population is 12,230 which is 85% of the university population. The ratio of faculty to students is 1:18.

Name of Building/Offices	CASS	CCS	CEBA	CED	COE	CON/HR	CSM	IDS	Admin Bldng	KTTO
	2170	1004	1323	2330	3240	523	2364	1044	66	2
Name of Building/Office	Hostel	MICEL	IPDM	Alumni Office	Dormitory	Gymnasium	PPD	SPMD	PRISM	CET/IACET
	2	1	3	1	9	9	45	10	6	6
Name of Building/Office	Clinic	Legal Office	OVCRE	SID Office	OVCPD	HVACR	CET	Admin Guardhouse	Information Office	MSU-IIT Coop
	14	1	55	1	1	1	2	1	1	2
Name of Building/Office	Chancellor's Office	Mini Theatre	Motor Pool	Cultural Development	DSA	DTAP	ICTC	Institute Secretary	IASU	MILO
	4	1	3	4	2	8	11	4	4	3
Name of Building/Office	OARP	OBS	Office of the Chancellor	OVCAA	OVCAF	OVCPD	OVCRE	Purchasing Office	Main Library	
	1	2	18	5	7	10	39	12	20	

Table 2.3: Population of MSU-IIT as of 2022

In 2022, the College of Engineering has the highest number of students and staff recording 3,240 persons, followed by College of Science and Mathematics with a 2,364 persons, then College of Education with 2,330 persons, College of Arts and Social Sciences with 2,170 persons, College of Economics, Business, and Accountancy with 1,323 persons, College of Computer Studies with 1,004 persons, and College of Nursing with 523 persons.

2.6.1 Population Density

The increased annual growth trend from 2008 to 2015 translates to a more dense population in the university reaching up to 5.6% in 2013.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population	24,390	25,160	26,135	26,170	27,525	29,070	29,778	30,342	24,259	19,009
Growth Rate		+3.2%	+3.9%	+0.1%	+5.2%	+5.6%	+2.4%	+1.9%	-20%	-21%
Density	2,677	2,762	2,869	2,873	3,021	3,191	3,269	3,331	2,663	2,087

Table 2.4: Population Density, MSU-IIT 2008 to 2018

The population density of MSU-IIT is low which averages at 2,874 persons per hectare. The university has the highest population density of 3,331 persons per hectare in 2015 and lowest population density of 2,087 per hectare in 2017.

2.6.2 Population by Gender

The gender distribution of student population MSU-IIT has a slightly higher percentage of female students with an average of 61% and 39% male students. The total number of students in the university is 12, 230 which translates to 7,460 female and 4,770 male students.CASS, CEBA, CED and CON have higher female students of up to 76% while CCS and COET have higher male students of up to 61%.

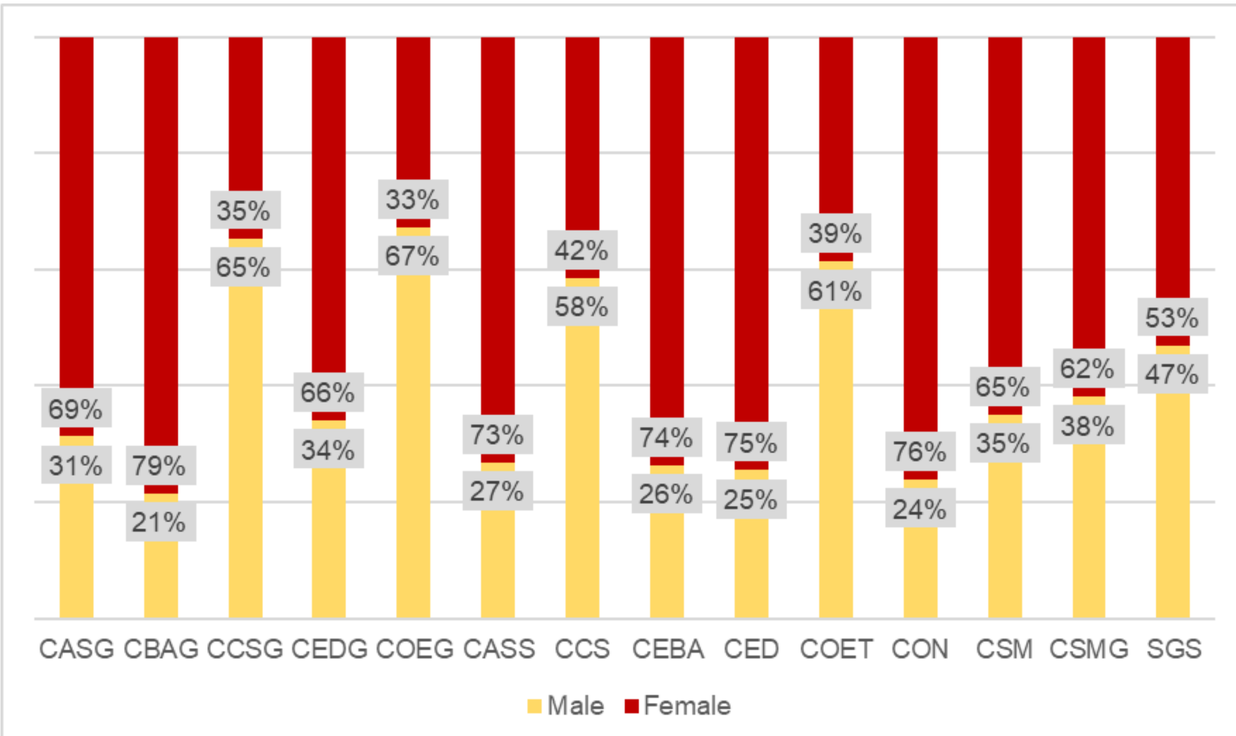


Figure 2.7: Student Gender Distribution per College

2.7 Economic Profile of the Study Area

According to the report published by the Philippine Statistics Authority in 2021, the economy of Northern Mindanao showed a 6.3% growth in the regional structure. A total of Php 872.9 billion Gross Regional Domestic Product (GRDP) was recorded in the economy which was Php 5.5 billion more than in 2019 when the pandemic started and making it sufficient to cover the economic loss in 2020. In the same report, there are three (3) main drivers of economic gain in the region. Manufacturing as an economic driver has the highest rate of 8.2% growth, followed by wholesale and retail with up to 4.9%, and agriculture, forestry, & fishing making 3.8%.

		Annual		
		2019	2020	2021
NCR	National Capital Region	6,224,134,457	5,599,931,197	5,845,285,166
CAR	Cordillera Administrative Region	321,722,276	288,876,582	310,587,541
I	Ilocos Region	630,362,667	581,877,977	608,596,586
II	Cagayan Valley	411,513,567	371,102,979	389,903,924
III	Central Luzon	2,183,779,631	1,881,277,315	2,020,780,298
IVA	CALABARZON	2,831,599,919	2,534,444,265	2,728,307,401
	MIMAROPA Region	386,783,632	357,780,630	369,712,025
V	Bicol Region	564,941,774	517,770,299	540,141,707
VI	Western Visayas	913,909,365	825,369,599	874,079,838
VII	Central Visayas	1,254,113,393	1,134,912,345	1,195,834,479
VIII	Eastern Visayas	469,292,504	434,767,718	460,977,813
IX	Zamboanga Peninsula	396,878,798	376,299,326	397,863,853
X	Northern Mindanao	867,432,424	821,433,093	872,937,569
XI	Davao Region	900,885,668	833,225,496	882,035,530
XII	SOCCSKSARGEN	469,982,193	449,247,792	472,531,682
XIII	Caraga	306,260,878	285,001,928	305,561,020
BARMM	Bangsamoro Autonomous Region in Muslim Mindanao	249,157,465	244,524,738	262,917,404
	Philippines	19,382,750,611	17,537,843,279	18,538,053,835

Table 2.5: Gross Regional Domestic Product, Annual 2019 to 2021, At Constant 2018 Prices

2.8 Relevance of the Stormwater and Wastewater Project to Development

MSU-IIT has since committed to become a developed and sustainable institution and with the expected increase of flood probability in the coming years, the preparation of a drainage master plan to address flooding within the campus will support MSU-IIT through its growth. The study will provide a perspective on the impact of an effective drainage system to flooding and pollution by evaluating and assessing the current drainage system within the campus.

This research aims to contribute to the improvement of environmental and social concerns within the university. As an institution of higher learning, MSU-IIT is expected to care for the environment and it can be demonstrated through conducting this study because one of the core of this study would be the management and prevention of potential pollutants, which can directly pose a threat to the overall health and well-being of the population and wildlife, from entering natural bodies of water in the city. Additionally, property damage and opportunity loss can be significantly prevented if flooding and pollution is to be addressed in MSU-IIT together with further stress and anxiety among students, professors, and staff who study and work everyday.

3 DESCRIPTION OF EXISTING STORMWATER AND WASTEWATER SYSTEM

In this chapter, the existing stormwater and wastewater drainage of MSU-IIT together with its appurtenant structures will be discussed. Consequently, a general drainage inventory will be presented which summarize the findings after the series of field surveys was performed to validate the quantity and quality of both systems. An overview of the Sewage Treatment Plant of MSU-IIT shall be presented. In addition, existing rivers & creeks together with the flood prone areas of Barangay Tibanga will be determined as well to visualize how flooding behaves in the study area.

3.1 Description Of Existing Drainage and Appurtenant Structures

A series of surveys were conducted within MSU-IIT to locate the existing drainage and sewage system. A reconnaissance survey was initially launched to explore drainage infrastructure conditions and availability of the site. Simultaneously, a preliminary survey was performed to collect adequate data for the drainage and sewage system inventory. A secondary survey was initiated to update the record of the existing system. Tables 3.1, 3.2, and 3.3 details the manhole and catchment basin inventory produced from the survey of the existing drainage and sewage of MSU-IIT.

The drainage system consists of three (3) drainage types which are Reinforced Concrete Pipe Culvert (RCPC), Open Drainage Canal, and Box Drainage Type. In Table 3.1, tha drainage types are presented together with their respective dimensions.

Drainage Type	Length (Ln. meter)	Width/Diameter
Box Type	576.47	6" (0.15 m)
Open Canal Type	342.86	6" (0.15 m)
Reinforced Concrete Pipe Culvert (RCPC)	974.93	18” - 36" Ø (0.90m)

Table 3.1: Description of Existing Drainage Structures

On the other hand, the appurtenant structures in MSU-IIT are manholes and catchment basins and the total number of drainage manholes is 35 units while there are 27 units of catch basins in the campus.

Location	Drainage Type	Manhole		
		Dimension (in)	Quantity	Condition
CASS	Open Canal & RCPC	19.7 x 19.7	6	Partially silted and covered in vegetation
CEBA	Open Canal	19.7 x 19.7	1	
CET	Box Type			
COET	RCPC	19.7 x 19.7	6	Partially silted
CSM	RCPC	19.7 x 19.7	4	Partially silted
CSS	RCPC	-		
Dorm	RCPC & Box Type	19.7 x 19.7	5	Silted, blocked by garbage, & covered in vegetation
IDS	Box Type			
Lawn	RCPC& Box Type	19.7 x 19.7	1	
PRISM	RCPC			
Twin Court	RCPC	19.7 x 19.7	12	Partially silted

Table 3.2: Description of Existing Manhole

Location	Drainage Type	Catchment Basin		
		Dimension (in)	Quantity	Condition
CASS	Open Canal & RCPC	17.7 x 17.7	8	
CEBA	Open Canal	17.7 x 17.7	3	Partially silted
CET	Box Type			

COET	RCPC	17.7 x 17.7	7	
CSM	RCPC			
CSS	RCPC			
Dorm	RCPC & Box Type			Silted, blocked by garbage, & covered in vegetation
IDS	Box Type			Silted, blocked by garbage, & covered in vegetation
Lawn	RCPC& Box Type			
PRISM	RCPC	17.7 x 17.7	9	
Twin Court	RCPC			

Table 3.3: Description of Existing Catchment Basin

The MSU-IIT drainage system comprises two major lines: one major line starts from the Administrative Office to the outlet near the Alumni Boarding House, and another major line stretches from the campus entrance gate to an outlet in the back of the PRISM building as illustrated in Figure 3.1.

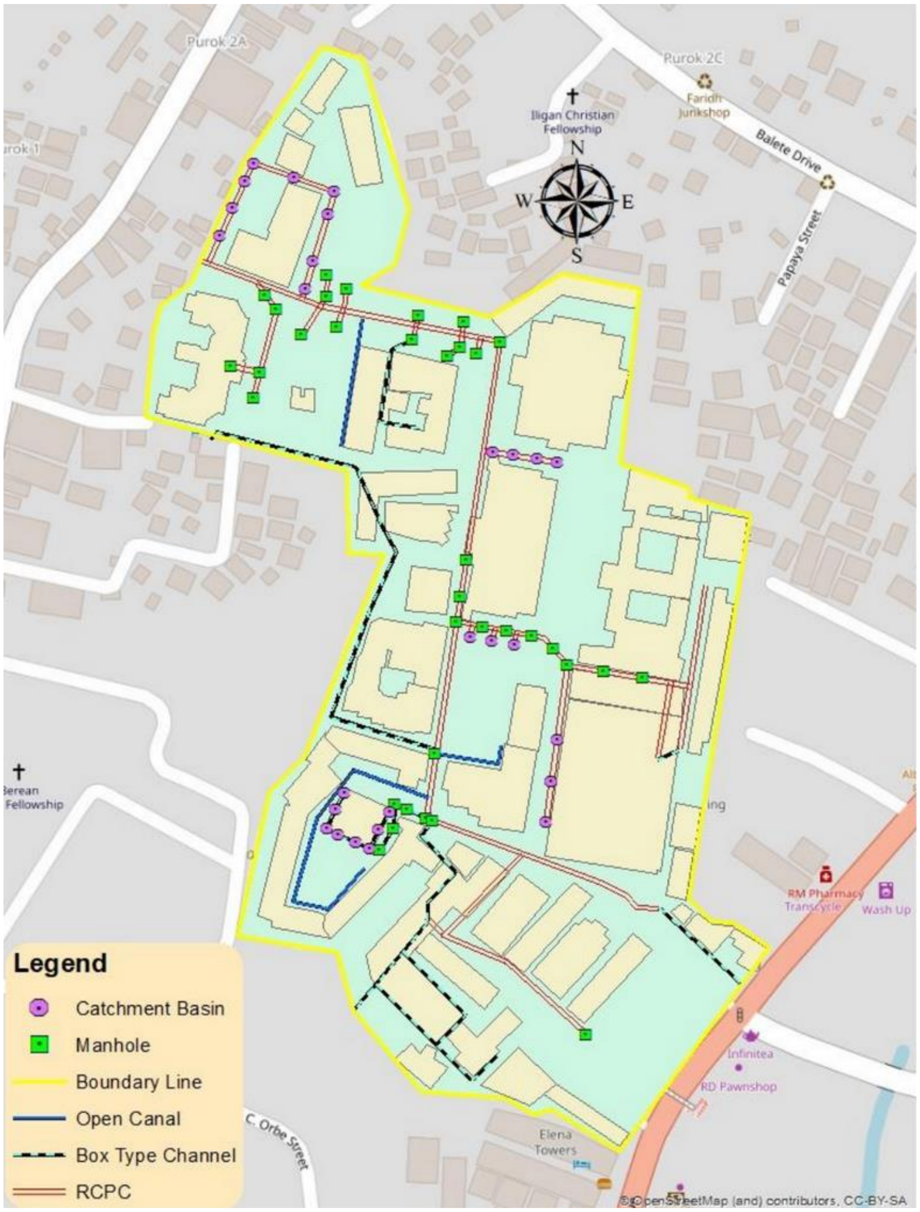


Figure 3.1: Existing Drainage and Appurtenant Structures Map of MSU-IIT

3.3 Description of Sewage Treatment Plant

3.3.1 Background of Sewage Treatment Plant

Currently, the Sewage Treatment Plant inside the campus caters to only selected buildings namely CSM, COE, CED, CBA and the Engineering Technology building with a total occupancy of 6,000 people. Table 3.4 shows the typical water-use and characterization studies for institutional facilities and it will be used to calculate the sewage design.

Use	Unit	Flow, gal/unit day	
		Range	Typical
Hospital, Medical	Bed	130-260	150
Rest Home	Resident	5-150	90
School, day			
i. with cafeteria, gym, & showers	Student	15-30	25
ii. with cafeteria only	Student	10-20	15
iii. with cafeteria & gym	Student	5-15	10
ix. school, boarding	Student	50-80	75

Source: Wastewater Engineering 3rd Edition, Metcak & Eddy

Table 3.4: Typical water-use values for institutional facilities

In Table 3.5, the calculation of volumetric flow rate is shown by multiplying the population, 6859, and typical per capita flow, 12.67 gallons per day resulting in 328 m^3 per day or 13.67 m^3 per hour . A peak flow factor of 1.5 is employed which makes a typical peak flow rate 19 gal per day that is equal to 492 m^3 per day or 20.50 m^3 per hour.

Population	Values	PHP Per Capita Typical Values, gal/day	Volumetric Flow Rate (gpd/m^3/day)
Faculty & Student Population, Total	6,859	12.67	86, 903 gpd =328.0 m^3/day =13.67 m^3/hr
Peak Flow Factor	x 1.5	19	130, 355 gpd =492 m^3/day =20.50m^3/hr

Table 3.5: Assumed Volumetric Flow Rate

3.3.2 Sewage Characteristics

Typical sewage characteristics with seven (7) design parameters are tabulated to show the design values of the Sewage Treatment Plant (Table 3.6).

Parameters	Influent	Septic Tank Removal Rate		Influent Value To STP	Designed Treated Water Effluent Values	DAO 35 Effluent Standard Values
		%	Effluent Values			
BODr,mg/l	500	30	350	350	30	50
COD,mg/l	1000	30	700	420	60	100
TSS, mg/l	500	70	150	150	50	70
TDS, mg/l	1000	30	700	700	700	---
FOG,mg/l	40	70	12	12	3	5
Color, pcu	850	50	425	425	150	150
E. Coli, MPN/100ml	>100,000	50	>50,000	>50,000	<5,000	<5,000
Volumetric Flow Rate	328 m³/day					
Peak Flow Rate	492 m³/day					

Source: AEI, computational assumptions

Table 3.6: Sewage Characteristics, designed removal rates and effluent values

3.4 Description Of Existing Rivers And Creeks

Whilst it is important to investigate the urban drainage system, it is equally important to take into account the existing rivers and creeks. It is considered that rivers and creeks are natural drainage systems of any landscape. The existing rivers and creeks in Iligan City are shown in **Table 3.7** together with the attributes associated with each feature.

Name of River or Creek	Existing Width (m)	Priority Length (m)	Tributary	Location of outlet
Mandulog River	70-200	4800	Manggas Creek	Iligan Bay
Iligan River	40-70	3500	Baslayan Creek	Iligan Bay
Manggas Creek	8	3869.76	Luinab Creek	Mandulog River
Sarangay Creek	6	1079.92	-	Iligan Bay
Baslayan Creek	6	1928.85	Salabao Creek	Iligan Bay
Salabao Creek	12	1754	Baslayan Creek	Iligan River
Camagi Creek	8	550.13	-	Iligan Bay
Bulog Creek	10	615.21	-	Iligan Bay

Table 3.7: Existing Rivers and Creeks

Iligan City comprises two major waterways (Mandulog River and Iligan River) and six minor waterways (Manggas Creek, Sarangay Creek, Baslayan Creek, Salabao Creek, Camagi Creek, and Bulog Creek. Both major and minor waterways in Iligan City serve as administrative boundaries between barangays. The waterways listed in here are the rivers and creeks that can be found in the urban center that provides natural drainage of the area.

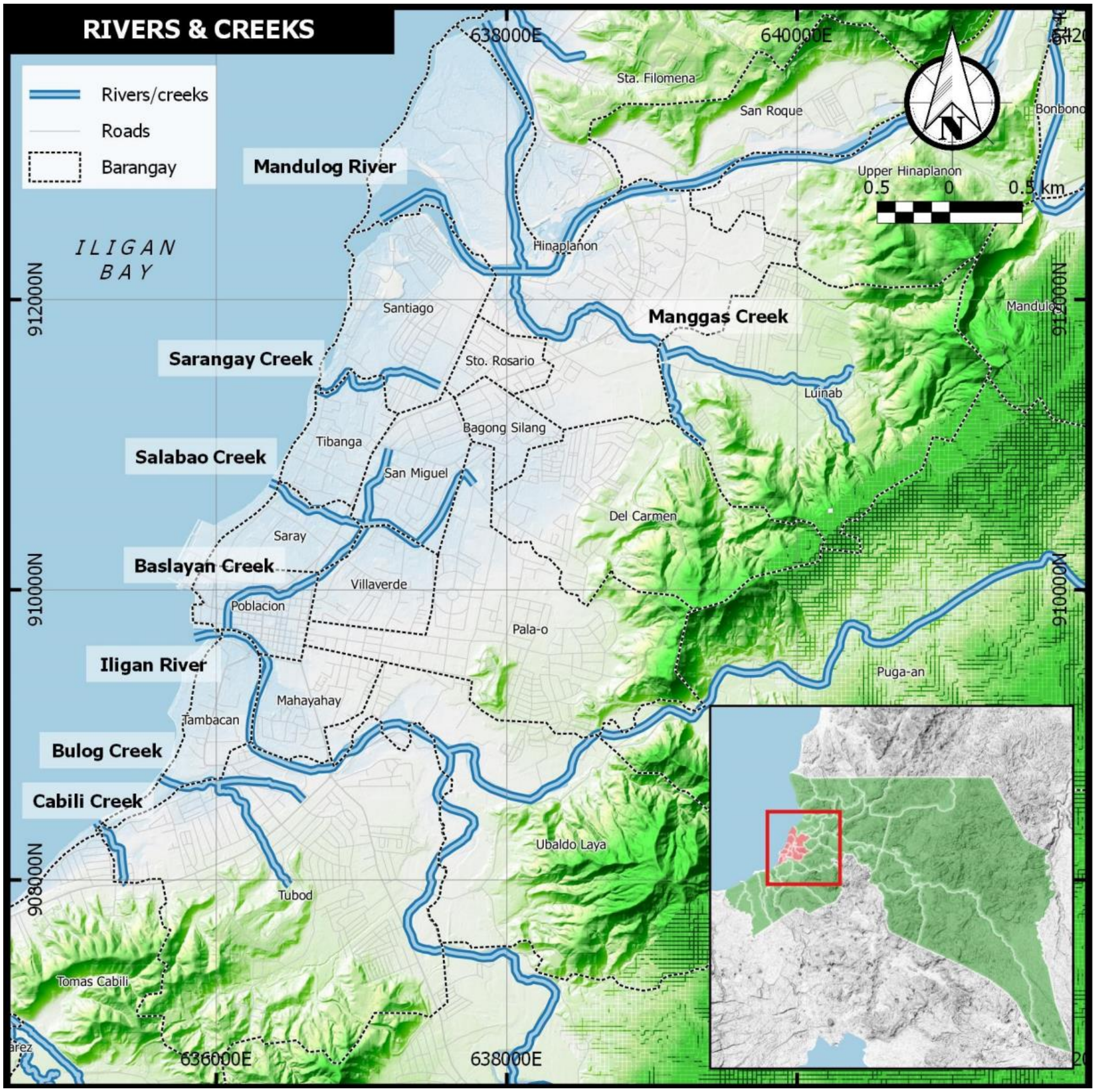


Figure 3.2: Existing Rivers and Creeks in the Urban Center of Iligan City

Three of the six minor waterways in Iligan City bounds Barangay Tibanga where MSU-IIT is located. These waterways are Sarangay Creek, Salabao Creek, and Baslayan Creek. In the succeeding section, the aforementioned minor waterways will be discussed along with initial assessment during the ocular inspection.

3.4.1 Description of Sarangay Creek

Sarangay Creek is located North of Barangay Tibanga which flows from Antonio Bartolomeo Jr. Avenue to Iligan Bay. It approximately stretches 1.08 kilometers and serves as an administrative boundary between Barangay Tibanga and Barangay Sto.

Rosario. It is shown in Figure 3.# the current condition of the outlet of Sarangay Creek. It's completely silted and blocked by garbage and vegetation.

Figure 3.2

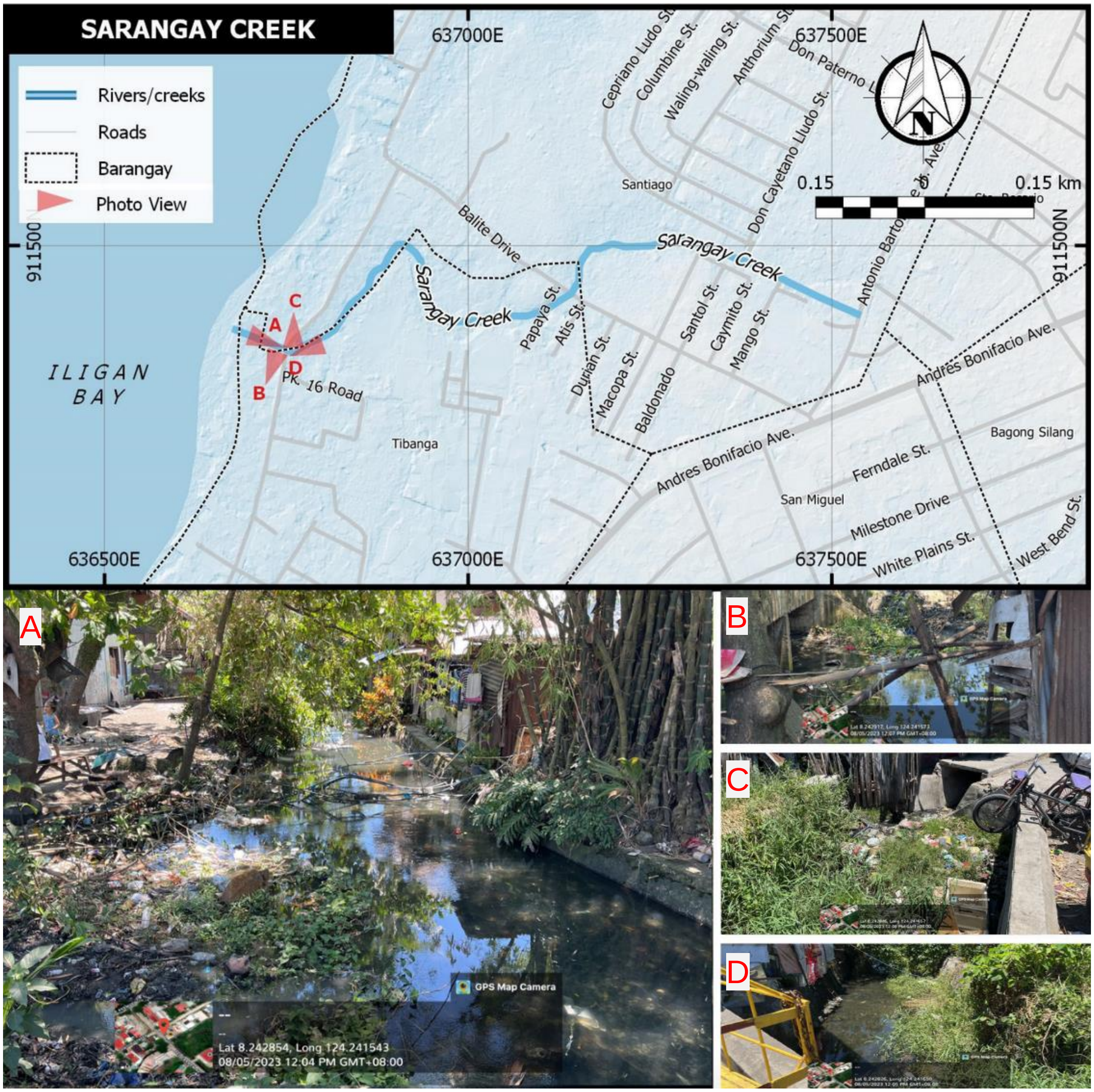


Figure 3.3: Sarangay Creek

3.4.2 Description of Baslayan & Salabao Creek

Barangay Tibanga is bounded by Baslayan Creek in the East and Salabao Creek in the South. Baslayan Creek stretches 1.92 km to Iligan River while Salabao Creek extends 1.75 km to Iligan Bay. Upon the ocular inspection of the waterways, it is found that both creeks are silted, as well as partially blocked by garbage and vegetation.

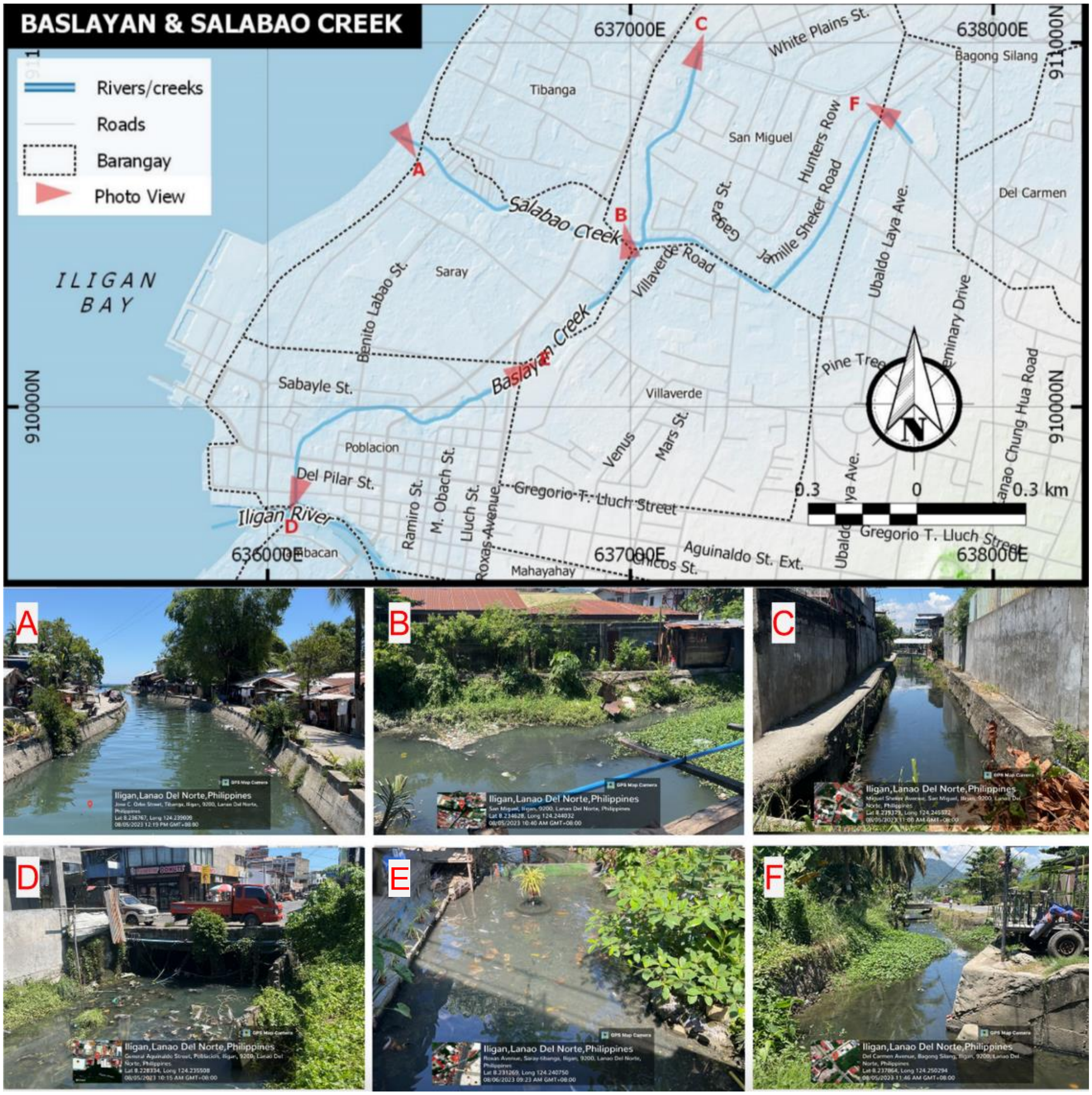


Figure 3.4: Baslayan & Salabao Creek

3.5 Description of Flood Prone Areas of Barangay Tibanga

Barangay Tibanga is one of the coastal barangays of Iligan City that is characterized by a flat terrain and low-lying elevation making it suitable for residential and institutional land use. However, the said characteristics in addition to the growing population of the area, which then affects the ground infiltration capacity, translates to a higher susceptibility of flooding.

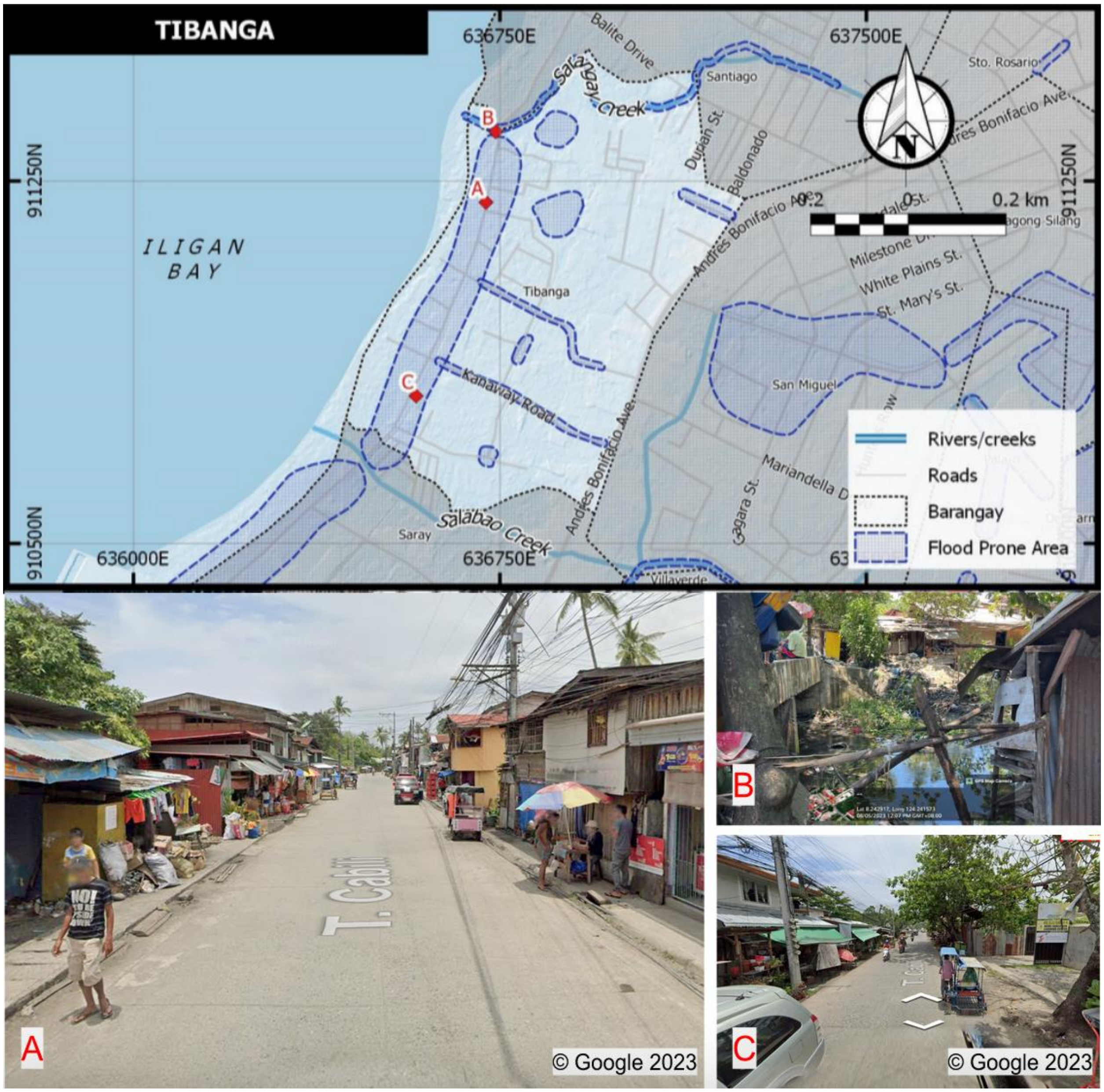


Figure 3.5: Flood Prone Areas of Barangay Tibanga

3.5 Summary of Findings

The current condition of the drainage system of MSU-IIT can be classified as in fair condition. Sediments, garbage, and vegetation results in the blocking of water flow from the drainage inlet to the outlet and as a consequence, the flooding inside the campus during heavy rainfall. In the Barangay level, the condition of the drainage system is the same as that of MSU-IIT on a larger scale. This occurrence signals the implementation of a robust and straightforward management plan of the drainage systems to ensure minimum damages in property and opportunity.

4 HYDROLOGICAL ANALYSIS

The simulation of the existing drainage system of MSU-IIT using GIS and SWMM will be discussed in this section. The succeeding subsections will interpret the simulation results of the drainage network.

4.1 Data Parameters

4.1.1 Sub-catchment Areas

A sub-catchment is similar to a smaller piece of a jigsaw puzzle which collects water when it rains. It can be a mini-land area that has its own terrain that leads to one exit drain. In MSU-IIT, the total land area is 9.1 hectares or 22.50 acres which was then divided to 178 sub-catchment areas for the simulation. The longest path water takes in the drainage system is 587.56 or 1927.69 feet.

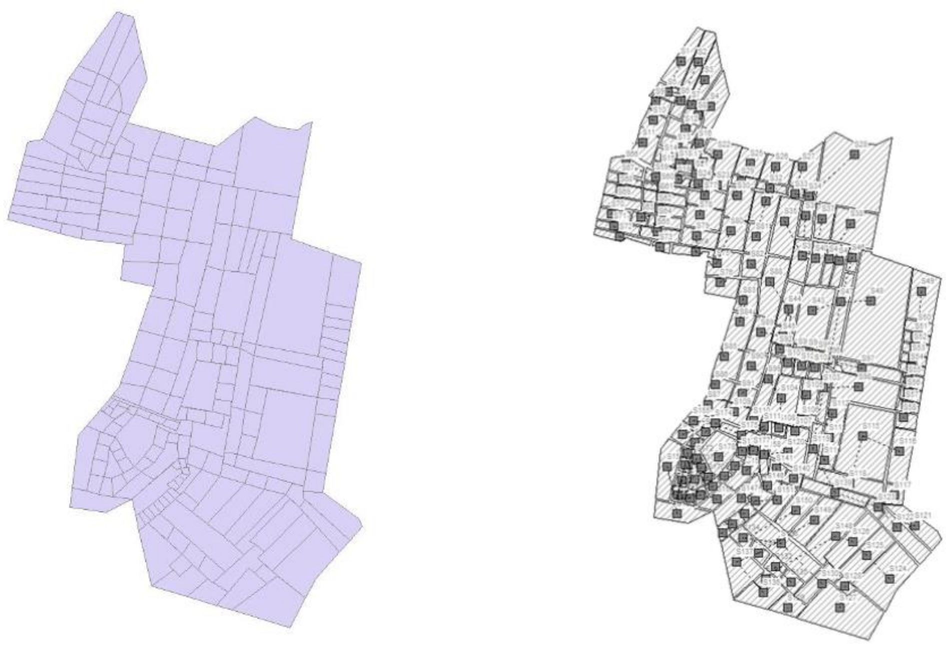


Figure 4.1: Sub-catchment Areas of MSU-IIT

4.1.2 Slope

The slope is one of the common parameters used by several formulas in estimating run-off. It is included in pipeline designs to aid the transportation of liquids in a downward direction as well as prevent accumulation of liquid in the pipe system. It is an important data parameter that was used and manipulated for the Manning's equation as well as for the subcatchments to enable the simulation. The slope used in this study ranges from 1-2%.

4.1.3 Rainfall Intensity

Rainfall intensity refers to the ratio of the quantity of rain (rainfall depth) falling during a certain period to the duration of the period and is expressed in depth units per unit time, usually as mm per hour (mm/hr). The rainfall intensity data was obtained from PAGASA, Lumbia, CDO which was used to enable the simulation. The sets of data used were in 2-yrRRP, 10-yrRRP and 25-yrRRP to identify whether the channel's capacity is in good condition to mitigate floods or poses issues that need improvement.

4.1.4 Manning's Coefficient

The Manning's n is a coefficient which represents the roughness or friction factor of channels. Manning's n-values can be calculated from field measurements but for convenience, they are often selected from existing tables. Their values will depend on the type of material the water will flow on. The Manning's coefficients utilized in this study were 0.017 for Rough Forms Concrete (Closed Conduit) and 0.030 for Vegetal (Open Conduit).

4.2 Hydraulic Analysis

Hydraulic analysis for each river or creek under existing conditions was carried out to determine the adequacy of the waterway to convey the runoff due to the design storm.

Modeling was done using the PCSWMM (Storm Water Management Model) model from the Computational Hydraulics Institute in order to quantify flood levels for each waterway.

4.2.1 Analysis of Flood Inundation

From the conducted hydraulic analyses on the modeled study area using the design floods 5, 10, 25, 50 and 100 years, runoff inundation maps were obtained.

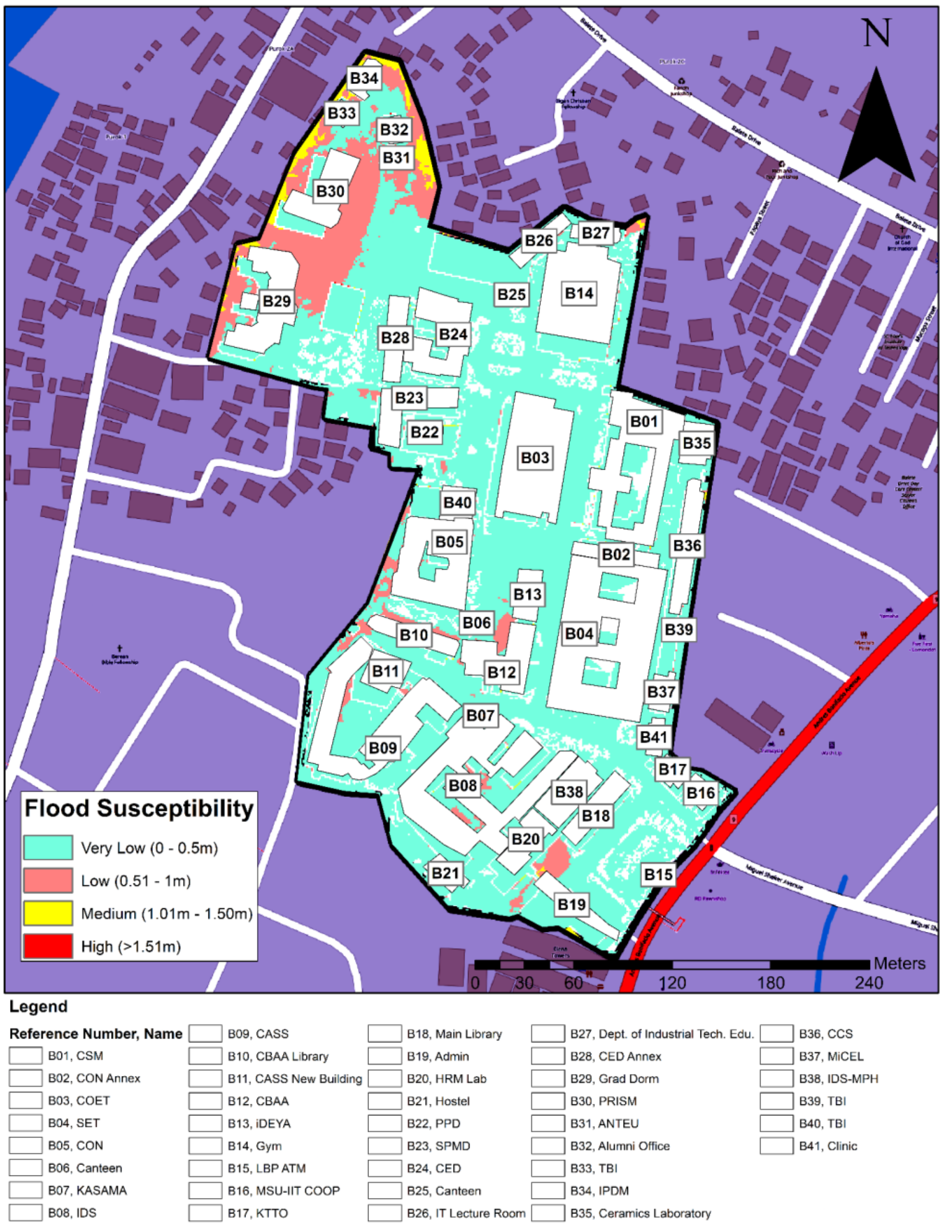
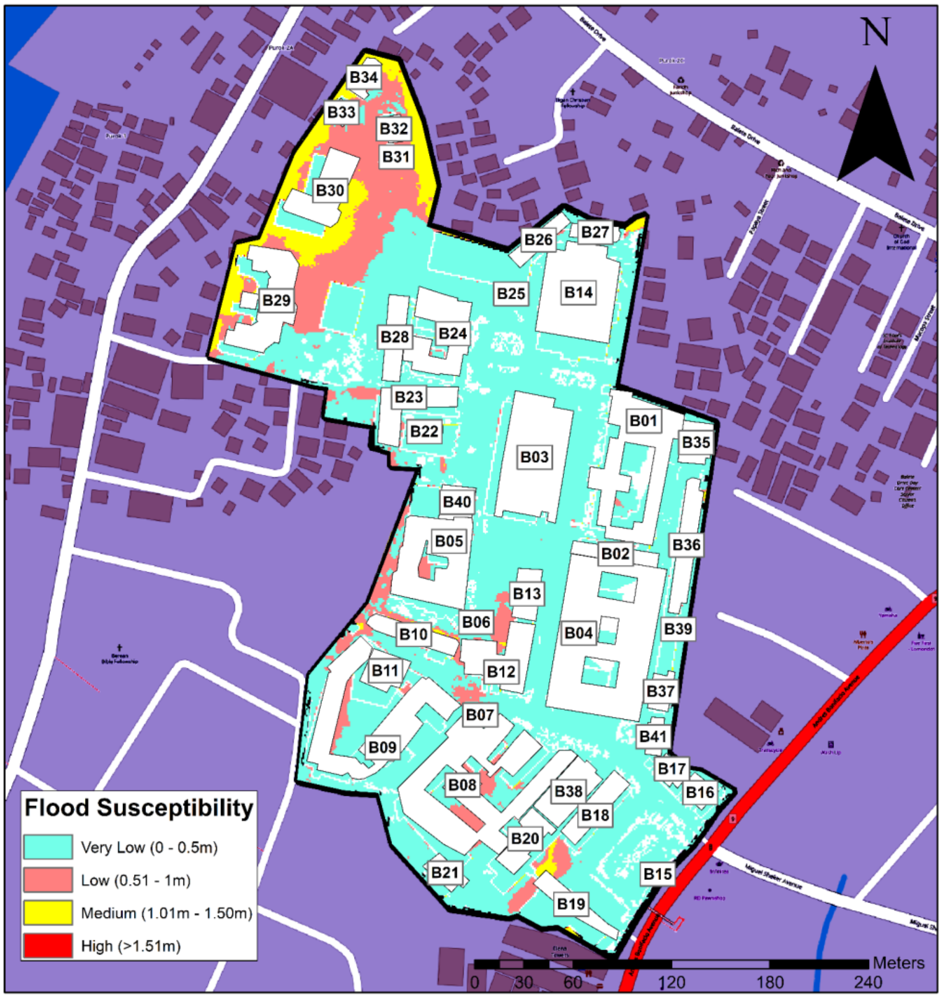


Figure 4.2: Flood Susceptibility of MSU-IIT (5 year)

Most of the inundated rainwater falls within the range Very Low to Low. The area with the least inundation of stormwater is identified to be beside the guardhouse. The area with the apparent highest level of inundation is at the area around Bahay-Alumni and PRISM buildings in MSU-IIT.



Legend

Reference Number, Name

B01, CSM	B09, CASS	B18, Main Library	B27, Dept. of Industrial Tech. Edu.	B36, CCS
B02, CON Annex	B10, CBAA Library	B19, Admin	B28, CED Annex	B37, MiCEL
B03, COET	B11, CASS New Building	B20, HRM Lab	B29, Grad Dorm	B38, IDS-MPH
B04, SET	B12, CBAA	B21, Hostel	B30, PRISM	B39, TBI
B05, CON	B13, iDEYA	B22, PPD	B31, ANTEU	B40, TBI
B06, Canteen	B14, Gym	B23, SPMD	B32, Alumni Office	B41, Clinic
B07, KASAMA	B15, LBP ATM	B24, CED	B33, TBI	
B08, IDS	B16, MSU-IIT COOP	B25, Canteen	B34, IPDM	
	B17, KTTO	B26, IT Lecture Room	B35, Ceramics Laboratory	

Figure 4.3: Flood Susceptibility of MSU-IIT (10 year)

The depths of the 10 year Rainfall Return Period simulation above roofs are mostly found to be within the range of Low. At lower elevation, areas near PRISM, Graduate Dormitory, IPDM, resulted in an increase in depth (1.01m - 1.50m).

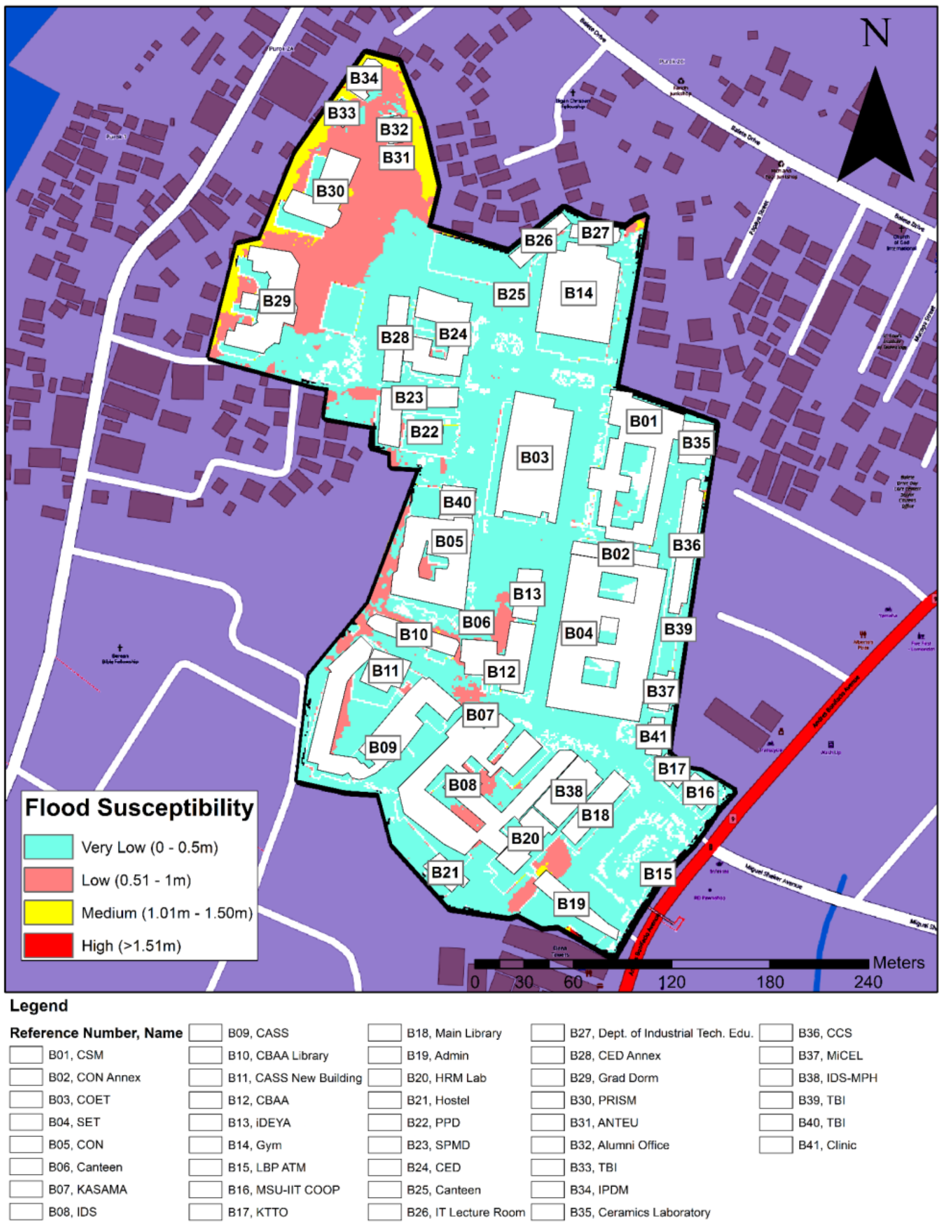


Figure 4.4: Flood Susceptibility of MSU-IIT (25 year)

Depth values of the 25 year falling under the ranges of 0.51m -1m have become more apparent. Inundation along the areas with lowest elevation in the study area has also exhibited having larger depths than the previous inundation maps for the design floods of 5 and 10 years.

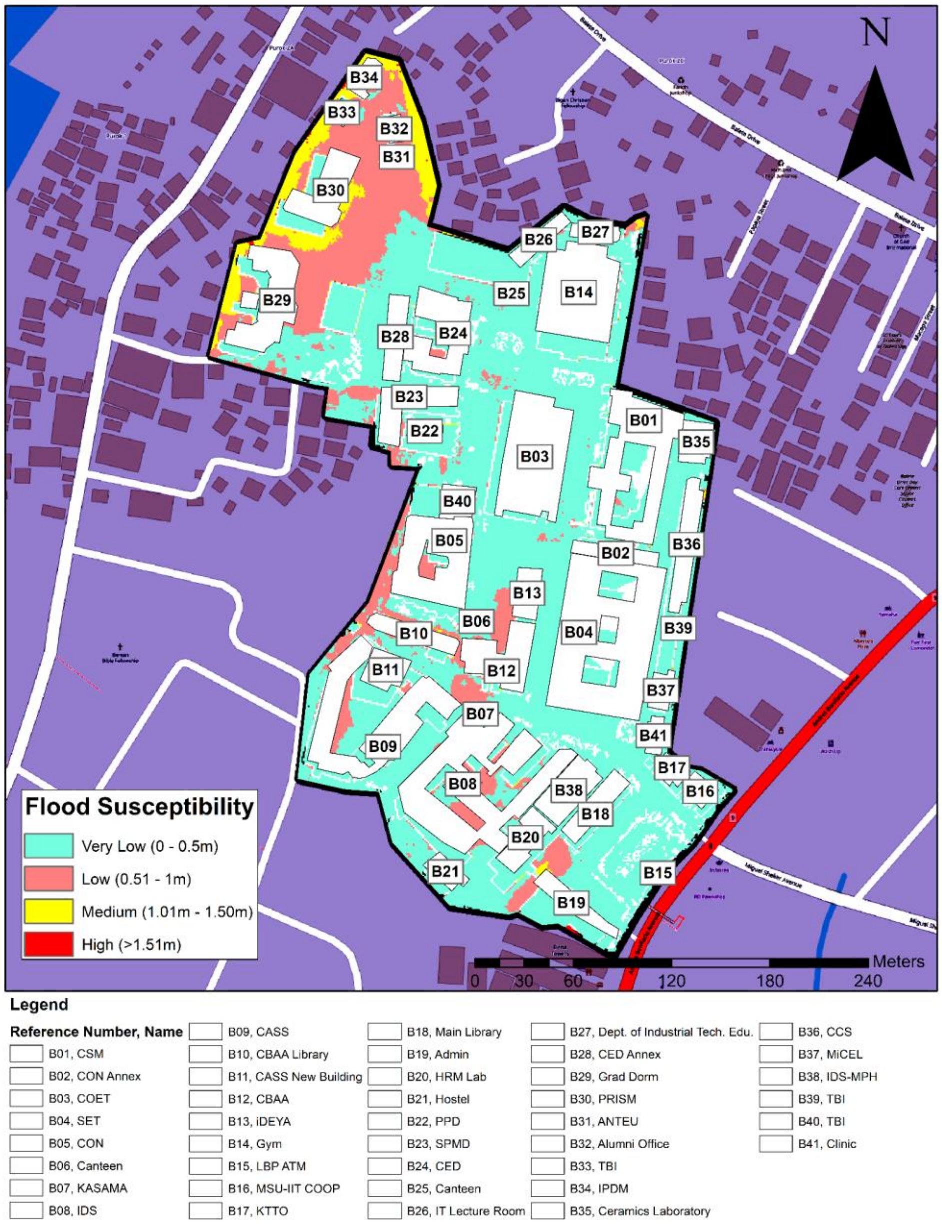


Figure 4.5: Flood Susceptibility of MSU-IIT (50 year)

For the 50-year inundation map shown above, the values for the depth mostly fell under the top-half of ranges of values. The area nearest to the existing creek, beside

PRISM, just outside MSU-IIT further exhibits the deepest value for depths among all the depth values acquired.

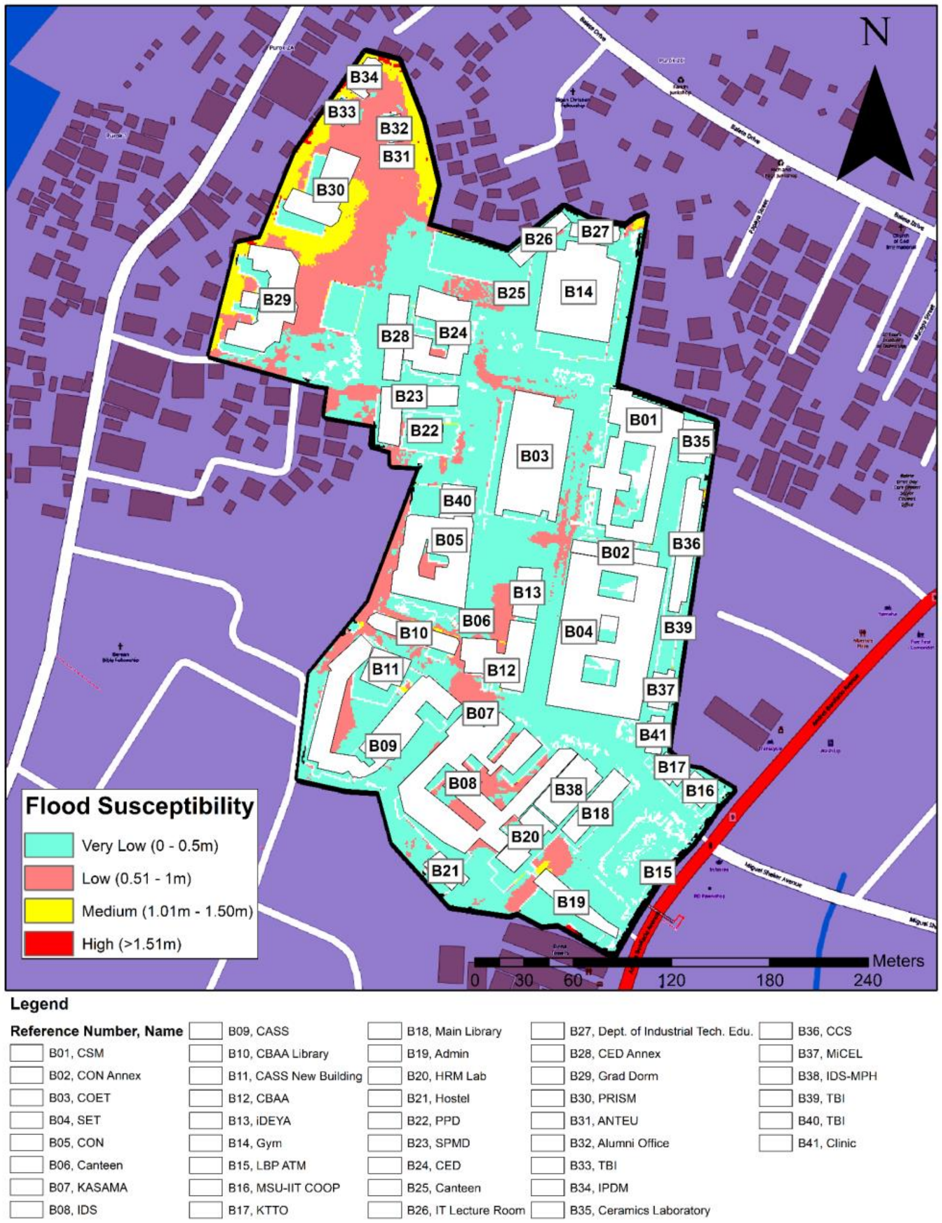


Figure 4.6: Flood Susceptibility of MSU-IIT (100 year)

The difference in flood depth for the 5, 10, 25, 50 and 100 years is not quite observable in the maps presented above. Higher depths of flood mostly occurs at the lower elevation of the campus i.e. PRISM, Graduate Dormitory, IPDM etc. Also, it is predominantly developed along the border surrounding the area near the outlet as shown above. The flood depth for the 100 year return period is around 1.5m.

	5 year	10 year	25 year	50 year	100 year
Volume of Runoff (m3)	345,375.22	380,960.93	385,871.09	387,757.67	406,841.12
Discharge (m3/s)	4.00	4.41	4.47	4.49	4.71

Table 4.1: Runoff and Discharge values per rainfall return period

The estimated peak discharge of the campus at the 5 years return period is 4 m3/s while the peak discharge increased over time for the 10, 25, 50 and 100 years return period is estimated at 4.41, 4.47, 4.49 and 4.71 m3/s respectively. Similarly, the volume of runoff also raised over time with values of 345,375.22, 380,960.93, 385,387.09, 387,757.67 and 406,841.12m3 at 5, 10, 25, 50 and 100 year return period respectively.

4.2.2 Analysis of MSU-IIT Drainage System

Summary

Due to its proximity to the shore and flat topography, MSU-IIT finds itself situated in an area prone to flooding. Compounding these factors is the extensive construction on the campus, which has resulted in a substantial concrete coverage, impeding natural infiltration. As a result water either flows on the surface or enters the drainage system. Observations were done and it was identified that there is a need for improvement in these specific segments of the drainage system at MSU-IIT.

Some of the channels are not in good condition to relay the water into the outfall as observed during their ocular inspection. Some of the channels are partially obstructed due to the presence of sediments of varying heights and vegetation growth. This obstruction has made it difficult at the outfall for water to flow out of the campus. There was also a lack of drainage line in some parts of the campus especially along the road in front of the COET campus. During heavy rainfall, flooding is to be expected in these areas. The evaluation of the drainage system at MSU-IIT involved comparing the predicted discharges obtained through SWMM simulations with the maximum discharge calculated using Manning's equation. The assumption made during this assessment was that the channels were in a state of full flow, allowing for the estimation of the maximum discharge. The result shows that some of the channels were not sufficient enough in accommodating their respective predicted discharges. During the 2-yrRRP simulation, there is a total number of 39 channel failures which covers one-third of the total number of channels. Then, 50 channels failed during the 10-yrRRP simulation covering about 44.6% of the total number of channels. Lastly, a total number of 56 channels failed during the 25-yrRRP simulation which accounted for 50% of the total channels in MSU-IIT. Most of the channel failures appear to be in the first main line since most of the discharges from different sources accumulate there.

An additional noteworthy observation is that the failure of channels or conduits does not necessarily imply flooding in a particular area but rather indicates the capacity limitations of the affected channels. This observation is significant because it helps distinguish between channel failures and the actual occurrence of flooding. This usually happens when conduits in a relatively elevated area fail but the runoff produced from the excess discharge the channels couldn't accommodate would accumulate in a lower elevated point which then turns into ponding.

To validate this understanding, an ocular inspection was conducted in areas where channel failures were observed, particularly in the CCS's channels identified on the 2-year channel failure map. Surprisingly, despite the failures in the channels, no instances of flooding were observed in those specific areas during the inspection. This further supports the notion that channel failures alone do not always translate into immediate flooding in the surrounding areas.

5 PROPOSED STRUCTURAL INTERVENTIONS

5.1 STRUCTURAL INTERVENTIONS

The proposed engineering program focuses on design of the main channel of stormwater drainage. These engineering measures are to address flooding in areas verified on site during the survey and other foregoing issues validated by the results of the flood inundation and hydraulic models (Figure 5.1).

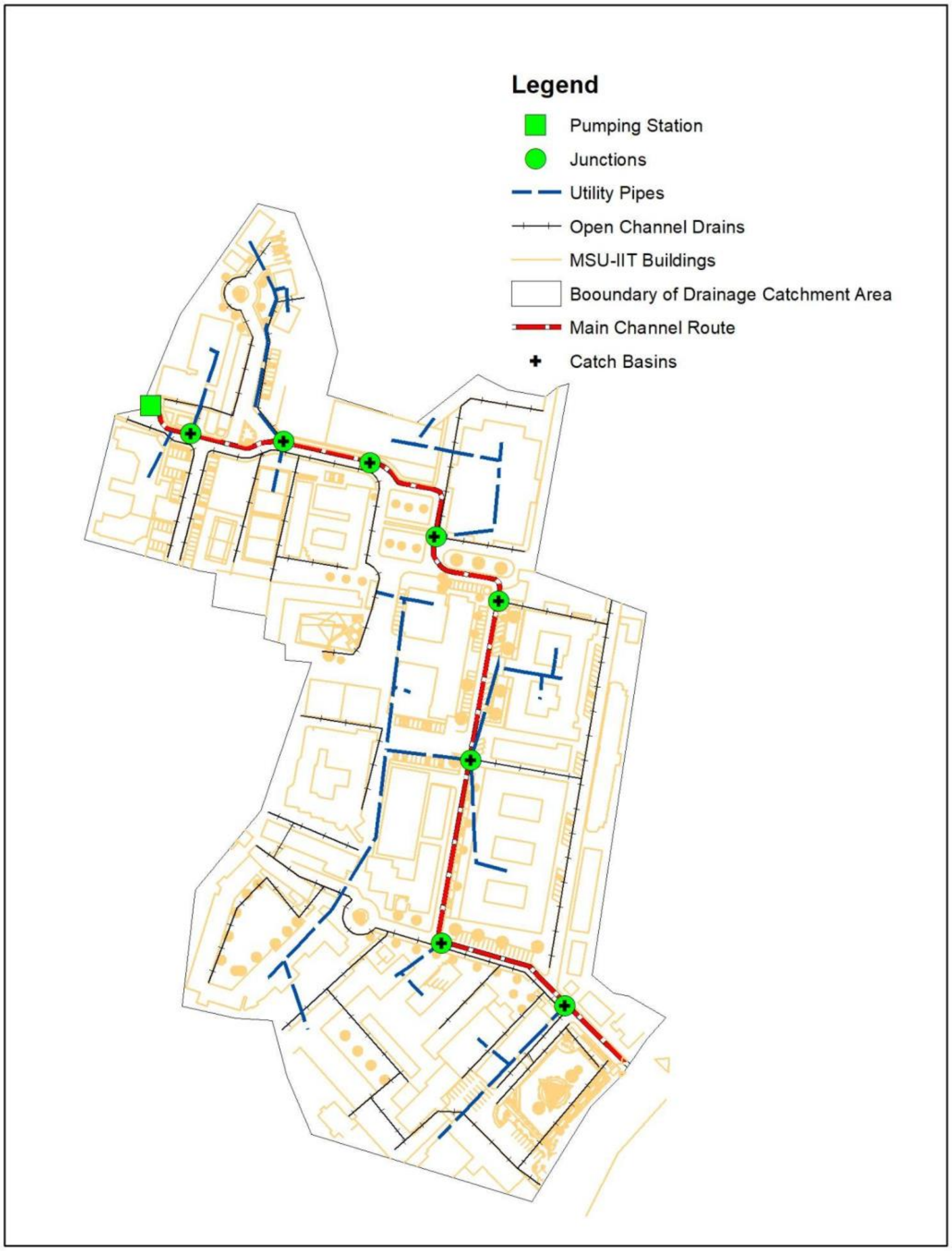


Figure 5.1: Proposed Engineering Interventions

5.1.1. New Drainage Mains

The main channel is by incorporating the use of reinforced concrete single barrels. The use of single barrels significantly limits the main channel route positioning to car lanes within MSU-IIT. Referencing the previously developed inundation maps, consistency in showing which areas are of lower elevations and are susceptible to flood inundation was significantly apparent. And by virtue of the shortest length acquirable, the main channel route is ultimately designed to be as shown below.

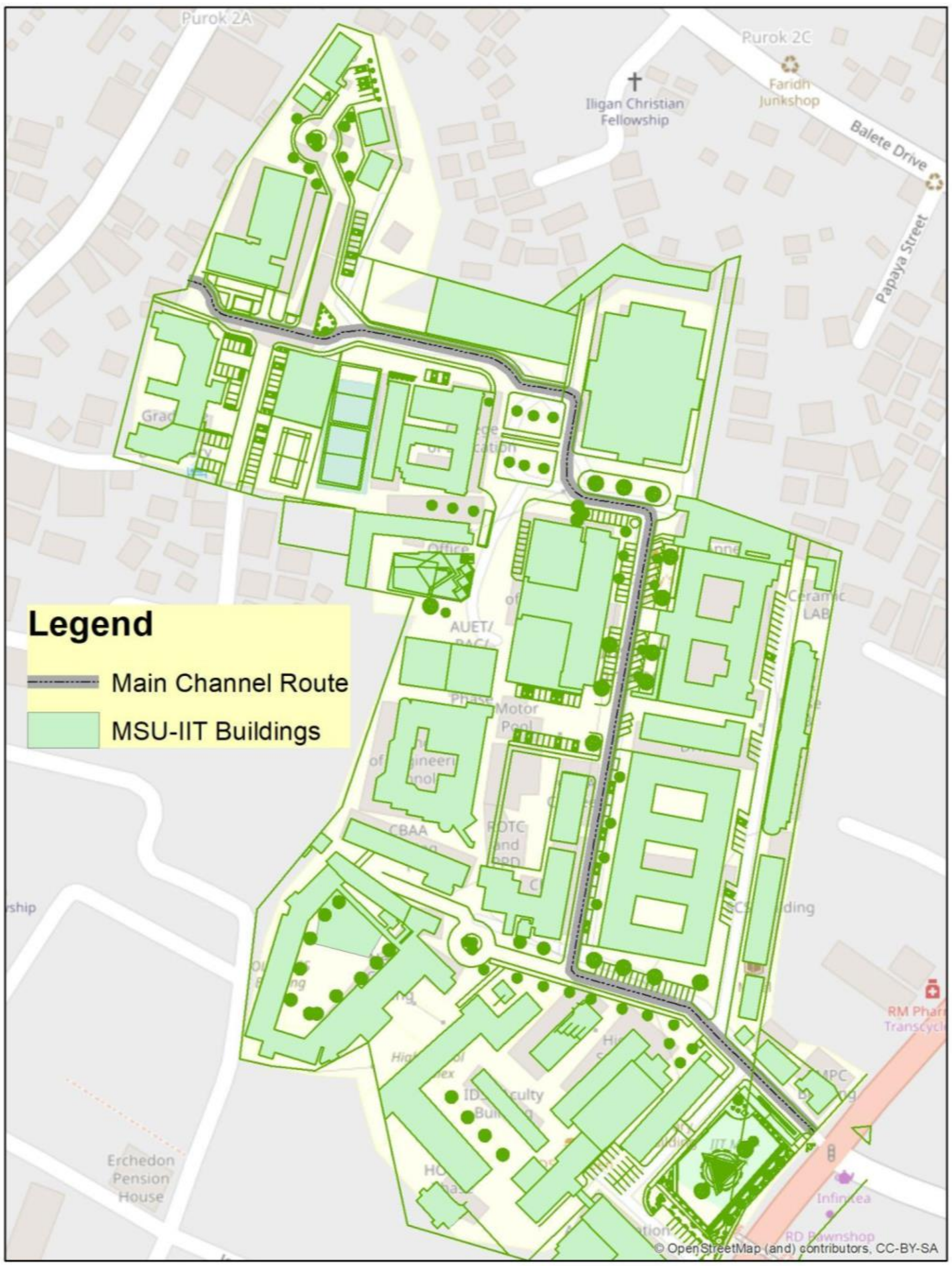


Figure 5.2: Proposed Route for the Main Channel of MSU-IIT Drainage System Composed of Reinforced Concrete Single Barrels

For the proposed underground drainage system, the main channel was placed on the right side of the road when entering the campus. With holes on the canal cover and catch basins at each junction, drainage of surface water is ensured and occurrence of stagnant water on the road will be minimal. A connecting underground canal also ensures that the water on the left side of the road will be passed through to the main channel and prevent overflow.

The connecting canal is designed to have the same slope as the right side of the road. The main channel is also designed to be right under the base course. For safety purposes, the trench or the concrete encasement of the utility pipes will be a distance away from the canal and catch basin, with a vertical clearance of 600 mm from the ground and 500 mm horizontal clearance from the adjacent canal.

Catch basins will be placed at every junction and will be covered with a 0.6 x 0.6 x 0.03 steel grating. The opening towards the main channel is designed to be 0.3 m. The canal cover will be reinforced concrete, with holes spaced 0.30 m between each one along the center for surface water drainage.

An overhead of 0.50 m will be added on the height of the main channel to make way for the openings which will also serve as an extra capacity. The openings on both sides will be 0.30 m, the same as the thickness of the main channel

From the conducted survey in this study, it was determined that the elevation of the starting point of the main channel is 3.04 meters and the elevation of the supposed last point is 0.559 meters. The stations used in the survey were plotted within the proposed main channel route of the drainage.

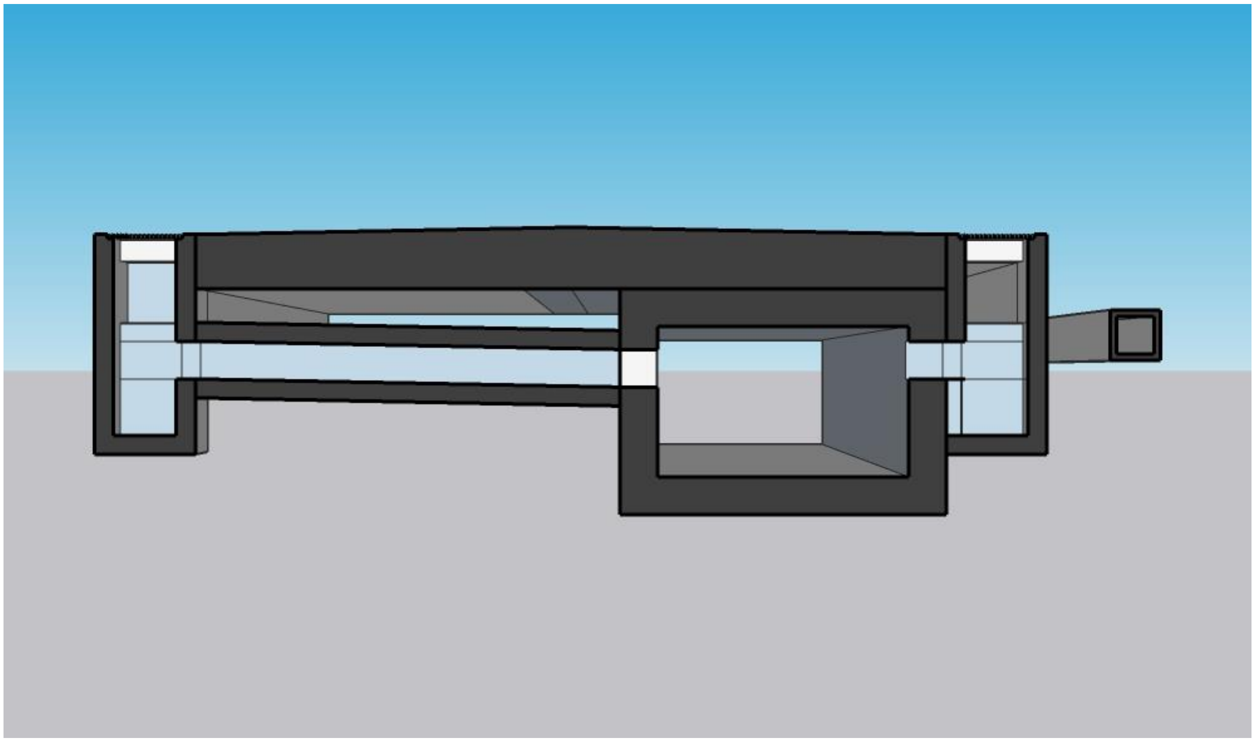


Figure 5.3: Proposed Drainage Design for the Main Channel of MSU-IIT Drainage System

6 SOCIAL DEVELOPMENT AND ENVIRONMENTAL PROGRAM (MANAGEMENT PLAN)

6.1 Social Issues and Concerns

6.1.1 Introduction

The problem of drainage has its underlying socio-economic factors while it is considered a technical issue. In this context, the drainage problem in MSU-IIT can be viewed as an adverse effect of industrialization.

Iligan City, where MSU-IIT is resided, has been dubbed as the “Industrial Center of the South” as its economy is largely based on heavy industries. Iligan's economy scaled-up when more large industries opened investments after the Maria Cristina Falls was utilized as power generating plant in the early 50's. The city grew into a highly urbanized city in 1983 after this had an impressive revenue collection performance. Iligan City eventually became an important economic center in Northern Mindanao because of its industries, commercial centers and educational facilities.

The institute’s infrastructures, particularly the drainage channels, were laid out in the university’s development decades ago. These however could no longer respond to the present demands of the growing populace. Recently, activities within the university are often distracted by frequent flooding caused by intense rainfall which is aggravated during high tide. Flooding usually affects the city's major business districts and the areas where important offices, institutions and other facilities are located

The current need of the institute to improve its drainage facilities can spur advancement as this can hasten the flow of the constituents of the campus and its services.

6.1.2 Extent of Flooding

The study by the Mines and Geo-sciences Bureau (MGB) in March 2010 identified 40 of the 44 barangays in Iligan City as flood-prone. Barangay Tibanga is located near the coastal area which is low lying and prone to flooding. This area is problematic as it is easily flooded during heavy rains and it takes longer time for the water to subside due to its low elevation of the ground. Notably, observations within MSU-IIT reveal that flood-prone areas are concentrated near COET, the region between CEBA and CASS, and IDS. Aside from the natural causes (intense rainfall aggravated by high tide), flooding in Iligan City is worsened by some human interventions specifically the following:

- the indiscriminate dumping of solid wastes which clogged most drainage lines,
- encroachment of structures within the waterways and easements;

6.1.3 Clogged Drainage, Catch Basins and Manholes

According to the findings during the visual inspection, certain drainage areas consist of open channels that gradually accumulate debris originating from higher elevations, including dirt, pebbles, garbage, and other waste materials. As a consequence, a significant number of channels exhibit sediment deposition to varying extents, while others have experienced partial blockage due to the growth of vegetation, and the presence of garbage. These obstructions significantly disrupt the smooth flow of water, impeding the overall effectiveness of the drainage system. The accumulation of garbage poses environmental risks and obstructs the channels, while the growth of vegetation further complicates the situation by reducing the visual clarity of the channel and potentially causing additional blockages. Moreover, the presence of sediments adds to the challenges by reducing the channel's capacity and increasing the potential for flooding. Under these circumstances, it is plausible that the underground culvert pipes, despite lacking verification, are susceptible to debris blockages. This poses another substantial challenge since these pipes are inaccessible for maintenance, thereby exacerbating the issue.

There are a total of 35 manholes and 27 catch basins within the premises of MSU-IIT (Figure #) . Some manholes were excluded due to being inaccessible and lack of verification regarding their functionality. Also, potential flood risks can arise when manholes and catchment basins are damaged or clogged, posing a potential risk to the inflow within the drainage line and potentially obstructing the free flow of water.

Location	Drainage Type	Catchment Basins		
		Dimensions (m)	Quantity	Condition
CASS	Open Canal & RCPC	0.5m x 0.5m	8	Not accessible
CEBA	Open Canal	0.5m x 0.5m	3	Partially silted
CET	Box Type			Not accessible
COET	RCPC	0.5m x 0.5m	7	Not accessible
CSM	RCPC			Not accessible
CCS	RCPC	-		Not accessible
Graduate Dormitory	RCPC & Box Type			Silted, blocked by garbage & covered in vegetation
IDS	Box Type			Silted, blocked by garbage & covered in vegetation
Lawn	RCPC & Box Type			Not accessible
PRISM	RCPC	0.5m x 0.5m	9	Not accessible
Twin Court	RCPC			Not accessible

Table 6.1: Description of Existing Catch basins

Location	Drainage Type	Manhole		
		Dimensions (m)	Quantity	Condition
CASS	Open Canal & RCPC	0.5m x 0.5m	6	Partially silted and covered in vegetation
CEBA	Open Canal	0.5m x 0.5m	1	Not accessible
CET	Box Type			Not accessible
COET	RCPC	0.5m x 0.5m	6	Partially silted
CSM	RCPC	0.5m x 0.5m	4	Partially silted
CCS	RCPC	-		Not accessible
Graduate Dormitory	RCPC & Box Type	0.5m x 0.5m	5	Silted, blocked by garbage & covered in vegetation
IDS	Box Type			Not accessible
Lawn	RCPC & Box Type	0.5m x 0.5m	1	Not accessible
PRISM	RCPC			Not accessible
Twin Court	RCPC	0.5m x 0.5m	12	Partially silted

Table 6.2: Description of Existing Maholes

6.2 Proposed Community Development Program

Given the plan to improve the drainage system of MSU-IIT and to ensure the implementation of the planned long and short term technical solutions for the appurtenant structures and drainage mains, the following Institute Development Programs are recommended that will directly address the above -mentioned social issues.

6.2.1 Community Participation in Solid Waste Management

Consistent and deliberate public education on proper waste disposal is necessary to gradually change the people's mindset and behavior toward solid waste management. Participation in solid waste management can provide a venue for the people to learn and enhance their skills in promoting an environment-friendly community. The following interventions are recommended:

- Strengthen the implementation of solid waste management program by enhancing the IEC program through intentional and long term positive messaging. Positive messaging will be designed to change people's behavior and practice toward proper solid waste over a long period of time;
- Promotion of best practices in solid waste management;
- Conduct of skills training related to solid waste management, e.g. how to make compost; making of novelty items from recyclable materials;
- Regular waste audits to assess the types and quantities of waste generated on campus
- Conduct of development researches on solid waste involving the community
- Consistent monitoring and reporting of waste management in the university.

In addition, the institute will activate and strengthen its Solid Waste Management Board (SWMB) which will develop, oversee, monitor and ensure the implementation of the solid waste management programs and projects.

7 ECONOMIC ANALYSIS (INVESTMENT PLAN)

Iligan City is frequently experiencing flooding primarily due to intense rainfall, which is aggravated by high tide. As reported, forest denudation and clogged drainage are among the major factors that caused flooding in the city. Clogged drainage is due to improper disposal of solid waste materials from residential and commercial areas.

The offices and colleges for the drainage master plan are within the flood-prone areas. The recent flood susceptibility assessment of these barangays is shown in the table below.

College/Office	Flood Susceptibility
CSM	Low
CON Annex	Very Low
COET	Low
SET (Old Building Complex)	Low
College of Nursing	Low
CON Canteen	Low
KASAMA	Low
IDS	Low
College of Arts and Social Sciences	Low
CEBA Library	Low
CASS New Building	Low
College of Economics, Business and Accountancy	Low

iDEYA	Low
Gymnasium	Very Low
LBP ATM	Very Low
MSU-IIT COOP	Very Low
KTTO	Very Low
Main Library	Very Low
Admin Bldg	Very Low
HRM Laboratory	Low
Hostel	Very Low
Physical Plant Division	Low
Supply and Property Management Building	Low
CED	Low
Canteen	Low
IT Lecture Room	Very Low
Dept. of Industrial Tech. Edu.	Very Low
CED Annex	Very Low
Graduate Dormitory	Low
PRISM	Medium
Admin & Non-teaching Employees Union	Medium
Alumni Office	Medium
TBI (Beside IPDM)	Medium
IPDM	Medium
Ceramic Training Center	Very Low
College of Computer Studies	Very Low

MiCEL	Very Low
IDS-MPH	Very Low
TBI (Near CCS)	Very Low
TBI (Near CON)	Very Low
Clinic	Very Low

Table 7.1: Flood Susceptibility Assessment

To address the negative impact of flooding in the priority flood prone buildings of MSU-IIT, the formulation of a Drainage Master Plan becomes essential. The plan is envisioned to include a holistic flood control program with corresponding investments and analysis of economic efficiency and sustainability. The latter involved an economic evaluation that examines the viability and efficiency of the proposed urban drainage and improvement of related works master plan.

The urban drainage master plan will help improve MSU-IITs existing infrastructures that will resolve socio-economic issues and concerns arising from the flooding incidents in identified areas in the institute. The national government is helping the Iligan city's infrastructure development, particularly the flood control interventions through the Department of Public Works and Highways (DPWH). The program implementation will eventually have significant social and health impacts to MSU-IIT, which may include improvement of access to public facilities and enhancement of development programs.

Economic Costs

The economic costs involved in the development of urban drainage and improvement of related works of MSU-IIT are as follows: Estimated Project Costs. The estimated costs of the proposed priority programs and projects for the urban drainage and improvement of related works in MSU-IIT is presented in Table 7.2

Investment Requirements. The total investment requirement to implement the proposed components of the drainage master plan amounted to PhP58.62 million (Table 7.4). This amount includes the funds needed for structure excavation (Common Soil) of PhP3.14 million (5% of total investment requirement), embankment from roadway excavation (Common Soil) of PhP681.20 thousand (1% of total investment requirement); aggregate subbase course of PhP1.26 million (2% of the total investment requirement); portland cement concrete pavement of PhP12.67 million (22% of the total investment requirement), reinforcing steel (Grade 40) of PhP18.91 million (32% of the total investment requirement) and structural concrete (CLASS A) of PhP21.98 million (37% of the total investment requirement).

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DESCRIPTION	QUANTITY	UNIT	UNIT COST	AMOUNT
STRUCTURE EXCAVATION (Common Soil)	5,381.42	Cu.M.	₱583.37	₱3,139,358.99
EMBANKMENT FROM ROADWAY EXCAVATION (Common Soil)	1,560.70	Cu.M.	₱436.47	₱681,198.73
AGGREGATE SUBBASE COURSE	527.4	Cu.M.	₱2,379.97	₱1,255,196.18
PORTLAND CEMENT CONCRETE PAVEMENT (Unreinforced, 0.28 m thick, 14 days)	5,274.00	Sq.M.	₱2,401.44	₱12,665,201.44
REINFORCING STEEL (Grade 40)	190,614.28	Kg.	₱99.18	₱18,905,124.29
STRUCTURAL CONCRETE (CLASS A), 28 DAYS	2,124.55	Cu.M.	₱10,344.44	₱21,977,280.00
			GRAND TOTAL	₱58,623,359.62

Table 7.2: Summary of Estimated Cost

7.3.2 Economic Benefits

Economic benefits constitute the extent to which the project contributes to increasing the value of consumption available to society. Economic benefits represent the societal contribution of preparing the master plan for the drainage and improvement of related works in MSU-IIT.

Generally, the benefits that can be derived from urban drainage and improvement of related works can be categorized into protection, economic and amenity benefits. Among the direct and indirect benefits are the following:

Protection Benefits

(a) Reduction of risks to human life

(b) Reduction in flood damage both to public facilities (roads, utilities and associated facilities) and private structures

(c) Reduction on emergency relief costs

(d) Reduction on health hazards from water borne diseases and unsanitary conditions

(e) Reduction on traffic accidents due to street flooding

(f) Improvement of water quality

Economic Benefits

(a) Reduction of damage to property and assets

(b Reduction in street maintenance costs on the prevention of runoff damage

(c) Reduction of interruption/lost to services

Amenity Benefits

(a) Improvement in aesthetic and visual impact of the institute given increased open space

(b) More comfortable living environment and improved public convenience

(c) Enhancement of recreational opportunities to include access to parks and other recreational area

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