Stormwater Drainage Data Inventory

Phuentsholing Thromde

June 2025

Strengthening Risk Information for Disaster Resilience in Bhutan (RIR) Project

INFRASTRUCTURE PLANNING AND FLOOD ADAPTATION DIVISION
DEPARTMENT OF HUMAN SETTLEMENT
MINISTRY OF INFRASTRUCTURE AND TRANSPORT
ROYAL GOVERNMENT OF BHUTAN

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ACKNOWLEDGEMENT

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IPFAD would like to express its appreciation to the Phuntsholing Thromde for their kind cooperation and on-site assistance throughout the course of the study. Their support and facilitation were vital in ensuring the smooth execution of the field surveys and data collection

We would also like to thank Geomatics and Logistic Division (GLD), DHS for developing the web-based GIS platform for the stormwater inventory that can be viewed online and downloaded.

TABLE OF CONTENTS

TABLE OF FIGURES

1. INTRODUCTION

1.1. Background

In Bhutan, until recently, the majority of urban towns, including Phuentsholing Thromde, have developed organically in the absence of structured urban planning frameworks. As a result, essential infrastructure systems such as stormwater drainage were often constructed without proper design guidelines, planning standards, or climate resilience considerations. This has significantly increased the vulnerability of urban areas to localized flooding, waterlogging, and other socio-environmental risks.

Despite the growing need, stormwater management planning remains largely absent across Bhutan's urban centers. Furthermore, there is a lack of reliable, spatially referenced data on existing drainage infrastructures across the country. This data deficiency poses a significant barrier to the effective planning, design, and implementation of climate-resilient stormwater management solutions.

As part of the initiative to address these gaps, the Infrastructure Planning and Flood Adaptation Division (IPFAD) under the Department of Human Settlement, Ministry of Infrastructure and Transport, has initiated a stormwater drainage inventory for Phuentsholing Thromde. The study was undertaken with financial support from the World Bank through the 'Strengthening Risk Information for Disaster Resilience in Bhutan Project.

1.2. Objective

The primary objective of this initiative was to establish a comprehensive web-based geospatial database of existing stormwater drainage infrastructure within the Phuentsholing Thromde. The data collected through this inventory will support future formulation of stormwater management plans.

The specific objectives are:

- Document and digitize existing drainage networks.
- Assess current conditions.
- Identify critical problem areas.

1.3. Description of Study Area

The study area includes the Phuentsholing Thromde, as shown in Figure 1

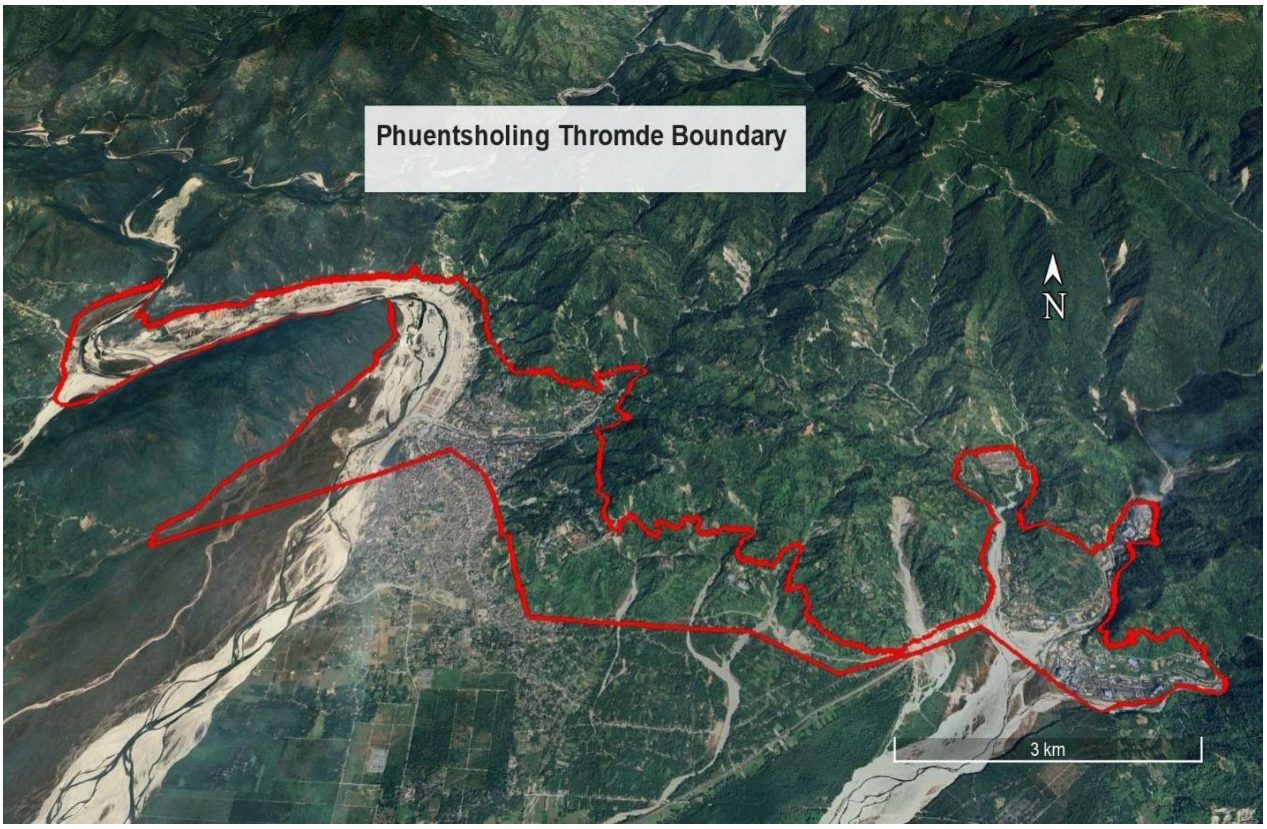


Figure 1: Study Area

2. METHODOLOGY

2.1. Field Survey

The field survey for the stormwater drainage inventory in Phuentsholing Thromde was conducted by the Infrastructure Planning and Flood Adaptation Division (IPFAD) using high-precision Real-Time Kinematic (RTK) surveying equipment. The use of RTK ensured accurate geolocation of each drainage asset, forming the spatial backbone of the geodatabase.

The survey was structured to capture a wide array of data points essential for assessing the drainage infrastructure. Each drainage segment was uniquely identified by a specific ID and name, facilitating accurate tracking and reference throughout the assessment process. This systematic approach not only enhances data integrity but also streamlines future monitoring and maintenance efforts.

The drains were classified by function into two categories:

- **Primary Drains**: These drains constitute the main conduits for stormwater conveyance and are responsible for managing the main flow of water.
- **Secondary Drains**: These drains collect and channel runoff from smaller catchments or local sources into the primary network.

This functional differentiation is vital for understanding the overall efficiency of the drainage system and for prioritizing the maintenance activities.

Additionally, the survey recorded the type of drainage for each identified drain, categorizing them as either:

- **Open Channels**: These are exposed systems and typically easier to inspect and maintain.
- **Closed Channels:** These are enclosed systems that are either covered or piped systems requiring more specialized maintenance and diagnostics.

To facilitate assessment of the physical and hydraulic performance of each drain, detailed structural attributes were also collected, including:

- **Section Type:** Each drain was classified as either rectangular or trapezoidal.

- **Dimensions:** The drain height and width, which directly influence flow capacity, were measured. These measurements are essential for evaluating whether the drain can handle the expected water volumes during peak flow periods.
- **Wall thickness**: This provides an indication of structural stability and resistance to erosion or collapse.
- **Material Type**: This provides the material type that the drain is made up of, including Random Rubble Masonry (RMM), concrete or earthen drains.

Furthermore, the survey captured site-specific conditions and issues affecting system performance, including:

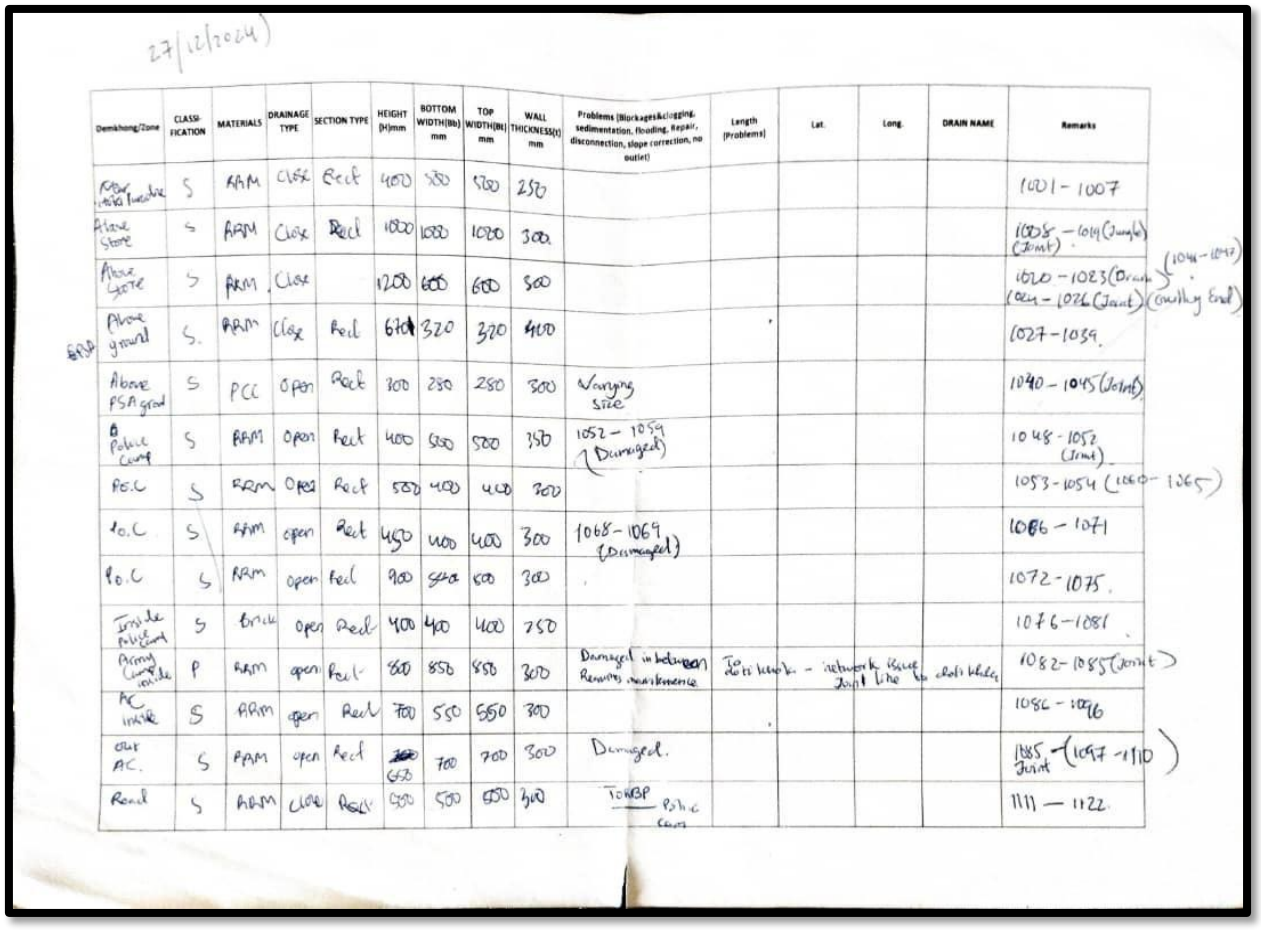
- Blockages due to debris accumulation,
- Sediments impairing the flow capacity,
- Structural failures, such as cracked or collapsed sections, and
- Poor or undefined discharge points, leading to localized flooding or erosion.

The location of each outlet was also recorded to complete the network mapping and to trace flow pathways from origin to discharge, facilitating both catchment-level analysis and identification of critical control points.

2.1.1 Data Collection at Site

The team from the Infrastructure Planning and Flood Adaptation Division visited the Phuentsholing Thromde on December 22, 2024, to collect the data for the existing drainage. The survey team from IPFAD, with assistance from the Thromde officials, conducted the survey over the course of one month, covering the Phuentsholing Thromde from the Phuentsholing Township Development Plan (PTDP) to the Pasakha Industrial State.

Figure 2: Field Data Collection



Demkhong/Zone	CLASSIFICATION	MATERIALS	DRAINAGE TYPE	SECTION TYPE	HEIGHT (H)mm	BOTTOM WIDTH(Bb) mm	TOP WIDTH(Bt) mm	WALL THICKNESS(t) mm	Problems (Blockages&clogging, sedimentation, flooding, Repair, disconnection, slope correction, no outlet)	Length (Problems)	Lat.	Long.	DRAIN NAME	Remarks
Near [illegible]	S	RRM	Close	Rect	400	500	500	250						1001 - 1007
Above Store	S	RRM	Close	Rect	1000	1000	1000	300						1008 - 1019 (Joint)
Above Store	S	RRM	Close		1200	600	600	500						1020 - 1023 (Drain) (1044 - 1047) (Outlet) 1024 - 1026 (Joint) (Outlet)
Above ground	S	RRM	Close	Rect	670	320	320	400						1027 - 1039
Above FSA gate	S	PCC	Open	Rect	300	250	250	300	Varying size					1040 - 1045 (Joint)
Police Camp	S	RRM	Open	Rect	400	500	500	350	1052 - 1059 (Damaged)					1048 - 1052 (Joint)
P.O.C	S	RRM	Open	Rect	500	400	400	300						1053 - 1054 (1060 - 1065)
P.O.C	S	RRM	open	Rect	450	400	400	300	1068 - 1069 (Damaged)					1066 - 1071
P.O.C	S	RRM	open	Rect	900	500	500	300						1072 - 1075
Inside Police Post	S	Brick	open	Rect	400	400	400	250						1076 - 1081
Army Camp inside	P	RRM	open	Rect	850	850	850	300	Damaged in between Requires maintenance	Intermittent - network issue Joint line to [illegible]				1082 - 1085 (Joint)
AC Inside	S	RRM	open	Rect	700	550	550	300						1086 - 1096
Other AC.	S	RRM	open	Rect	~~600~~ 650	700	700	300	Damaged.					1085 - (1097 - 1110) Joint
Road	S	RRM	Close	Rect	550	500	550	300	TOWBP Police Camp					1111 — 1122

Figure 3: Data Collected at the Site

2.2 Digitization and GIS Integration

After the field survey, the collected drainage data were organized, cleaned, and processed for integration into a GIS environment. Each drain's attributes, including location, type, dimensions, condition, and outlet points, were recorded using standardized formats to ensure consistency.

The data were then digitized and mapped using ArcGIS. This involved creating a geodatabase where each drainage segment was linked to its corresponding attribute data. Photographs taken during the survey were also tagged and attached for visual reference.

Furthermore, problem areas identified in the field, such as blocked or damaged drains, were marked on the map for easy identification and follow-up.

After the completion of digitization and GIS integration, the storm drainage inventory was published to a web-based GIS platform to allow remote access and visualization. This involved exporting the geospatial data layers to a compatible web format and uploading them to a GIS server environment. A web map was then configured with relevant symbology, layer controls, and attribute pop-ups to allow users to interact with the data. Customized tools such as search, filter, and identify functions were added to improve usability. The final web application was embedded into a publicly accessible website, ensuring that the drainage network data is easily navigable through a standard web browser without the need for specialized GIS software.

This digital integration ensures future updates can be seamlessly incorporated as the drainage infrastructure evolves.

3. RESULTS AND INVENTORY OUTPUT

3.1. Overview of Collected Data

A total length of approximately 37.2 km of drainage is mapped, with 285 numbers of drainage segments identified. Of these, 41.4 % are Primary drains while the rest 58.6 % were identified as Secondary drains. Moreover, 68 % are open channels while the remaining 32 % are closed channels. Furthermore, 92% are rectangular section type, while the remaining 8% are trapezoidal. Finally, 57.2% are made of Random Rubble Masonry (RMM), 5% are made of Reinforced Cement Concrete (RCC), 28.4% made of Plain Cement Concrete (PCC), and the remaining 9.4% is made up of Brick Masonry.

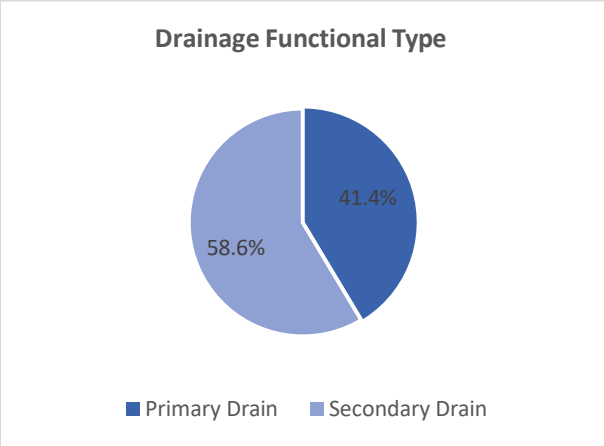


Figure 4: Drainage classification (Functional Type)

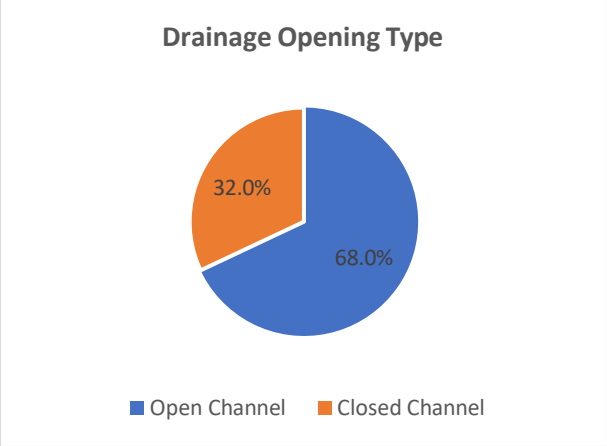


Figure 5: Drainage Classification (Opening Type)

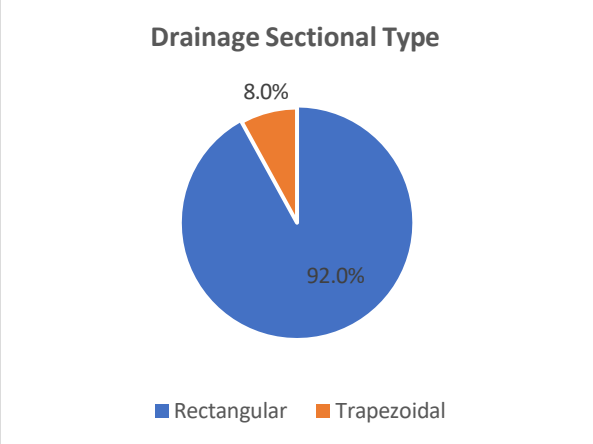


Figure 6: Drainage Classification (Section Type)

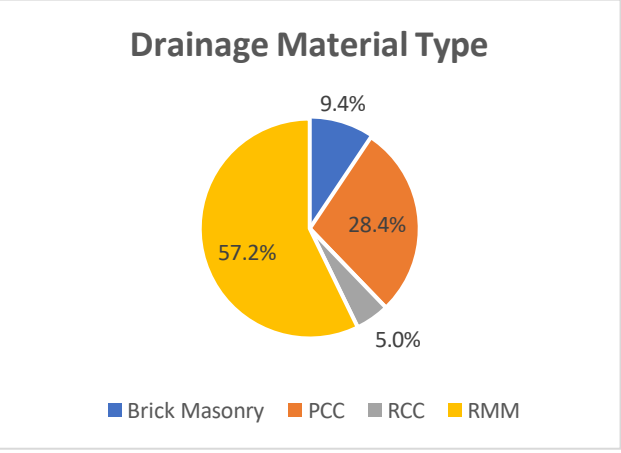


Figure 7: Drainage Classification (Material Type)

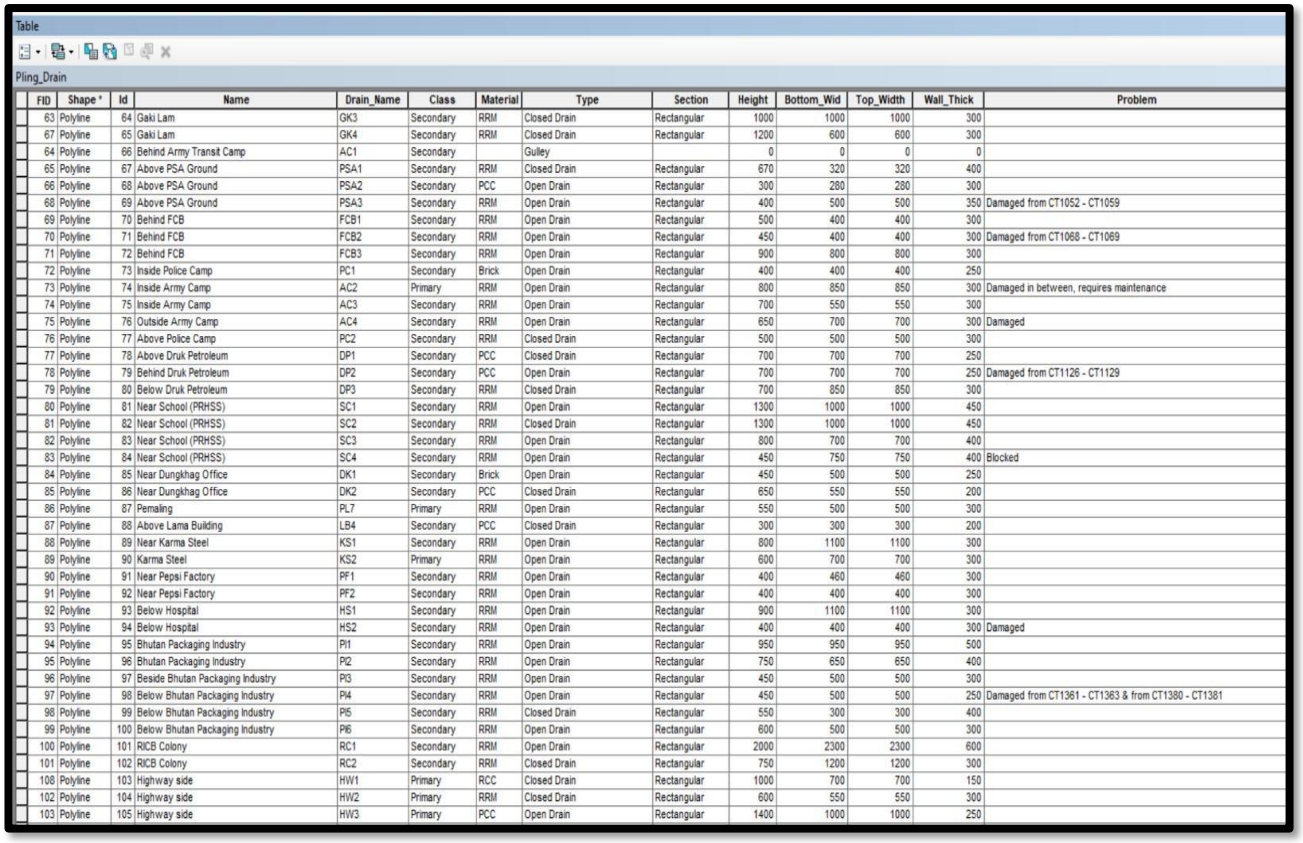
3.2 GIS data inventory of existing drainage

The GIS inventory produced through this project provides a detailed digital mapping of the existing stormwater drainage infrastructure within the Phuntsholing Thromde. Each drainage segment captured during the survey was georeferenced and digitized in a GIS environment, with attributes linked to corresponding spatial features.

The attribute data includes segment ID, location, functional classification (primary or secondary), structural details (open or closed), section type (rectangular or trapezoidal), material type, and dimensional measurements (height, width, thickness). Additionally, photographs captured on-site were linked to their respective locations for visual reference.

This comprehensive geodatabase allows stakeholders to visualize the drainage network, query data based on attributes, and overlay other planning or hazard information for further analysis. Figures 8 and 9 illustrate the map showing survey point ID of drains sample attribute tables extracted from the GIS database.

Figure 8: Drainage with Survey point ID in GIS



Table

Pling_Drain

FID	Shape *	Id	Name	Drain_Name	Class	Material	Type	Section	Height	Bottom_Wid	Top_Width	Wall_Thick	Problem
63	Polyline	64	Gaki Lam	GK3	Secondary	RRM	Closed Drain	Rectangular	1000	1000	1000	300	
67	Polyline	65	Gaki Lam	GK4	Secondary	RRM	Closed Drain	Rectangular	1200	600	600	300	
64	Polyline	66	Behind Army Transit Camp	AC1	Secondary		Gulley		0	0	0	0	
65	Polyline	67	Above PSA Ground	PSA1	Secondary	RRM	Closed Drain	Rectangular	670	320	320	400	
66	Polyline	68	Above PSA Ground	PSA2	Secondary	PCC	Open Drain	Rectangular	300	280	280	300	
68	Polyline	69	Above PSA Ground	PSA3	Secondary	RRM	Open Drain	Rectangular	400	500	500	350	Damaged from CT1052 - CT1059
69	Polyline	70	Behind FCB	FCB1	Secondary	RRM	Open Drain	Rectangular	500	400	400	300	
70	Polyline	71	Behind FCB	FCB2	Secondary	RRM	Open Drain	Rectangular	450	400	400	300	Damaged from CT1068 - CT1069
71	Polyline	72	Behind FCB	FCB3	Secondary	RRM	Open Drain	Rectangular	900	800	800	300	
72	Polyline	73	Inside Police Camp	PC1	Secondary	Brick	Open Drain	Rectangular	400	400	400	250	
73	Polyline	74	Inside Army Camp	AC2	Primary	RRM	Open Drain	Rectangular	800	850	850	300	Damaged in between, requires maintenance
74	Polyline	75	Inside Army Camp	AC3	Secondary	RRM	Open Drain	Rectangular	700	550	550	300	
75	Polyline	76	Outside Army Camp	AC4	Secondary	RRM	Open Drain	Rectangular	650	700	700	300	Damaged
76	Polyline	77	Above Police Camp	PC2	Secondary	RRM	Closed Drain	Rectangular	500	500	500	300	
77	Polyline	78	Above Druk Petroleum	DP1	Secondary	PCC	Closed Drain	Rectangular	700	700	700	250	
78	Polyline	79	Behind Druk Petroleum	DP2	Secondary	PCC	Open Drain	Rectangular	700	700	700	250	Damaged from CT1126 - CT1129
79	Polyline	80	Below Druk Petroleum	DP3	Secondary	RRM	Closed Drain	Rectangular	700	850	850	300	
80	Polyline	81	Near School (PRHSS)	SC1	Secondary	RRM	Open Drain	Rectangular	1300	1000	1000	450	
81	Polyline	82	Near School (PRHSS)	SC2	Secondary	RRM	Closed Drain	Rectangular	1300	1000	1000	450	
82	Polyline	83	Near School (PRHSS)	SC3	Secondary	RRM	Open Drain	Rectangular	800	700	700	400	
83	Polyline	84	Near School (PRHSS)	SC4	Secondary	RRM	Open Drain	Rectangular	450	750	750	400	Blocked
84	Polyline	85	Near Dungkhag Office	DK1	Secondary	Brick	Open Drain	Rectangular	450	500	500	250	
85	Polyline	86	Near Dungkhag Office	DK2	Secondary	PCC	Closed Drain	Rectangular	650	550	550	200	
86	Polyline	87	Pemaling	PL7	Primary	RRM	Open Drain	Rectangular	550	500	500	300	
87	Polyline	88	Above Lama Building	LB4	Secondary	PCC	Closed Drain	Rectangular	300	300	300	200	
88	Polyline	89	Near Karma Steel	KS1	Secondary	RRM	Open Drain	Rectangular	800	1100	1100	300	
89	Polyline	90	Karma Steel	KS2	Primary	RRM	Open Drain	Rectangular	600	700	700	300	
90	Polyline	91	Near Pepsi Factory	PF1	Secondary	RRM	Open Drain	Rectangular	400	460	460	300	
91	Polyline	92	Near Pepsi Factory	PF2	Secondary	RRM	Open Drain	Rectangular	400	400	400	300	
92	Polyline	93	Below Hospital	HS1	Secondary	RRM	Open Drain	Rectangular	900	1100	1100	300	
93	Polyline	94	Below Hospital	HS2	Secondary	RRM	Open Drain	Rectangular	400	400	400	300	Damaged
94	Polyline	95	Bhutan Packaging Industry	PI1	Secondary	RRM	Open Drain	Rectangular	950	950	950	500	
95	Polyline	96	Bhutan Packaging Industry	PI2	Secondary	RRM	Open Drain	Rectangular	750	650	650	400	
96	Polyline	97	Beside Bhutan Packaging Industry	PI3	Secondary	RRM	Open Drain	Rectangular	450	500	500	300	
97	Polyline	98	Below Bhutan Packaging Industry	PI4	Secondary	RRM	Open Drain	Rectangular	450	500	500	250	Damaged from CT1361 - CT1363 & from CT1380 - CT1381
98	Polyline	99	Below Bhutan Packaging Industry	PI5	Secondary	RRM	Closed Drain	Rectangular	550	300	300	400	
99	Polyline	100	Below Bhutan Packaging Industry	PI6	Secondary	RRM	Open Drain	Rectangular	600	500	500	300	
100	Polyline	101	RICB Colony	RC1	Secondary	RRM	Open Drain	Rectangular	2000	2300	2300	600	
101	Polyline	102	RICB Colony	RC2	Secondary	RRM	Closed Drain	Rectangular	750	1200	1200	300	
108	Polyline	103	Highway side	HW1	Primary	RCC	Closed Drain	Rectangular	1000	700	700	150	
102	Polyline	104	Highway side	HW2	Primary	RRM	Closed Drain	Rectangular	600	550	550	300	
103	Polyline	105	Highway side	HW3	Primary	PCC	Open Drain	Rectangular	1400	1000	1000	250	

Figure 9: Attribute Table

3.3 Web-Based GIS Platform

To enhance accessibility and usability, the digitized drainage inventory was published on a web-based GIS platform. The system allows users to interact with the drainage data through a standard web browser without requiring specialized GIS software. The platform includes features such as attribute pop-Ups, whereby **c**licking on any drainage segment displays its detailed attribute information. The inventory can be accessed through the website https://inframap.ddnsfree.com/#/ Figures 10, 11, and 12 provide screenshots demonstrating the structure and usability of the web GIS system.

Figure 10: Overview of Web Based Drainage System

Figure 11: Overview of web-based drainage system with linked attribute

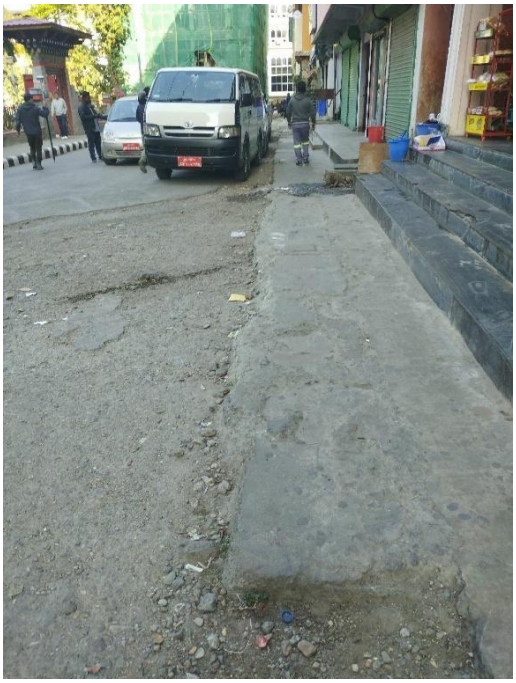
Figure 12: Overview of web-based drainage system with photos of the drains

4. IDENTIFIED ISSUES AND OBSERVATIONS

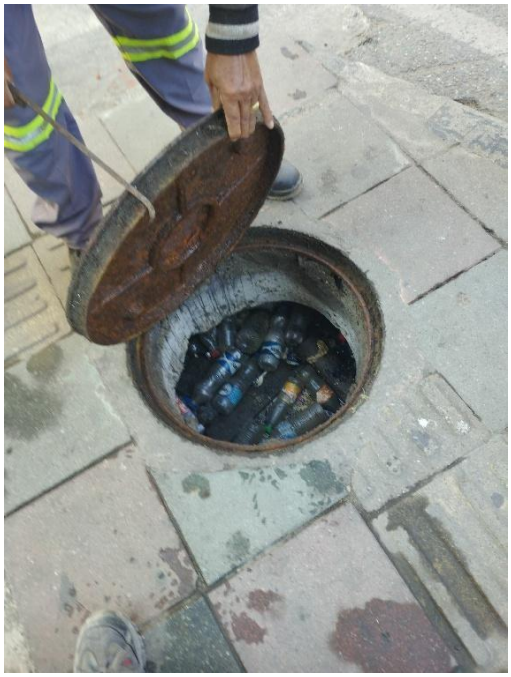
4.1. Problematic Points:

Several problematic points were identified during the field survey. In the geodatabase, these points are marked with red lines. Common issues include blockages, deteriorated conditions, and missing outlet connections. These problems are primarily attributed to poor maintenance, siltation, structural failures, and informal extensions of the drainage network.

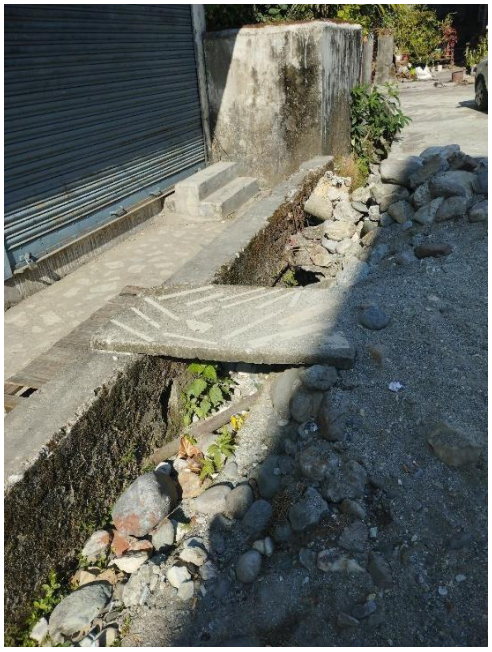
	
Damaged drain near the terminal	Damaged drain inside Thromde Parking



Blocked Drain above Zangdopelri



Blocked Drain near Kaja Throm

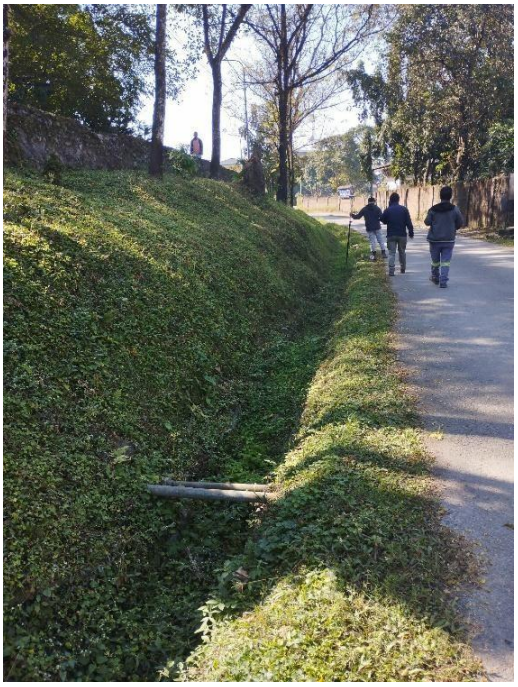


Damaged Drain above PSA ground

Damaged Drain behind FCB

Blocked Drain near School (PRHSS)

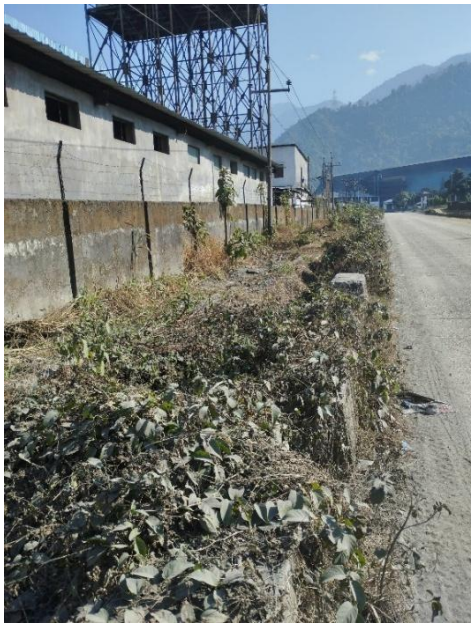
Damaged Drain below Hospital



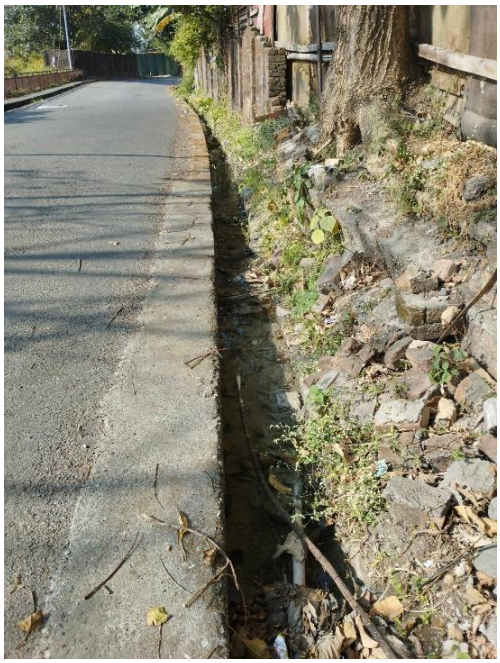
Damaged Drain outside Army Camp

Damaged Drain behind Druk Petroleum

Blocked Drain at Kabrayter



Damaged and Blocked Drain at Pasakha Industrial State



Damaged Drain below Bhutan Packaging Industry

Damaged Drain near BOD

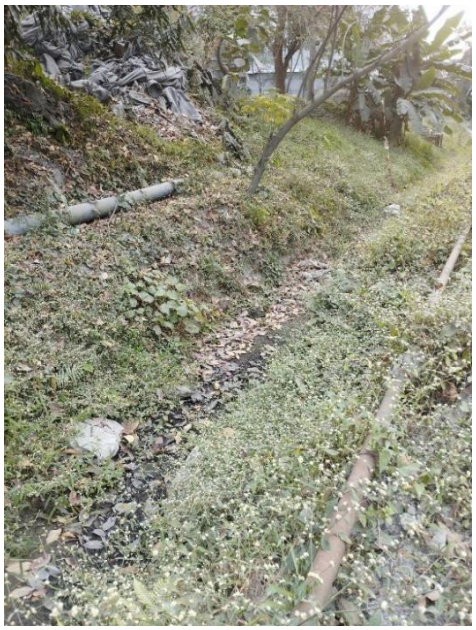
 Damaged Drain at Pasakha Industrial State	 Damaged Drain at Pasakha Industrial State

Figure 13: Problematic Drains observed in Phuentsholing Thromde

The majority of the failures occurred in areas with steep gradients or inadequate maintenance. Structural deficiencies, lack of lining, and clogged inlets were common contributing factors.

5. CONCLUSION

This spatial mapping supports analysis of drainage coverage, system performance, and areas requiring maintenance or upgrades. Subsequently, the final GIS output provides a clear, organized view of the existing drainage network in Phuentsholing Thromde and serves as a valuable tool for future stormwater planning and infrastructure development. The inventory can be accessed through the website https://inframap.ddnsfree.com/#/

The storm drainage inventory conducted for Phuentsholing Thromde has resulted in the successful development of a comprehensive spatial database and web-accessible GIS platform.

The key findings include:

- A total of 37.2 km of drains surveyed and digitized.
- Detailed classification by function, structure, section type, and material.
- Identification of several critical problem areas that require urgent intervention.

This geospatial inventory is intended to support:

- Strategic stormwater management planning,
- Infrastructure upgrading and maintenance scheduling,
- Integration into broader climate resilience and urban planning frameworks.