JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE PROJECT FOR COMPREHENSIVE TRAFFIC MANAGEMENT PLAN FOR METRO MANILA

TECHNICAL REPORT NO. 3

WAZE DATA DASHBOARD AND USER MANUAL

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ALMEC CORPORATION
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TRANSPORTATION RESEARCH INSTITUTE CO., LTD.

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ABBREVIATIONS

CSV	comma-separated values
CTMP	Comprehensive Traffic Management Plan
GCE	google compute engine
GCP	google cloud platform
GCS	google cloud storage
IAM	identity and access management
JICA	Japan International Cooperation Agency
JPT	JICA Project Team
MMDA	Metropolitan Manila Development Authority
VM	virtual machine

1 OUTLINE OF WAZE TRAVEL SPEED DASHBOARD

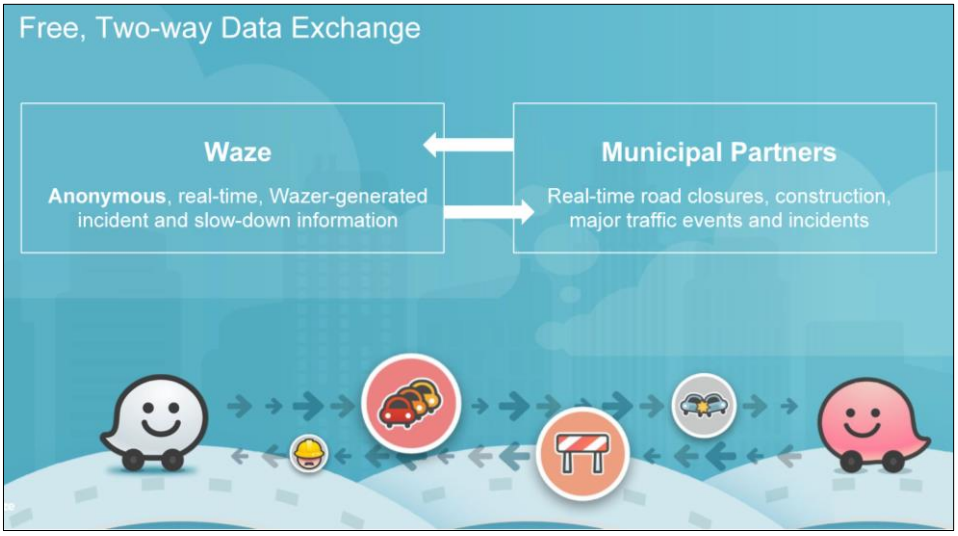
1.1 Introduction

On 3 November 2016, MMDA and Waze (under Alphabet [Google]) signed a memorandum of understanding (MOU) for a data-sharing partnership. Waze has been implementing a free reciprocal traffic information program, named “Connected Citizens Program” or CCP (it is now called Waze for Cities, https://www.waze.com/wazeforcities/), and as part of this program, it is working on a sharing initiative with MMDA.

Based on Waze data, there are 2.4 million active Wazers in the Philippines, who use the app for an average of 110 minutes per day. This number is about seven times more than the average of Wazers worldwide, which is about 15 minutes per day. While Wazers are on the app, GNSS location information acquired by each Wazer's smartphone is sent to the Waze server, indicating that a large amount of data is being collected by Waze.

In terms of data provision, instead of MMDA providing information on traffic restrictions, road construction, major traffic events, and traffic accident to Waze, Waze provides anonymized real-time travel speeds where traffic jams occur and traffic events that are collected from Wazers.

However, the utilization of Waze data had not progressed on the MMDA side. Hence, the JICA Project Team (JPT) deemed it necessary to acquire the data and create a database, i.e., a travel speed dashboard, to understand the temporal-spatial continuum of travel speeds on the road network in Metro Manila. The JPT developed a travel speed dashboard and used this database to identify bottlenecks causing traffic congestion. MMDA can use it for a before-and-after evaluation of the implementation of congestion countermeasures and traffic policies.



Source: WAZE

Figure 1.1: Connected Citizens Program

1.2 Concept of Travel Speed Dashboard

The JPT developed Travel Speed Dashboard based on the following concepts:

(i) Store travel speed data from Waze;

(ii) Visualize the travel speed situation on the road network in Metro Manila from a bird's-eye view;

(iii) Can search and retrieve data based on some criteria (e.g., year, month, day of the week, speed level, road type) and visualize the travel speed situation; and

(iv) Can output data to create a time-space diagram to identify bottlenecks in each corridor.

1.3 Waze Data Specification

Data from Waze is provided in XML or JSON format via the Waze application programming interface (API), and real-time data is updated every 2 minutes.

A feed reader module has already been developed for MMDA by Waze's partner company Thinking Machines, which allows users to regularly retrieve and record data in a database via the Waze API.

Table 1.1: Event Information and Travel Speed Data provided by Waze 1

Element	Value	Description
pubMillis	Timestamp	Publication date (Unix time – milliseconds since epoch)
location	Coordinates	Location per report (X Y - Long-lat)
uuid	String	Unique system ID
magvar	Integer (0-359)	Event direction (Driver heading at report time. 0 degrees at North, according to the driver's device)
type	See alert type table	Event type
subtype	See alert sub types table	Event sub type - depends on atof parameter
reportDescription	String	Report description (supplied when available)
street	String	Street name (as is written in database, no canonical form, may be null)
city	String	City and state name [City, State] in case both are available, [State] if not associated with a city. (supplied when available)
country	String	(see two letters codes in http://en.wikipedia.org/wiki/ISO_3166-1)
roadType	Integer	Road type (see road types table in the appendix)
reportRating	Integer	User rank between 1-6 (6 = high ranked user)
jamUuid	string	If the alert is connected to a jam - jam ID
Reliability (new)	0-10	How reliable is the report…..
reportByMunicipalityUser	Boolean	Alert reported by municipality user (partner) Optional.

Source: Waze

Table 1.2: Event Information and Travel Speed Data provided by Waze 2

Element	Value	Description
pubMillis	Timestamp	Publication date (Unix time – milliseconds since epoch)
type	String	TRAFFIC_JAM
line	List of Longitude and Latitude coordinates	Traffic jam line string (supplied when available)
speed	Float	Current average speed on jammed segments in Km/h
length	Integer	Jam length in meters
delay	Integer	Delay of jam compared to free flow speed, in seconds (in case of block, -1)
street	String	Street name (as is written in database, no canonical form. (supplied when available)
city	String	City and state name [City, State] in case both are available, [State] if not associated with a city. (supplied when available)
country	String	available on EU (world) server (see two letters codes in http://en.wikipedia.org/wiki/ISO_3166-1)
roadType	Integer	Road type (see road types table in the appendix)
startNode	String	Nearest Junction/steet/city to jam start (supplied when available)
endNode	String	Nearest Junction/steet/city to jam end (supplied when available)
level	0 - 5	Traffic congestion level (0 = free flow 5 = blocked).
uuid	Long integer	Unique jam ID
turnLine	Coordinates	A set of coordinates of a turn - only when the jam is in a turn (supplied when available)
turnType	String	What kind of turn is it - left, right, exit R or L, continue straight or NONE (no info) (supplied when available)
blockingAlertUuid	string	if the jam is connected to a block (see alerts)

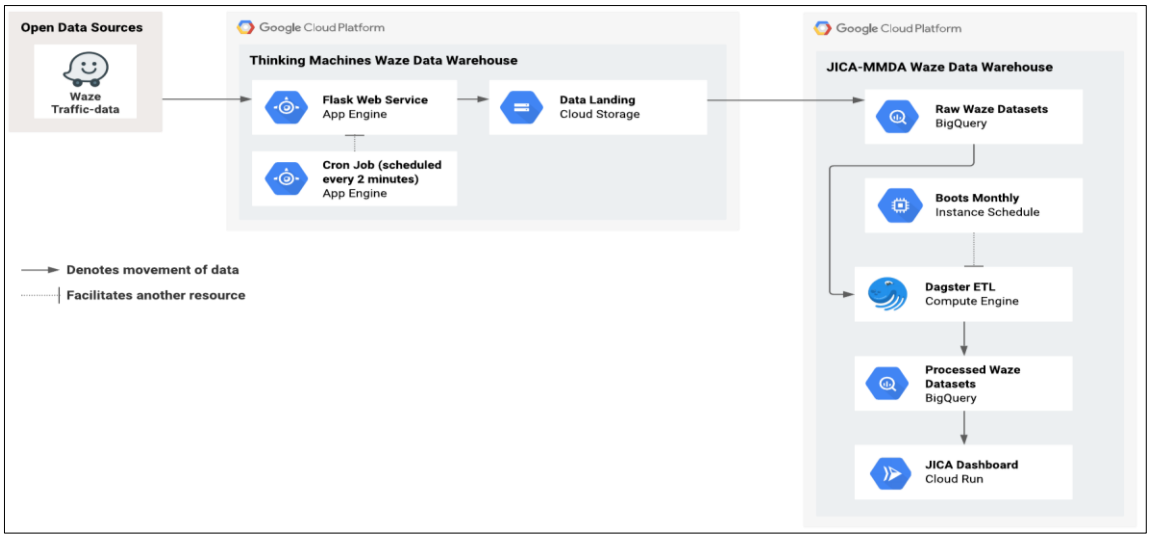
Source: Waze

1.4 Development of Pipeline for Aggregation

JPT developed a “pipeline” to generate data for the dashboard based on Waze data. The pipeline is shown in Figure 1.2, where the data from “Waze-Traffic-Data” is stored in the “Thinking Machine Waze Data Warehouse” every two minutes, and the data in the “JICA-MMDA Waze Data Warehouse” is stored once a month.

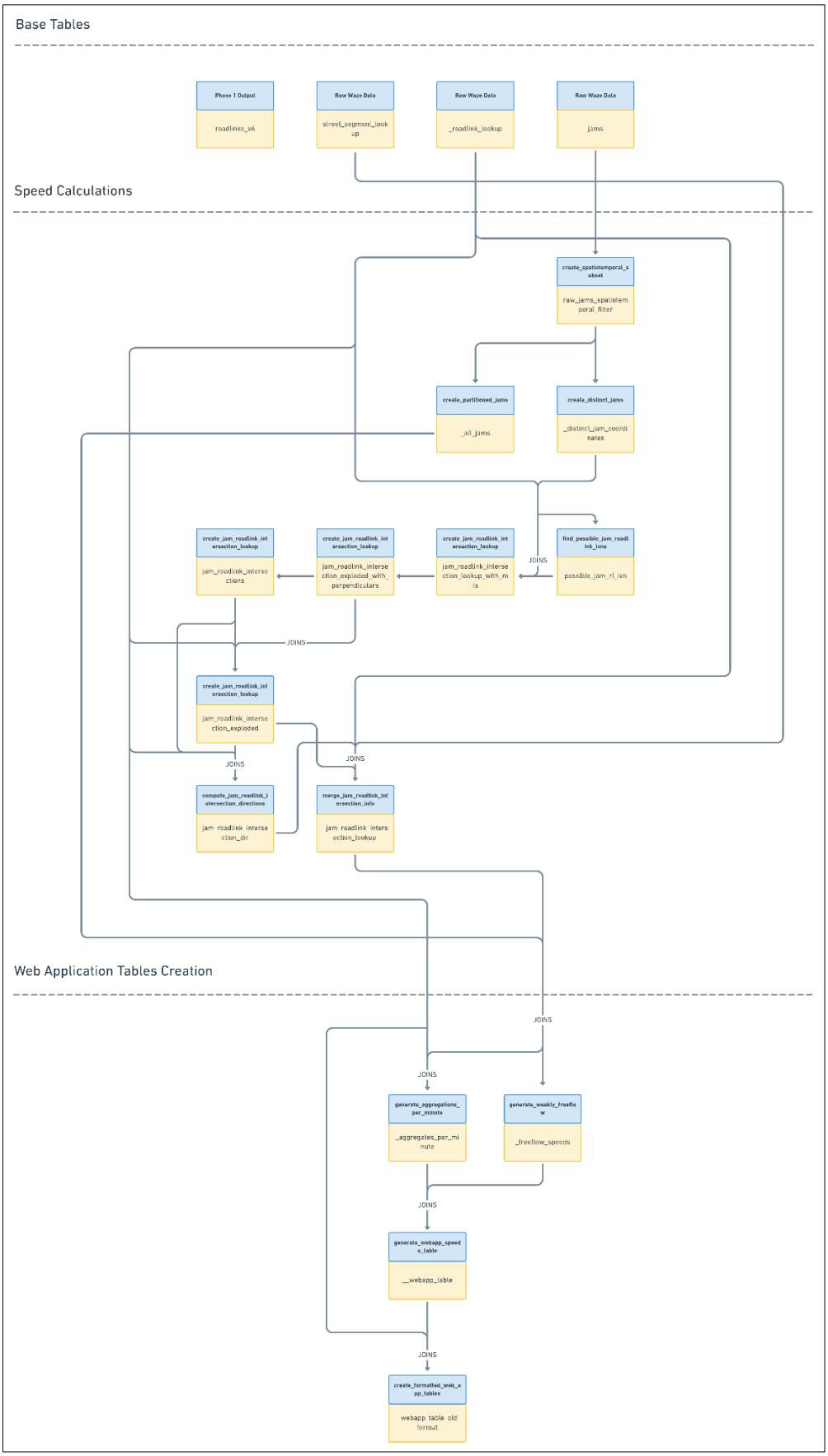
Waze data updates traffic information every two minutes. However, the dashboard is not intended to visualize real-time traffic conditions. After a certain amount of traffic data has been accumulated, it can be aggregated and analyzed to provide a bird's-eye view of the traffic condition on a road network that is continuous in time and space. Therefore, the dashboard is designed to be updated once a month based on Waze data.

Figure 1.3 shows the full data stream in the data warehouse. The blue boxes represent the pipeline tasks, while the yellow boxes represent the output tables generated by that specific pipeline task. It gets raw data from Waze, stores it in the jams table, then undergoes a series of data transformations before getting to the final road link lookup table.



Source: JPT

Figure 1.2: Diagram of the Data Platform



Source: JPT

Figure 1.3: Data Flow for the Travel Speed Dashboard

1.5 Development of Travel Speed Dashboard

The Travel speed dashboard has functions of the visualization dashboard can be broadly divided into two: (1) color-coded display of travel speeds, and (2) color-coded display of the percentage of time for a given travel speed in a given period.

(a) **Color-coded Display of Travel Speeds:** The dashboard calculates the travel speeds on each road link based on the difference between the travel speed data obtained from Waze data and free-flow speed data and displays them in different colors.

(b) **Color-coded Display of the Percentage of Time for a Given Travel Speed in a Given Time:** In contrast, this function specifies, for example, that the percentage of travel speeds below 30km/h was 30% or more on a weekday in January 2021. The system then extracts and displays the road sections where the travel speed has been decreasing (going below 30km/h) for a long time (for more than 30% of the specified period). This function shows the more serious areas, or bottlenecks, where the slowdown continues for a long time.

The color-coding of travel speeds is based on the conditions in Table 1.3.

Table 1.3: Color Coding based on Travel Speed

	R	G	B
5	112	48	160
10	192	0	0
15	255	102	255
20	255	0	0
25	226	107	10
30	247	150	70
35	255	255	0
40	146	208	80
45	0	176	80
50	183	222	232
60	0	176	240
70	0	112	192
80	0	32	96

Source: JPT

The dashboard visualizes jams at the road link level given the following parameters:

(a) **Percentage of Time below a Given Speed:** Only displays the road links that meet the percent of occurrence.

(b) **Speed:** Only displays the road links that are selected in the range.

(c) **Worst Road Links based on Percentage of Time:** Narrows down the search to worst road links in terms of jams or delays.

(d) **Road Links with Speeds below a Given Speed:** Only displays the road links that are selected in a range.

(e) **Time of Day:** Selected time from the 24-hour data.

(f) **Day of Week:** Selected day/s of the week.

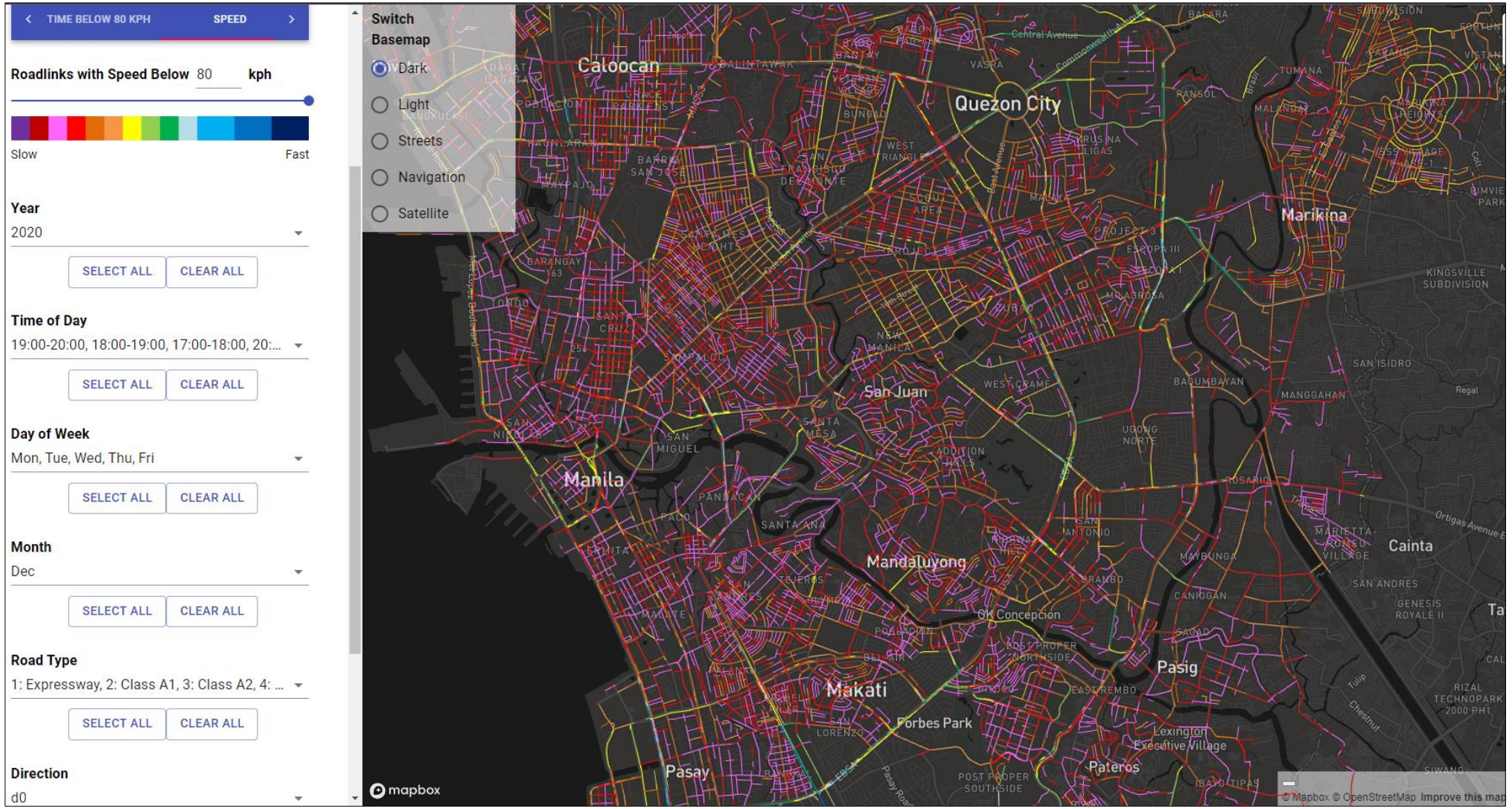
(g) **Month:** Selected month/s of the year.

(h) **Road Type:** Selected road type (expressway, Class A1, Class A2, Class B, Class C, Class D, and Others).

(i) **Direction:** d0 (eastbound/northbound) and d1 (westbound and southbound).

In addition, the dashboard has a function to visualize and display the aggregate results, as shown in Figure 1.4.

It also has a function to output the data being displayed as CSV data and to output CSV data to create a time-space diagram. After updating the map, the attributes of the entire road network and the space-time table of the circumferential and radial roads may be exported as CSV. It is also possible to output a CSV file to create a time-space diagram of bottlenecks in each corridor, as shown in Table 1.4.



Source: JPT

Figure 1.4: Waze Dashboard App

Table 1.4: Exported Data to Create a Time-Space Diagram

street_unique	speed	speed_d0	speed_d1	hours_bel	hours_wit	percentag	roadType	WKT
Visitacion _s0_i1_m0	6.684746	6.684746	10.94025	92	92	100	4: Class B	LINESTRING(121.078923 14.549337, 121.078923 14.549524, 121.078919994702 14.5500920013086)
Visitacion _s0_i1_m1	6.691159	6.691159	10.85533	92	92	100	4: Class B	LINESTRING(121.078919994702 14.5500920013088, 121.078916 14.550847)
145: C.M. Recto W _s0_i20_m1	6.693152	6.693152	10.24576	92	92	100	3: Class A2	LINESTRING(120.967800942099 14.6031513691485, 120.967596 14.602929, 120.967465 14.6025205, 120.967422384671 14.602472987088)
145: C.M. Recto E _s0_i22_m1	6.921812	6.921812	12.95029	92	92	100	3: Class A2	LINESTRING(120.967518601271 14.6025312963146, 120.967498 14.6025045, 120.967206 14.602131, 120.966977006048 14.6019239056777)
DoÃ±a Julia Vargas Ave _s0_i1_m0	7.21471	7.21471	20.31826	92	92	100	4: Class B	LINESTRING(121.075903 14.58331, 121.075517 14.583564)
130: Sergeant Emilio Rivera W _s0_i6_m4	7.238297	7.238297		92	92	100	3: Class A2	LINESTRING(120.996539213069 14.6440715949523, 120.995827 14.644054, 120.995709 14.644051, 120.995641954524 14.6440476552145)
DoÃ±a Julia Vargas Ave _s0_i0_m1	7.298587	7.298587	21.3512	92	92	100	4: Class B	LINESTRING(121.076433794184 14.5829669504693, 121.076422 14.582975, 121.075903 14.58331)
DoÃ±a Julia Vargas Ave _s0_i2_m0	7.352681	7.352681	19.3313	92	92	100	4: Class B	LINESTRING(121.075517 14.583564, 121.075168 14.583775, 121.074867 14.583914, 121.074817432977 14.5839303313314)

	C1EB_1	C1EB_2	C1EB_3	C1EB_4	C1EB_5	C1EB_6	C1EB_7	C1EB_8	C1EB_9	C1EB_10	C1EB_11	C1EB_12	C1EB_13	C1EB_14	C1EB_15	C1EB_16	C1EB_17	C1EB_18	C1EB_19	C1EB_20	C1
roadlink_id	3383	3384	3385	3386	3387	3319	3318	3317	3316	3315	3312	3311	3310	3309	3308	3307	3306	3305	3304	3303	
street_unique	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	145: C.M.	14
corridor	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1EB	C1
route	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1	C1
direction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
bearing	46	46	45	46	44	220	222	221	221	221	228	251	256	256	256	286	290	291	291	291	
bq_roadlink_length	94.32	94.32	73.65	73.61	73.68	89.62	67.86	72.2	72.2	72.2	92.26	89.9	82.59	82.59	82.59	82.72	82.77	78.52	78.51	78.51	
roadType	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
start_point	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	P
end_point	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	POINT(12	P
0:00	15.4	15.4	13.51	13.51	13.51	14.45	14.15	14.2	14.39	20.31	20.31	19.8	14.88	14.93	14.74	14.84	15.54	16.83	24.36	24.76	
0:20	15.68	15.68	13.56	13.56	13.56	14.52	14.55	14.55	14.74	20.3	20.16	20.62	14.82	14.86	14.58	14.62	15.26	16.25	24.36	24.76	
0:40	15.68	15.68	13.61	13.61	13.61	14.71	14.65	14.65	14.84	20.82	20.73	19.15	14.45	14.49	14.36	14.37	14.99	15.83	24.36	24.69	
1:00	15.68	15.68	13.61	13.61	13.61	14.65	14.59	14.59	14.79	20.61	20.71	20.17	14.67	14.98	14.83	14.84	15.54	16.83	24.36	24.76	
1:20	15.68	15.68	13.61	13.61	13.61	14.25	14.28	14.28	14.47	20.47	20.47	19.08	14.75	14.79	14.57	14.84	15.54	16.83	24.36	24.76	
1:40	15.68	15.68	13.61	13.61	13.61	14.81	14.7	14.7	14.91	21.36	21.36	20.83	14.93	14.98	14.83	14.84	15.54	16.83	24.36	24.76	
2:00	15.68	15.68	13.61	13.61	13.61	14.81	14.7	14.7	14.91	21.36	21.36	20.83	14.93	14.98	14.83	14.84	15.54	16.83	24.36	24.76	
2:20	15.68	15.68	13.61	13.61	13.61	14.81	14.37	14.54	14.73	20.35	20.45	19.44	14.73	14.77	14.64	14.66	15.29	16.75	24.32	24.72	
2:40	15.68	15.68	13.47	13.47	13.47	14.81	14.7	14.7	14.91	21.36	21.36	20.47	14.74	14.78	14.65	14.66	15.22	16.83	24.36	24.76	
3:00	15.68	15.68	13.61	13.61	13.61	13.66	13.7	13.7	13.87	19.3	19.3	18.7	14.93	14.98	14.67	14.72	15.36	16.56	24.44	24.81	

Source: JPT

1.6 Utilization of the Dashboard

By using the developed Travel Speed Dashboard, the following use cases are expected:

(i) Understanding of the traffic situation in Metro Manila from a bird's-eye views

(ii) Identification of potential traffic bottlenecks based on quantitative analysis;

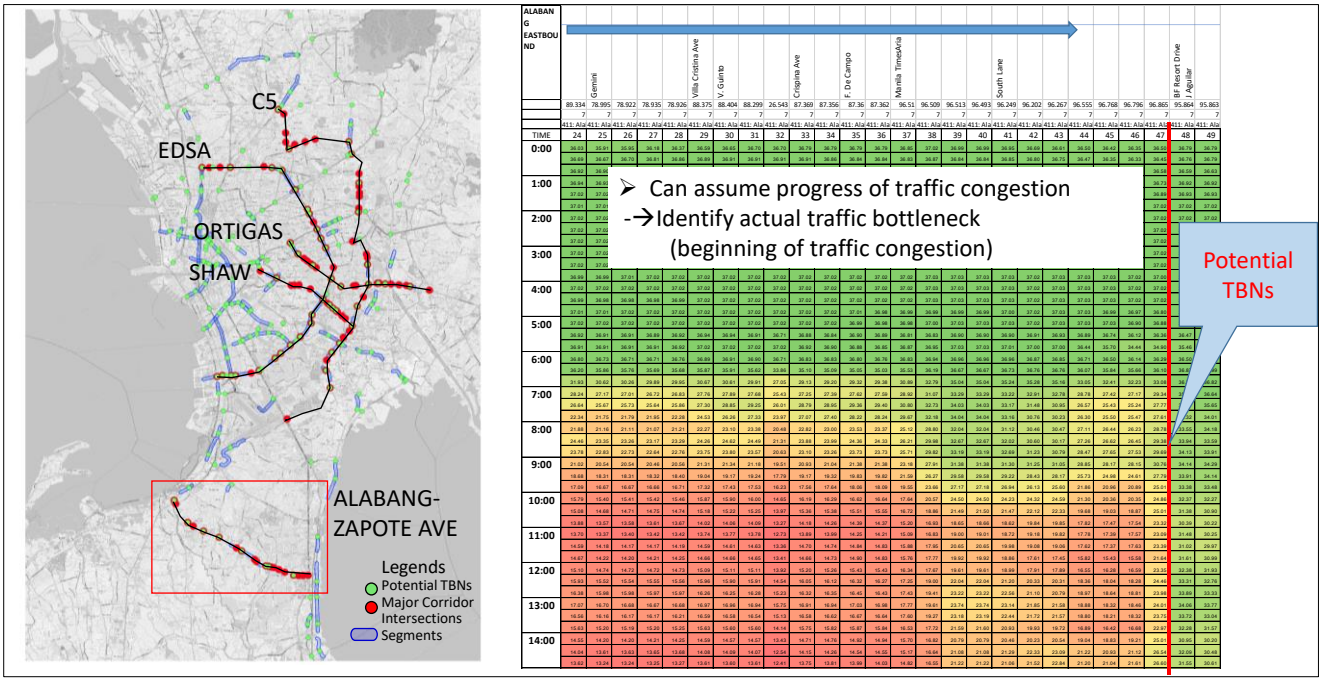
(iii) Analysis of traffic congestion at the corridor level;

(iv) Evaluation of the effectiveness of countermeasures by comparing between before and after implementation; and

(v) Analysis of the impact of severe incidents and events.

The above utilization can be referred to as TR4 Identification of Traffic Bottlenecks and Monitoring.

Figure 1.5 shows a sample of the use case of analyzing congestion using a time-space diagram. The vertical axis is time, and the horizontal axis is distance. The redder the color, the lower the speed. Based on the visualization, when and where congestion starts and how far it extends can be determined.

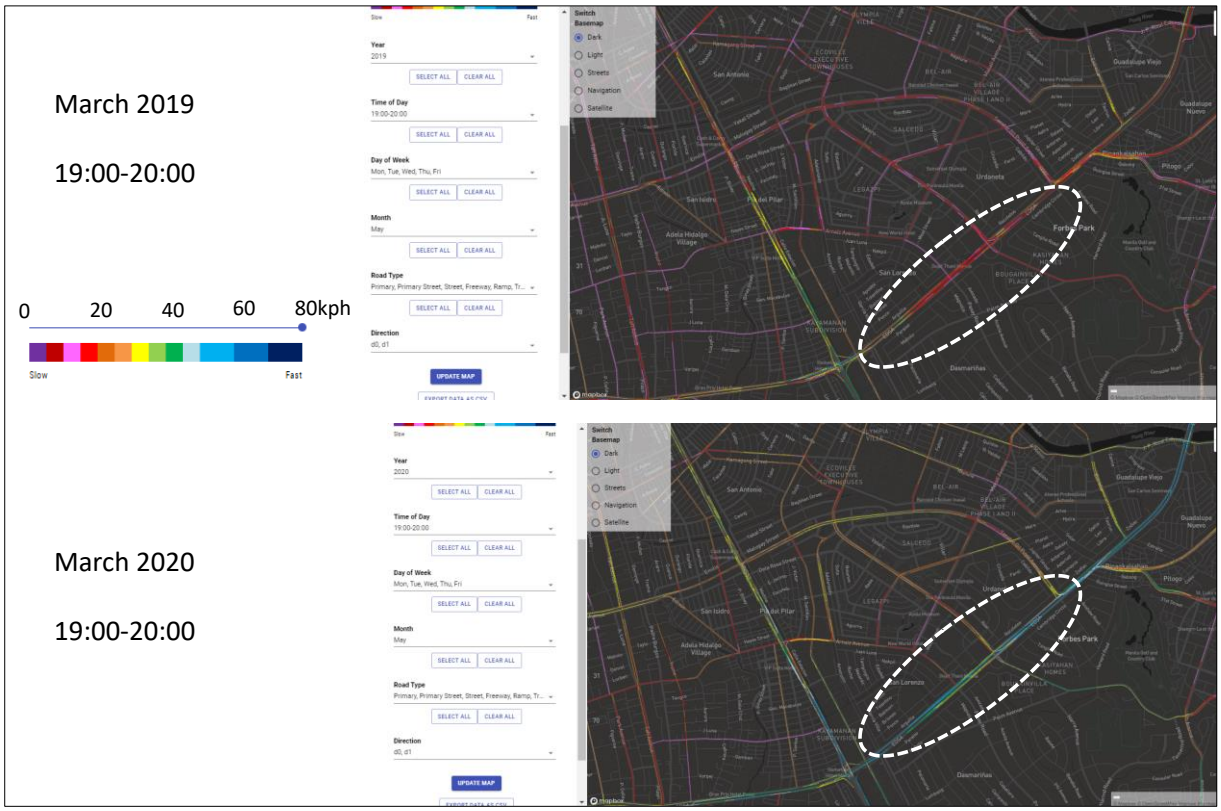


Source: JPT

Figure 1.5: Sample of a Time-Space Diagram to Analyze Congestion

Figure 1.6 compares the travel speed data between March 2019 before the pandemic curtailed public mobility and March 2020 when Metro Manila was placed under ECQ. Travel speeds on EDSA in 2019 were low at less than 20km/h, but 2020 figures showed around 60km/h.

Using these diagrams, the situation before and after significant events/incidents can be compared and the impact on traffic flow can be analyzed. MMDA can use these when considering interventions before such events happen. In addition, the effectiveness and impact of traffic management interventions on traffic flow implemented in conjunction with the opening of new roads and railway infrastructures can be verified.



Source: JPT

Figure 1.6: Travel Speeds on EDSA Before and During the Pandemic

2 DESIGN AND TECHNICAL DOCUMENTATION

2.1 Architecture of Platform

(1) Architecture Diagram

Figure 2.1 shows how data flows through the platform. The specific components are as follows:

(a) **Data Source:** Waze-traffic data is fetched via an API request to the GeoRSS API.

(b) **App Engine Cron Job:** makes an API request to Thinking Machines' internal Flask Web Service every two (2) minutes which orchestrates the fetching of Waze-traffic data and the automation of loading to a Google Cloud Storage bucket and BigQuery datasets.

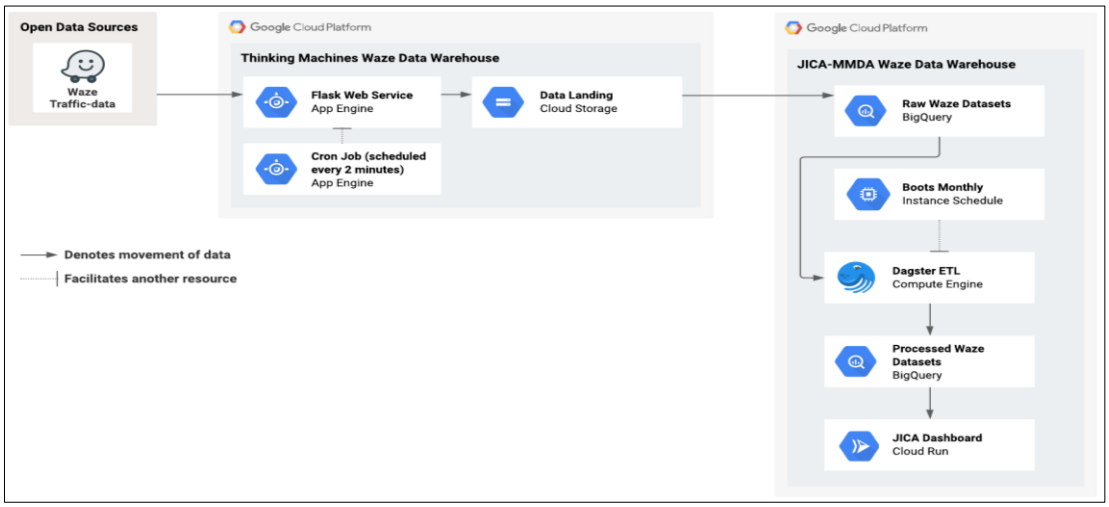
(c) **Raw Waze Dataset:** contains the tables for the raw Waze-traffic data i.e., irregularities, jams, and alerts.

(d) **Dagster:** runs the road links speed calculation steps on the Waze-traffic data from the Raw Waze Dataset.

(e) **Instance Schedule:** boots up the Compute Engine instance hosting the Dagster instance every first day of the month. Booting up the Compute Engine instance will run the road links speed calculation pipeline.

(f) **Processed Waze Dataset:** contains the Big Query output tables processed from road links speed calculation executed by the Dagster instance; tables in this dataset are ready for consumption in the JICA Dashboard Web App.

(g) **Cloud Run:** will host the Dashboard Web App which can query and display the processed Waze data from the Processed Waze Dataset in a map view.



Source: JPT

Figure 2.1: Diagram of the Data Platform

(2) Google Cloud Platform

This travel speed database and dashboard used could service “Google Could Platform”.

(a) **A Suite of Cloud Computing Services** that runs on the same infrastructure that Google uses internally for its end-user products (ex. Google Search, Gmail, and YouTube)

(b) **Wide Range of Services:** Computing, Storage, Big Data, Machine Learning, Networking, Developer Tools, and Management tools

(c) **Project Name:** MMDA-waze

(3) GCP Services

Listed in the chart below are the GCP services used for the project. Each of these services will be described in detail, and the role it plays in the project's overall architecture.

Table 2.1: GCP Services

Service	Description	Project Purpose
Cloud Storage	• File storage web service for storing and accessing data on the GCP infrastructure	• Host files generated by services within the Google Cloud Platform, audit logs, and Terraform backend
Big Query	• Serverless data warehouse that enables scalable analysis over petabytes of data via ANSI SQL	• Store raw Waze-traffic data, and run queries for the Waze Speed Calculation
Compute Engine	• Scalable and configurable virtual machines	• Run the Dagster Waze Speed Calculation pipeline monthly
Cloud Build	• Serverless CI/CD platform for building, testing, and deploying software	• Automate the building and pushing of the Dagster pipeline image to the Container Registry upon merging of change requests to the pipeline code in the GitHub repository
Cloud Identity and Access Management (IAM)	• Identity management solution for accesses to GCP's resources	• Control and limit access to the different services running on the Google Cloud Platform project
Container Registry	• Repository for storing, managing, and accessing the GCP project's Docker images	• Contain the images of the pipeline and dashboard code
Cloud Run	• Serverless platform for developing and deploying highly scalable containerized applications	• Hosts the container for the JICA dashboard web app

Source: JPT

(4) Cloud Storage (GCS)

Table 2.2: Cloud Storage used for the Project

Bucket Name	Description
*Artifacts.mmda-waze.appspot	Bucket used for storing Cloud Run builds artifacts
MMDA-waze_cloudbuild	Bucket used by Cloud Run for staging build objects
MMDA-waze-logsink	Bucket used for the GCP project logs
MMDA-waze-terraform	Bucket for storing Terraform state, Terraform automates the management of the GCP project's resources through code

Source: JPT

(5) Compute Engine (GCE)

Below is a list of all the GCE instances in this project and their respective purposes:

Table 2.3: GCE Instances in the Project

VM Name	Purpose
Dagster-monthly	VM instance that hosts the monthly Waze Speed Calculation pipeline for production use, started every first day of the month and turned off at the last minute of the day.
Dagster-monthly-dev	VM instance that hosts the Waze Speed Calculation pipeline for development use.

VM Name	Purpose
Dagster-historical	VM instance that hosts the historical Waze Speed Calculation pipeline for production use.
Dagster-historical-dev	VM instance that hosts the historical Waze Speed Calculation pipeline for development use.

Source: JPT

(a) **Instance Schedules**

Below is a list of all the instance schedules responsible for scheduling when to turn on and off the GCE instances in the project:

Table 2.4: Instance Schedules

Instance Schedule Name	Purpose
Monthly-speed-calculation-schedule	Starts the dagster VM every 12:00 AM Manila Time Zone on the first day of the month, and stops at 11:59 PM the same day.
Daily-speed-calculation-schedule	Starts the dagster-dev VM every 12:00 AM Manila Time Zone every day, and stops it at 6:00 AM the same day. Can be disabled during the non-development time to save costs.

Source: JPT

(6) Access and Security (IAM): Users and Service Accounts

End-user access and application access through service accounts are managed through Cloud Identity and Access Management (Cloud IAM.) Each user, group of users, or service account is assigned a role(s) to determine the level of access to GCP resources. A role is a collection of permissions that is granted to the users and determines the level of access to GCP resources. Permissions cannot be assigned directly to an individual user or group of users. Roles, instead of permissions, are granted to the users.

(a) **Service Accounts**

To run code in GCP, service accounts are required and assigned to applications. Each application can have as many service accounts as needed to represent the different logical components.

Below is a table that details the service accounts, purpose, and assigned roles:

Table 2.5: Service Account Details

Service Account Name	Purpose	Roles
waze-pipeline-service-account@mmda-waze.iam.gserviceaccount.com	• Service account used by the Waze Speed Calculation pipeline; also assigned to the Compute Engine instance hosting the pipeline	• BigQuery Data Editor • BigQuery Job User • BigQuery Read Session User • Secret Manager Secret Accessor • Storage Admin
waze-74407@appspot.gserviceaccount.com	• Service account for enabling the transfer of raw Waze-traffic data from Thinking Machines' internal `waze-174407` GCP project to the `mmda-waze` project	• BigQuery Data Editor • BigQuery Job User
mmda-waze-jica-dashboard@mmda-waze.iam.gserviceaccount.com	• Service account used by the JICA Dashboard web app in the dev environment deployed on Cloud Run	• BigQuery Data Viewer • BigQuery Job User • BigQuery Read Session User
mmda-waze-jica-dashboard-prod@mmda-waze.iam.gserviceaccount.com	• Service account used by the JICA Dashboard web app in the production environment deployed on Cloud Run	• BigQuery Data Viewer • BigQuery Job User • BigQuery Read Session User
218567230177@cloudbuild.gserviceaccount.com	• Service account used by Cloud Build when automating the building of the pipeline image and pushing it to the	• Cloud Build Service Account

Service Account Name	Purpose	Roles
	Container Registry	
jica-waze-pipeline-bqup@mmda-waze.iam.gserviceaccount.com	• Service account used by bqup for exporting the project's BigQuery structure and source code	• BigQuery Metadata Viewer
terraform-service-account@mmda-waze.iam.gserviceaccount.com	• Service account used for managing the project's GCP resources through Terraform	• Cloud Build Editor • Cloud SQL Admin • Compute Admin • Compute Network Admin • Service Account Admin • Service Account User • Project IAM Admin • Storage Object Admin

Source: JPT

(7) Google Groups

Table 2.6: Google Groups Purposes

Service Account Name	Purpose	Roles
mmda-waze-devs@thinkingmachin.es	• Google Group for developers and maintainers of the project	• Owner
jica-mmda-waze-clients@thinkingmachin.es	• Provides view access to all the GCP Project resources to the stakeholders	• Viewer
jica-mmda-waze-clients-bq-user@thinkingmachin.es	• Enables viewing of BigQuery data and metadata, and the usage of BigQuery jobs for analysis	BigQuery Data Viewer • BigQuery Job User

Source: JPT

(a) Networking

Table 2.7: Network used for the Project

Network	Subnetwork	Region	IP Address Ranges	Gateways
Dagster-network	DAGSTER-network-subnetwork	us-central1	10.0.0.0/16	10.0.0.1

Source: JPT

(8) BigQuery

BigQuery is an enterprise data warehouse that enables super-fast SQL queries using the processing power of Google's infrastructure.

The BigQuery (BQ) Project Structure follows Thinking Machine's (TM) project structure standards for data warehouses. These standards ensure a consistent high-quality structure and process to manage the BQ tables and views in the project.

(a) Cloud Run

For hosting the JICA Dashboard web application we run services in Cloud Run. We have separate services for the phase 1 and phase 2 versions of the web application listed below:

Table 2.8: Services Run in Cloud Run

Service Name	Description
mmda-waze-jica-dashboard-dev	Cloud Run service for the JICA dashboard web app for development purposes
mmda-waze-jica-dashboard-prod	Cloud Run service for the JICA dashboard web app for development
mmda-waze-jica-dashboard-phase-1-prod	Cloud Run service for the Phase 1 JICA dashboard web app for production use

Source: JPT

2.2 Aggregation Method

This chapter discusses the most crucial variables and terminologies involved in the computations. Shown below, is a table of summary of each variable, their descriptions, and what each one looks like in the data warehouse. Furthermore, each variable, along with visual examples, is further expounded upon in the succeeding subchapter.

(1) Variables

Table 2.9: Variables used in the Computations

Variable	Description	Sample Data
Road Type	• Numeric code for the type of road where the jam occurred	• 1 - street • 17 - private road
Roadlink	• <100m road segment splits	• Lawton Ave _s0_i1_m0 • A. Mabini Ave _s0_i0_m2
Freeflow Speed	• speeds along roads when and where there is no traffic (in m/s)	• 25.84 • 33.71
Jammed Speed	• average speed in a jam from Waze data (in m/s)	• 20.81 • 29.56
Direction	• pertains to the direction of the jam	• d0 • d1

Source: JPT

(a) **Jams**

Before defining the variables, it is crucial to define what a jam is as this is the main foundation of the calculations. According to Waze, a jam is recorded when the average speed among a certain number of cars on the road falls below 20% of the usual speed along that road. This “usual speed”, or what we call free flow speed, is the average speed of a car traveling when there is no heavy traffic (e.g. speeds of cars early in the morning).

(b) **Road Type**

Road types are numerical values that help us categorize the kind of road being considered. Shown below are the current values from the Waze documentation. For analysts, knowing the type of road they are dealing with will help them to have more accurate estimates of speed and other metrics.

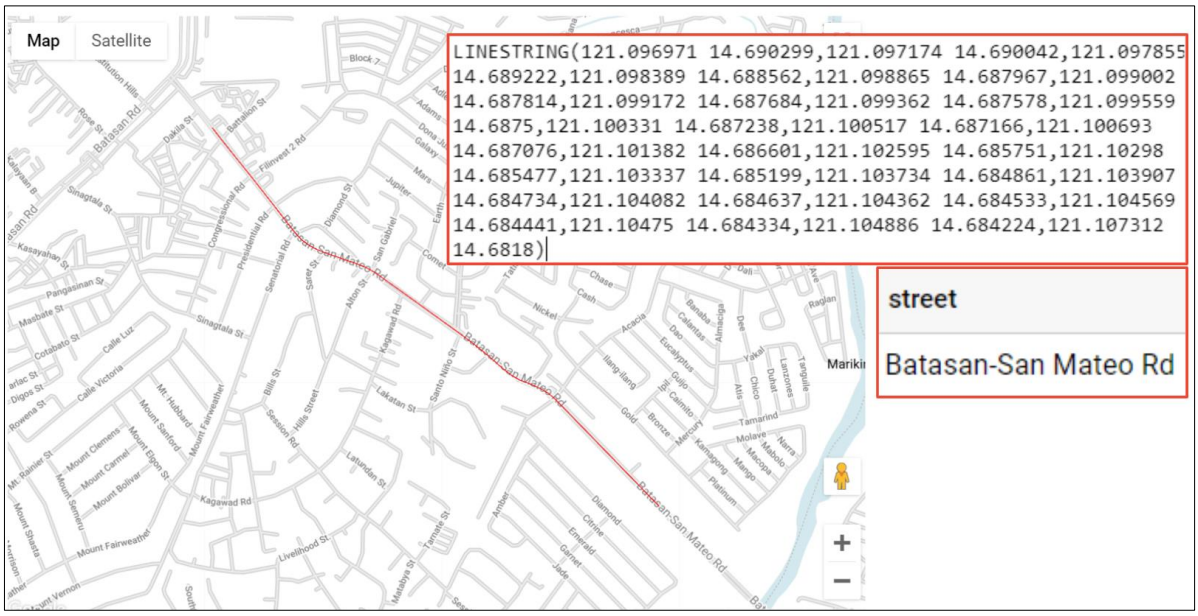
Table 2.10: Road Type Classification

Road Number	Road Type
1	Expressway
2	Class A1
3	Class A2
4	Class B
5	Class C
6	Class D
11	Others

Source: JPT

(c) **Road Links**

In Waze data, roads are lengths and lines defined by geographical coordinates. Roads are defined by linestrings, which are a connected series of line segments, often represented by a collection of longitude and latitude coordinates. The image below shows an example linestring, which, when transformed with geographic functions in the data warehouse, translates to the Batasan-San Mateo Road in Quezon City.



Source: JPT

Figure 2.2: Linestring Translation of Batasan-San Mateo

Road links are just smaller road segments with lengths less than 100m. The reason for splitting these roads into smaller segments is to further improve the accuracy and consistency of speed calculations on these roads, as jams are highly dependent on intersections. The way the team has split roads into road links involves two processes: the naming and the calculation processes.

(a) **How Road Links were Named**

Table 2.11: Naming of Road Links

Steps	Road Link Names
1, Starting with the original street name	Batasan-San Mateo Rd
2, This is then differentiated from other streets also named 10th Ave	Batasan-San Mateo Rd_s0
3, Splits by intersections with other streets	Batasan-San Mateo Rd _s0_i0, Batasan-San Mateo Rd _s0_i1, etc.
4, Split into <100m road links	Batasan-San Mateo Rd _s0_i0_m0, Batasan-San Mateo Rd_s0_i0_m1, etc.

Source: JPT

The first process is divided into four steps as shown in the table above. To further understand this, we take our previous linestring for example. We have a starting linestring for a road named Batasan-San Mateo Rd. This entire road length is further classified differently from those who have the same street name, resulting in naming conventions like Batasan-San Mateo Rd_s0 and Batasan-San Mateo Rd_s1 (Batasan-San Mateo Rd Street 0, Street 1). The third step further splits these unique streets by intersections, resulting in names like Batasan-San Mateo Rd_s0_i0 and Batasan-San Mateo Rd_s0_i1 (Batasan-San Mateo Rd Street 0 Intersection 0, Street 0 Intersection 1). Lastly, these are split into road link segments smaller than 100m, resulting in names like Batasan-San Mateo Rd_s0_i0_m0, Batasan-San Mateo Rd_s0_i0_m1.

(b) **How Road Links were Split**

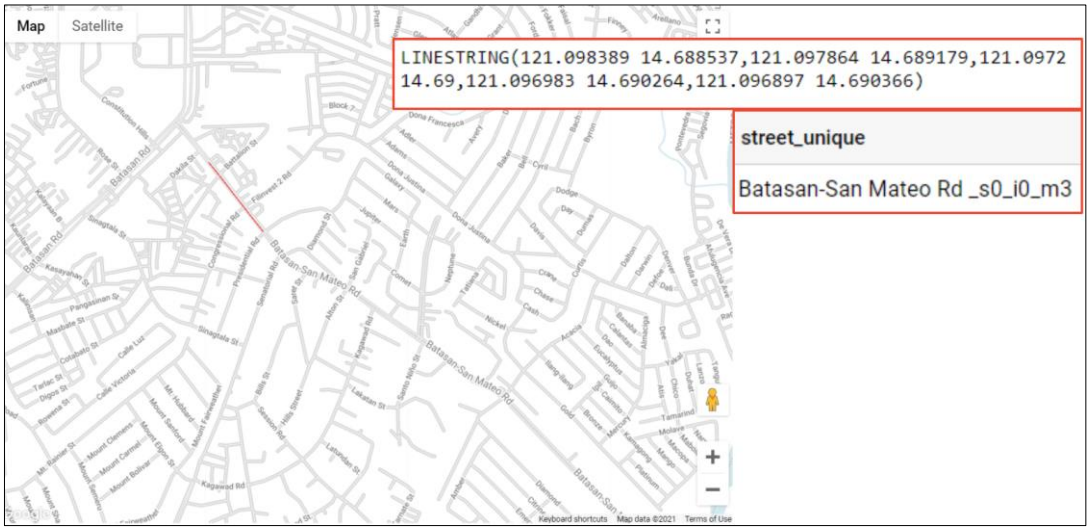
Table 2.12: Splitting the Road Links

Steps
1, Obtain the unique coordinates for each road in Waze from linestrings
2, Split the road into smaller segments based on its intersections with other roads
3, If there are any segments longer than 100m, split these into even smaller segments of length (original length)/100 each

Source: JPT

This second process is responsible for trimming the long linestrings into road link segments of less than 100m. For example, the raw linestring of Batasan-San Mateo Rd is more than 100m, thus, this will be continuously split using the steps as mentioned in the table until we satisfy our threshold.

Eventually, we arrive at segments that satisfy the conditions, as shown below.



Source: JPT

Figure 2.3: Trimmed Down Linestring of Batasan–San Mateo

Shown below is an example of how each linestring looks like in the data warehouse.

street_sim	coords
Aguho _s0_i5_m1	LINESTRING(121.063758056115 14.6312519123159, 121.063757 14.631249
Dona Elena _s0_i1_m0	LINESTRING(120.991699 14.740061, 120.991877 14.739989, 120.991967 14.
1: MacArthur Hwy _s0_i34_m5	LINESTRING(120.957229879193 14.7173402723181, 120.957229 14.717343
Martan _s0_i4_m0	LINESTRING(121.085607 14.69826, 121.085658 14.698434, 121.085657 14.6
Pio Pedrosa _s0_i0_m0	LINESTRING(120.987509 14.428312, 120.987678 14.428427, 120.987744 14.
38th _s0_i2_m0	LINESTRING(121.058929 14.557434, 121.058883 14.557557, 121.058826 14.
Emerald _s0_i1_m1	LINESTRING(121.032788079657 14.7085190162866, 121.032876 14.708505
F. Manalo _s1_i20_m0	LINESTRING(121.033038 14.599593, 121.033102 14.599696, 121.033198 14.
Katarungan _s1_i1_m1	LINESTRING(121.090846291434 14.6978167413849, 121.090846 14.697819
Don Mario _s0_i0_m0	LINESTRING(121.080546 14.679002, 121.080502 14.678936, 121.080452 14.
Tulip _s0_i0_m0	LINESTRING(121.011199 14.482859, 121.011091 14.482637, 121.01104 14.4

Source: JPT

Figure 2.4: Linetstring in Data Warehouse

(c) **Freeflow Speed**

One of the issues with Waze data is that it does not provide travel speeds in free-flow conditions, as Waze is primarily intended to display congested sections. To solve this issue, the travel speed during free flow is calculated from “jammed speeds”, “delay travel time between free flow and jammed condition,” and “jammed length” values in the Waze data. The specific calculation method is described below.

Free-flow speeds (in meters per second) are along roads when there is no traffic. Free-flow speed is a prerequisite to understanding the formula used for jammed speeds, as these are used to infer travel times along the unjammed parts of roads. This formula computes free-flow speeds:

$$\frac{length_{jam}}{\frac{length_{jam}}{speed_{jam}-0.1} - delay_{jam}}$$

Where: length_jam = length of jam according to Waze (in meters)
speed_jam = average travel speed along with the jam (in meters per second)
delay_jam = difference between the in-jam delayed travel time and the ideal free-flow travel time (in seconds)

For any given date and road link, this is applied in the following manner:

(i) Get the jams that occurred on the road link for that day and the past days;

(ii) Compute the free-flow speed using the formula;

(iii) Take the median free-flow speed among those jams.

Freeflow speeds (in meters per second) are the speeds along roads when there is no traffic. Freeflow speed is a prerequisite to understanding the formula that the team used for jammed speeds, as these are used to infer travel times along the unjammed parts of roads. Freeflow speeds were computed by this formula:

$$\frac{length_{jam}}{\frac{length_{jam}}{speed_{jam}-0.1} - delay_{jam}}$$

Where:

length_jam = length of jam according to Waze (in meters)
speed_jam = average travel speed along the jam (in meters per second)
delay_jam = difference between the in-jam delayed travel time and the ideal free-flow travel time (in seconds)

For any given date and road link, this is applied in the following manner:

(i) Get the jams that occurred on the road link for that day and the past days

(ii) Compute the free-flow speed using the formula

(iii) Take the median free-flow speed among those jams

(d) **Jammed Speed**

Jammed speed (in meters per second) is a metric that is provided by Waze data. It is the average speed of vehicles on a congested road. The jammed speed formula that the JPT

used was based on the inference from free-flowing speeds of vehicles on the road links. The formula for jammed speed is shown below.

$$\frac{(\Sigma length_{jam}) + (\Sigma length_{freeflow})}{(\Sigma traveltime_{jam}) + (\Sigma traveltime_{freeflow})}$$

Where: length_jam = length of jam accdg. to Waze (in meters)
length_freeflow = length of jam not occupied by length_jam (in seconds)
traveltime_jam = length_jam / jam speed (in meters)
traveltime_freeflow = length_freeflow / free-flow speed (in seconds)

(e) **Direction**

Direction pertains to the direction of a traffic flow on a road link. This is another important variable to be aware of, as shown in the final dashboard.

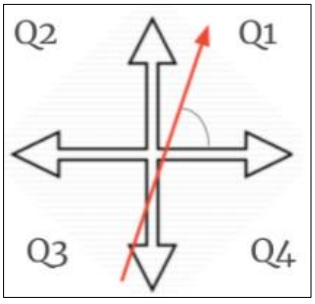
There are only two values for the road link directions: d0 and d1. Jams with d0 pertain to road links with traffic flows closer to either true East or true North or those that point towards Quadrant 1 of the XY plane. On the other hand, jams with d1 pertain to road links with traffic flows closer to either true West or true South or those that point towards Quadrant 3 of the XY plane.

Table 2.13: Definition of Directions

ITEM	In case of Double Link Road (eg. EDSA, C5, Ortigas, Quezon Ave…)	In case of NOT Double Link Road
"d0"	East Bound / North Bound	Existing "d0"
"d1"	West Bound / South Bound	Existing "d1"

Source: JPT

To further understand how direction is calculated, Figure 2.5 shows a specific example. If there exists a jam (the red arrow in the figure), and it's pointing towards Quadrant 1, leaning more towards the northern angle, following the conditions above, the jam direction is closer to the true North/true East rather than the true South/true West. Therefore, the direction of this jam is d0.



Source: JPT

Figure 2.5: Setting Directions of Traffic Flows

This variable will help distinguish the speeds between two opposing traffic flows on the same road link.

(2) Buffer Zones

Buffer zones will be set up to handle changes in Waze Road Data due to inaccurate GPS by the app. This does not guarantee that the changing Waze road data will always be

captured, but it increases the change of capture. The buffer zones are still able to distinguish overlapping road data due to overpasses or flyovers.

The size of the buffer zone will depend on road type and size. The same buffer zone range will apply every month and year. If the coordinates of the road change per run and these are not captured by the buffer zones, they will not be captured by the data.

(3) Corridor Maps and Visualizations

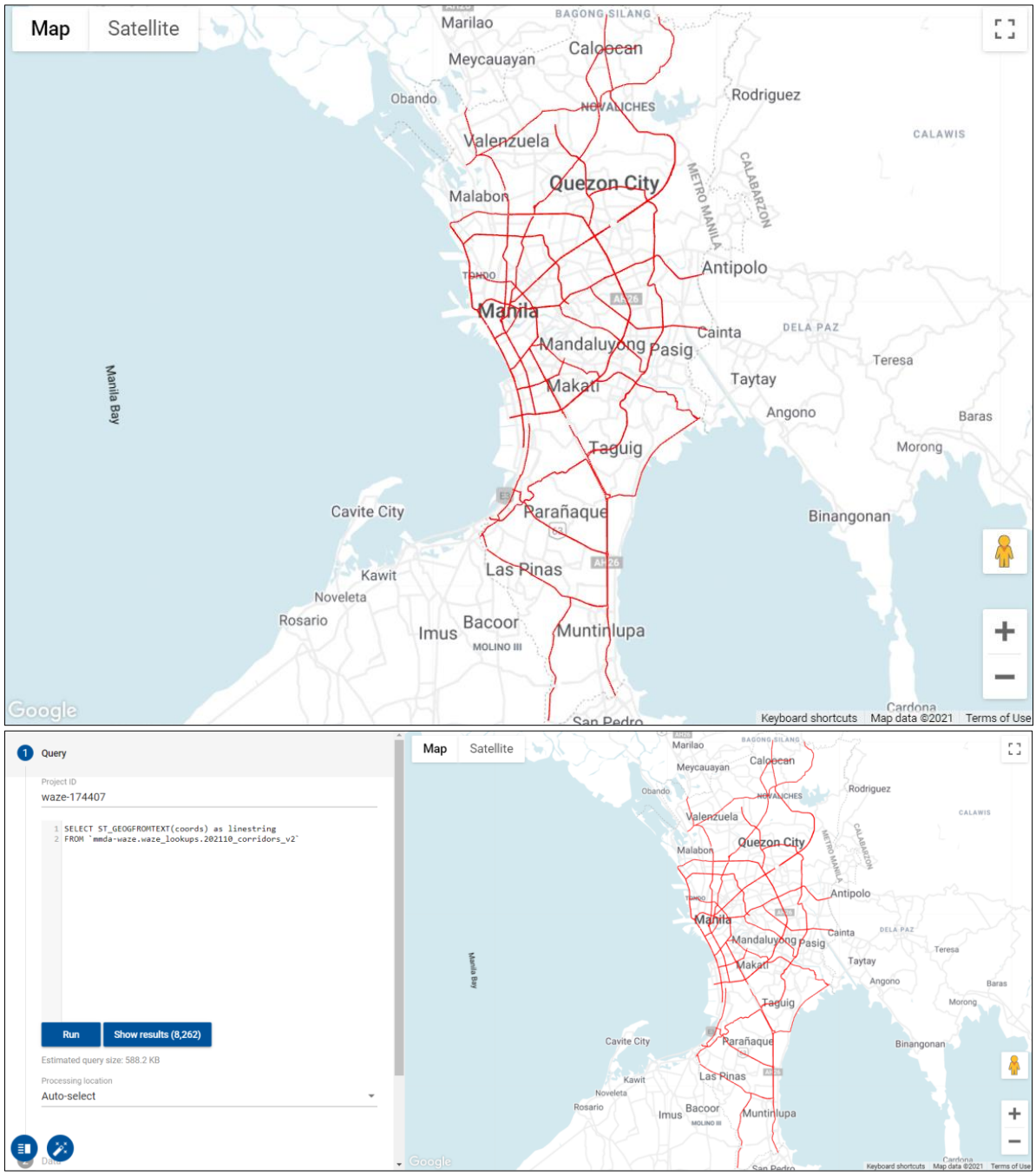
The road links per corridor were developed by JPT.

The maps show alignments of circumferential and radial roads and can be queried on BigQuery GeoViz.

Query:

```
SELECT ST_GEOGFROMTEXT(coords) as linestring

FROM `mmda-waze.waze_lookups.202110_corridors_v2`
```



Source: JPT

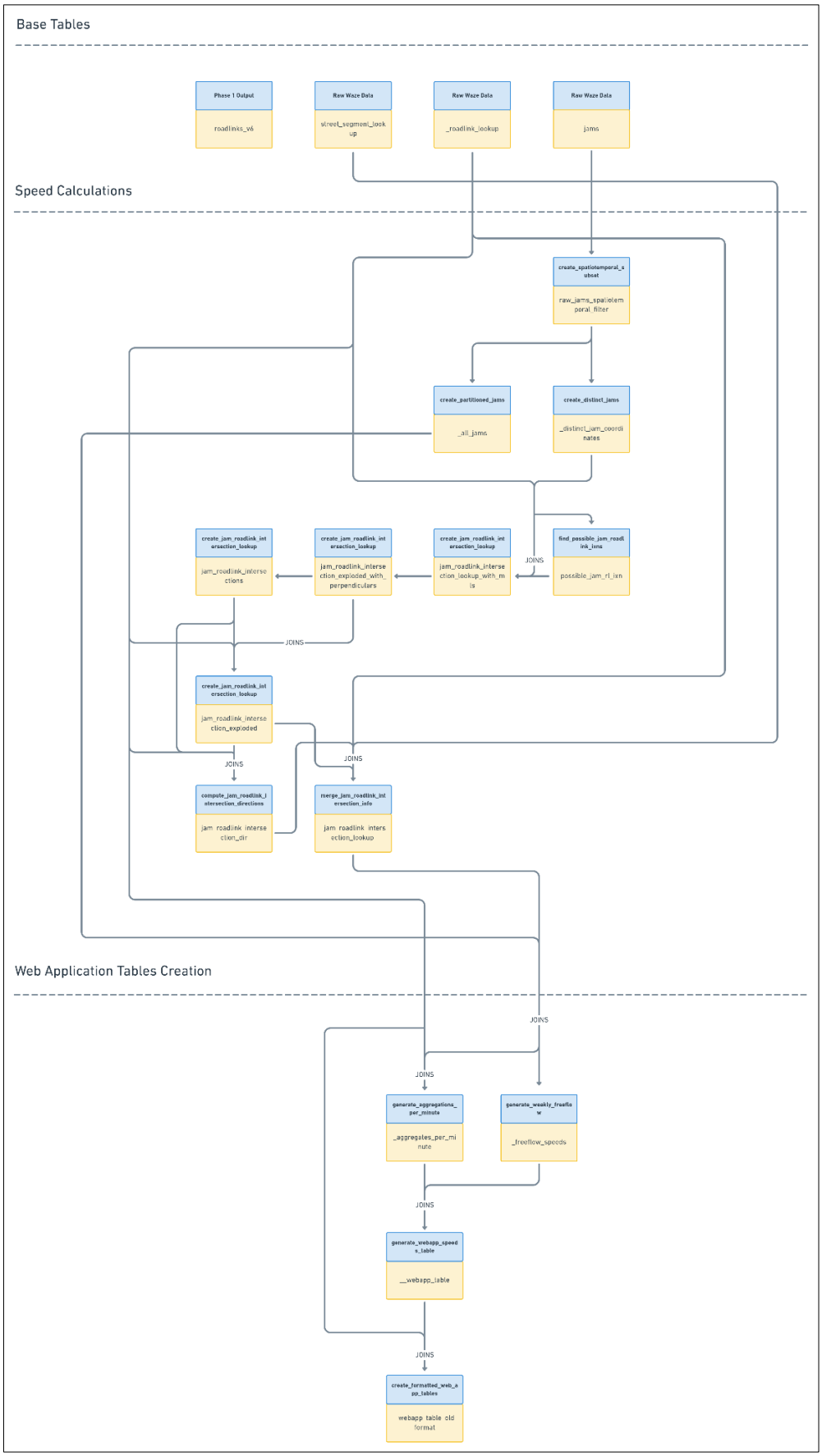
Figure 2.6: Alignments of Circumferential and Radial Roads in Metro Manila

2.3 Data

This section covers the data source used in the Waze Speed Calculation pipeline and the JICA Dashboard web app, BigQuery datasets, for storage of both raw and processed Waze-traffic data, frequency of data ingestion and processing, and the detailed flow of data from source to final tables produced.

(1) Data Flow

A better view of the flowchart can be seen in the Whimsical link here. This is the full data stream for the CTMP Project in the data warehouse. The blue boxes represent the pipeline tasks while the yellow boxes represent the output tables generated by that specific pipeline task. It gets raw data from Waze, stores it in the jams table, then undergoes a series of data transformations before we arrive at the final road link lookup table.



Source: JPT

Figure 2.7: Data Flowchart

(2) BigQuery Datasets

Table 2.14: Dataset Details

Dataset Name	Details
waze_lookups	Dataset for the processed and aggregated Waze-traffic data in production use; tables sourced by the JICA Dashboard web application in the prod environment are stored here; this dataset is updated monthly
waze_lookoups_dev	Dataset for the processed and aggregated Waze-traffic data in development use; tables sourced by the JICA Dashboard web application in the dev environment are stored here; use this dataset when testing changes introduced to the pipeline code before deploying to production
waze_traffic	Dataset for the raw Waze-traffic data: jams, alerts, irregularities; this dataset is updated every 2 minutes; for production use
waze_traffic_historical	Dataset for the raw Waze-traffic data: jams, alerts, irregularities; a historical copy up to a certain date but not appended every 2 minutes unlike `waze_traffic`
phase_1_web_app	Dataset for the processed Waze data ready for dashboard consumption; for production use

Source: JPT

(3) Data Dictionary and Data Processing

(a) Data Dictionary and Data Processing Sheet

Table 2.15: Data Dictionary and Data Processing Sheet

Project Name	Dataset Name	Table Name	Fields	Value	Description	Notes	Shared/Internal
mmda-waze	**waze_lookups**	**roadlinks_v6**	street_unique	STRING	Name string of the roadlink in **<street_name>_**	Used for prod/live dashboards	Shared
			WKT	LINESTRING	Linestring representation of the roadlink; contains the roadlink's coordinates that can be visualized using certain geographic functions	Used for prod/live dashboards	Shared
						Used for prod/live dashboards	
mmda-waze	**waze_lookups**	**_roadlink_lookup**	roadlink_id	INTEGER	Integer ID of the roadlink; unique identifier of each roadlink	Used for prod/live dashboards	Shared
			roadType	INTEGER	Integer representation of the road type; refer to either the Waze-traffic spec or JICA's documentation; used for more accurate estimates of vehicle speeds on that road type	Used for prod/live dashboards	Shared
			street_sim	STRING	Formatted name string of the roadlink	Used for prod/live dashboards	Shared
			coords	GEOGRAPHY	Linestring representation of the roadlink; contains the roadlink's coordinates that can be visualized using certain geographic functions	Used for prod/live dashboards	Shared
			angle	FLOAT	Angle of roadlink in degrees	Used for prod/live dashboards	Shared
			bq_roadlink_length	FLOAT	Length of the roadlink in meters	Used for prod/live dashboards	Shared
			buffered_6m	GEOGRAPHY	Polygon representation of the roadlink with 6.5m buffers on each side	Used for prod/live dashboards	Shared
mmda-waze	**waze_lookups**	**street_segment_lookup**	street	STRING	Name string of the roadlink in **<street_name>_s<i>** format where: street_name - refers to raw street name s<i> - ith roadlink with the same street name	Used for prod/live dashboards	Shared
			coords	STRING	Polygon/multilinestring representation of the street segment coordinates in string	Used for prod/live dashboards	Shared
			bearing	STRING	The angle of the roadlink with respect to the horizontal X axis	Used for prod/live dashboards	Shared
			direction_horizontal	STRING	Horizontal direction of the street E.g. E, W	Used for prod/live dashboards	Shared
			direction_vertical	STRING	Vertical direction of the street E.g. N, S	Used for prod/live dashboards	Shared
			direction_road	STRING	Direction of the road E.g. E, W, N, S	Used for prod/live dashboards	Shared
mmda-waze	**waze_lookups**	**_freeflow_speeds**	roadlink_id	INTEGER	Integer ID of the roadlink	Used for prod/live dashboards	Shared
			direction_jam	STRING	Direction of the jam E.g. N, S, E, W	Used for prod/live dashboards	Shared
			year	INTEGER	Year when jam occured	Used for prod/live dashboards	Shared
			month	INTEGER	Integer representation of month when jam occured (e.g 0 = January, 1 = February, etc)	Used for prod/live dashboards	Shared
			number_of_observations	INTEGER	Number of vehicle samples that were added to get this average freeflow speed value in that specific time frame	Used for prod/live dashboards	Shared
			freeflow_speed	FLOAT	Speeds of the vehicles without traffic (in meters per second)	Used for prod/live dashboards	Shared

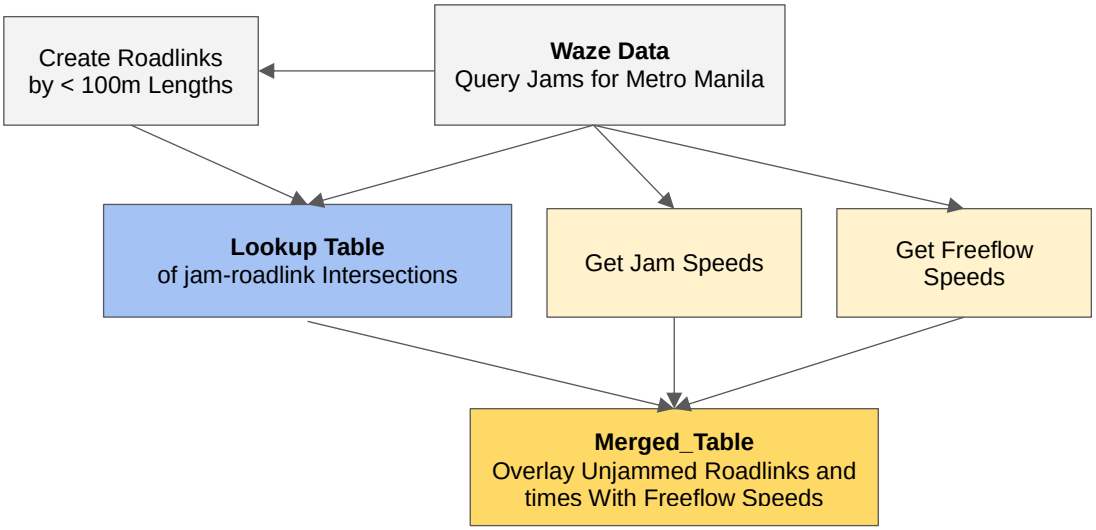
Project Name	Dataset Name	Table Name	Fields	Value	Description	Notes	Shared/Internal
mmda-waze	**waze_lookups**	**_aggregates_per_minute**	time	TIMESTAMP	Timestamp of jam recorded	Used for prod/live dashboards	Shared
			roadlink_id	INTEGER	Integer ID of the roadlink	Used for prod/live dashboards	Shared
			direction_jam	STRING	Direction of the jam captured by the roadlink	Used for prod/live dashboards	Shared
			rl_length	FLOAT	Length of the roadlink in meters	Used for prod/live dashboards	Shared
			ixn_total_length	FLOAT	Total length of intersection in meters	Used for prod/live dashboards	Shared
			ixn_length_multiplier	FLOAT	Integer multiplier of how much the intersection will grow based on aggregates	Used for prod/live dashboards	Shared
			freeflow_speed	FLOAT	Speeds of the vehicles without traffic	Used for prod/live dashboards	Shared
			jammed_time	FLOAT	Duration of jam in seconds	Used for prod/live dashboards	Shared
mmda-waze	**waze_lookups**	**__webapp_table_<date>**	roadlink_id	INTEGER	Integer ID of the roadlink	Used for prod/live dashboards	Shared
			direction_jam	STRING	Direction of the jam E.g. N, S, E, W	Used for prod/live dashboards	Shared
			day	DATE	Date of when the jam has occured	Used for prod/live dashboards	Shared
			hour	INTEGER	Total number of hours that a jam occured on that roadlink in a specific timeframe	Used for prod/live dashboards	Shared
			minute_bucket	INTEGER	Pertains to which minute time frame the jam was captured (segmented between 0 minutes, 20 minutes, and 40 minute time-windows between full hours); Has unique values of **0, 20, 40** only	Used for prod/live dashboards	Shared
			ave_speed	FLOAT	average travel speed along the jam (in meters per second)	Used for prod/live dashboards	Shared
mmda-waze	**waze_lookups**	**__webapp_table_old_format**	street_unique	STRING	Formatted ame string of the roadlink in **<street_name>_s<i>_i<j>_m<k>** format where: street_name - refers to raw street name s<i> - ith roadlink with the same street name i<j> - jth intersection of the roadlink m<k> - kth <100 meter split of the roadlink	Used for prod/live dashboards	Shared
			speed	FLOAT	freeflow speed of vehicles in that jam (meters per second)	Used for prod/live dashboards	Shared
			time	INTEGER		Used for prod/live dashboards	Shared
			day	INTEGER	Integer value to day of the month	Used for prod/live dashboards	Shared
			month	INTEGER	Integer value of month of the year (e.g. 0 = January, 1 = February)	Used for prod/live dashboards	Shared
			year	INTEGER	Year of when the jam occured	Used for prod/live dashboards	Shared
			date	DATE	Timestamp of when the jam occured	Used for prod/live dashboards	Shared
			roadtype	INTEGER	Integer representation of the road type of the roadlink; refer to either the Waze-traffic spec or JICA's documentation	Used for prod/live dashboards	Shared
			direction	INTEGER	Has only two values 0 and 1, which pertains to **d0** and **d1**. d0 are for jams closer to the direction of either the true East or true North. d1 for jams closer to the direction of either the true West or true South	Used for prod/live dashboards	Shared
mmda-waze	**waze_lookups**	**_average_ff_per_rl_dir**	street_unique	STRING	Formatted ame string of the roadlink in **<street_name>_s<i>_i<j>_m<k>** format where: street_name - refers to raw street name s<i> - ith roadlink with the same street name i<j> - jth intersection of the roadlink m<k> - kth <100 meter split of the roadlink	Used for prod/live dashboards	Shared
			roadlink_id	INTEGER	Integer ID of the roadlink	Used for prod/live dashboards	Shared
			direction	INTEGER	Has only two values 0 and 1, which pertains to **d0** and **d1**. d0 are for jams closer to the direction of either the true East or true North. d1 for jams closer to the direction of either the true West or true South	Used for prod/live dashboards	Shared
			freeflow_speed	FLOAT	Calculated freeflow speed in meters per second	Used for prod/live dashboards	Shared
			observations	INTEGER	Number of datapoints used to calculate the average freeflow speed	Used for prod/live dashboards	Shared

Project Name	Dataset Name	Table Name	Fields	Value	Description	Notes	Shared/Internal
N/A	**N/A**	**N/A**	ff_d0	INTEGER	**Alias from _average_ff_per_rl_dir** **If the value for the direction column above is 0, this refers to the freeflow speed average for that row's roadlink.** **Is the value of freeflow speeds that follow the direction of the roadlinks.**	Used for prod/live dashboards	Shared
			ff_d1	INTEGER	**Alias from _average_ff_per_rl_dir** **If the value for the direction column above is 1, this refers to the freeflow speed average for that row's roadlink.** **Is the value of freeflow speeds that follow the opposite direction of the roadlinks.**	Used for prod/live dashboards	Shared
			freq_d0	INTEGER	**Alias from _average_ff_per_rl_dir** **If the value for the direction column above is 0, this refers to the total number of observations (under the observation column).** **Total number of datapoints used to calculate ff_d0 values; more datapoints make the ff_d0 values much more significant and accurate**	Used for prod/live dashboards	Shared
			freq_d1	INTEGER	**Alias from _average_ff_per_rl_dir** **If the value for the direction column above is 1, this refers to the total number of observations (under the observation column).** **Total number of datapoints used to calculate ff_d1 values; more datapoints make the ff_d1 values much more significant and accurate**	Used for prod/live dashboards	Shared
waze-174407	**jica_2021_<suffix>**	**raw_jams_spatiotemporal_filter**	speed	FLOAT	Jam speed in meters per second	Used for dev/testing only, intermediate table used for computations	Internal
			street	STRING	Name string of the street specific to that city	Used for dev/testing only, intermediate table used for computations	Internal
			city	STRING	Name string of the city where the jam occurred	Used for dev/testing only, intermediate table used for computations	Internal
			length	INTEGER	Jam length in meters	Used for dev/testing only, intermediate table used for computations	Internal
			roadType	INTEGER	Integer representation of the road type; refer to either the Waze-traffic spec or JICA's documentation	Used for dev/testing only, intermediate table used for computations	Internal
			delay	INTEGER	difference between the in-jam delayed travel time and the ideal freeflow travel time (in seconds)	Used for dev/testing only, intermediate table used for computations	Internal
			jamTime	TIMESTAMP	Time the jam occurred	Used for dev/testing only, intermediate table used for computations	Internal
			coords	STRING	Linestring representation of where the jam occurred	Used for dev/testing only, intermediate table used for computations	Internal
waze-174407	**jica_2021_<suffix>**	**_distinct_jam_coordinates**	jam_id	INTEGER	Integer ID of the jam	Used for dev/testing only, intermediate table used for computations	Internal
			coords	STRING	Linestring representation of the jam coords in string	Used for dev/testing only, intermediate table used for computations	Internal
			street	STRING	Name string of the street where the jam occurred	Used for dev/testing only, intermediate table used for computations	Internal
			roadType	INTEGER	Road type of the street where the jam occurred	Used for dev/testing only, intermediate table used for computations	Internal
			num_jams	INTEGER	Number of times the jam occurred in the table	Used for dev/testing only, intermediate table used for computations	Internal
			bq_jam_length	FLOAT	Length of the jam linestring in meters	Used for dev/testing only, intermediate table used for computations	Internal
waze-174407	**jica_2021_<suffix>**	**_all_jams**	jam_id	INTEGER	Integer ID of the jam referenced in the _distinct_jam_coordinates	Used for dev/testing only, intermediate table used for computations	Internal
			time	TIMESTAMP	Start time of the jam	Used for dev/testing only, intermediate table used for computations	Internal
			jammed_speed	FLOAT	Jammed speed in meters per second	Used for dev/testing only, intermediate table used for computations	Internal
			freeflow_speed	FLOAT	Calculated freeflow speed in meters per second	Used for dev/testing only, intermediate table used for computations	Internal
waze-174407	**jica_2021_<suffix>**	**possible_jam_rl_ixn**	jam_id	INTEGER	Integer ID of the jam referenced in the _distinct_jam_coordinates	Used for dev/testing only, intermediate table used for computations	Internal
			street_jam	STRING	Name string of the street where the jam occurred	Used for dev/testing only, intermediate table used for computations	Internal
			street_sim	STRING	Formatted name string of the street where jam occurred **<street_jam>_s<i>_i<j>_m<k> format** where: street_name - refers to street where jam occured s<i> - ith roadlink with the same street name i<j> - jth intersection of the roadlink m<k> - kth <100 meter split of the roadlink	Used for dev/testing only, intermediate table used for computations	Internal

Project Name	Dataset Name	Table Name	Fields	Value	Description	Notes	Shared/Internal
waze-174407	**jica_2021_<suffix>**	**jam_roadlink_intersection_lookup_with_mls**	jam_id	INTEGER	Integer ID of the jam referenced in the _distinct_jam_coordinates	Used for dev/testing only, intermediate table used for computations	Internal
			jam_street	STRING	Name string of the street where the jam occurred	Used for dev/testing only, intermediate table used for computations	Internal
			street_sim	STRING	Formatted name string of the street where jam occurred **<jam_street>_s<i>_i<j>_m<k> format** where: street_name - refers to street where jam occured s<i> - ith roadlink with the same street name i<j> - jth intersection of the roadlink m<k> - kth <100 meter split of the roadlink	Used for dev/testing only, intermediate table used for computations	Internal
			roadlink_id	INTEGER	Integer ID of the roadlink that captured the jam	Used for dev/testing only, intermediate table used for computations	Internal
			intersection	GEOGRAPHY	Linestring representation of the intersection within the roadlink	Used for dev/testing only, intermediate table used for computations	Internal
			rl_length	FLOAT	Roadlink length in meters	Used for dev/testing only, intermediate table used for computations	Internal
			ixn_length	FLOAT	Intersection length in meters	Used for dev/testing only, intermediate table used for computations	Internal
waze-174407	**jica_2021_<suffix>**	**jam_roadlink_intersection_exploded_with_perpendiculars**	jam_id	INTEGER	Integer ID of the jam referenced in the _distinct_jam_coordinates	Used for dev/testing only, intermediate table used for computations	Internal
			roadlink_id	INTEGER	Integer ID of the roadlink that captured the jam	Used for dev/testing only, intermediate table used for computations	Internal
			intersection	STRING	Linestring representation of intersection coordinates in string	Used for dev/testing only, intermediate table used for computations	Internal
waze-174407	**jica_2021_<suffix>**	**jam_roadlink_intersections**	ixn_id	INTEGER	Integer ID of the intersection from the roadlink	Used for dev/testing only, intermediate table used for computations	Internal
			intersection	STRING	Linestring representation of the intersection coordinates	Used for dev/testing only, intermediate table used for computations	Internal
			ixn_length	FLOAT	Length of the intersection in meters	Used for dev/testing only, intermediate table used for computations	Internal
			angle	FLOAT	Angle of the intersection in degrees	Used for dev/testing only, intermediate table used for computations	Internal
			ixn_firstpoint	STRING	Linestring coordinates of starting point of the intersection on the map; connect to endpoint to draw intersection	Used for dev/testing only, intermediate table used for computations	Internal
			ixn_endpoint	STRING	Linestring coordinates of last point of the intersection on the map; connect to start point to draw intersection	Used for dev/testing only, intermediate table used for computations	Internal
waze-174407	**jica_2021_<suffix>**	**jam_roadlink_intersection_dir**	roadlink_id	INTEGER	Integer ID of the roadlink	Used for dev/testing only, intermediate table used for computations	Internal
			ixn_id	INTEGER	Integer ID of the intersection from the roadlink	Used for dev/testing only, intermediate table used for computations	Internal
			direction_flow	BOOLEAN	Boolean value to dictate if jam flows *with* or *against* predicted traffic direction	Used for dev/testing only, intermediate table used for computations	Internal
waze-174407	**jica_2021_<suffix>**	**_jam_roadlink_intersection_lookup**	jam_id	INTEGER	Integer ID of the jam	Used for dev/testing only, intermediate table used for computations	Internal
			roadlink_id	INTEGER	Integer ID of the roadlink that captured the jam	Used for dev/testing only, intermediate table used for computations	Internal
			capped_intersection_length	FLOAT	Length of the intersection in the roadlink in meters	Used for dev/testing only, intermediate table used for computations	Internal
			direction_flow	BOOLEAN	Boolean value to dictate if jam flows *with* or *against* predicted traffic direction	Used for dev/testing only, intermediate table used for computations	Internal
			direction_jam	STRING	Direction of the jam E.g. N, S, E, W	Used for dev/testing only, intermediate table used for computations	Internal

Source: JPT

(b) **Computations**



Source: JPT

Figure 2.8: Computation Flowchart

Details:

(i) Lookup Table is fixed on its location data across each run. (i.e. 150: Padre Burgos E _s0_i0_m0, primary roads will always have the same location coordinates) Based on 2018 to 2020 data.

(ii) Merged tables can be compared historically because road names and road types are fixed per location data.

Steps:

(i) Creation of < 100m road links based on unique road coordinates from Waze

(ii) Determine all unique jam-road link intersections

(iii) Determine the average speed per road link based on the speeds of the jams along them

(iv) Estimate the free-flow speed per road link based on speeds and travel times along unjammed portions of the road links

(v) Fill in free-flow speeds for road links and times that did not have jam data for a given road link.

(c) **Speed and Merged Table**

The Speed and Merged table are the resulting BigQuery table from the aggregated jammed speeds and free-flow speeds per road link. Initially, we use the jammed speeds to determine the average speed for a road link, however, in cases such that a road link does not have jam data, we estimate the free-flow speed for the road link based on speeds and travel times along its unjammed portions. We use the estimated free-flow speed to fill in the average speeds for road links that do not have jam data. The Speed and Merged table is the data source used by the JICA Dashboard Web application.

(4) Dagster

(a) **Dagster Instances**

Table 2.16: Dagster Instances

Instance/VM	Description
dagster-monthly	VM instance that hosts the monthly Waze Speed Calculation pipeline for production use.
dagster-monthly-dev	VM instance that hosts the monthly Waze Speed Calculation pipeline for development use.
dagster-historical	VM instance that hosts the historical Waze Speed Calculation pipeline for production use.
dagster-historical-dev	VM instance that hosts the historical Waze Speed Calculation pipeline for development use.

Source: JPT

(b) **Dagster Pipelines**

There is a single dagster pipeline responsible for orchestrating the Waze Speed calculation and producing the final BigQuery tables for the Dashboard web app: waze_lookup_pipeline. The dagster instance image is deployed as a Docker container in the dagster Compute Engine instance. The waze_lookup_pipeline does not have any defined scheduler in code to orchestrate the project's objective monthly run; rather we let the Instance Schedule monthly-speed-calculation-schedule run the pipeline for us in 1-month intervals.

(c) **VM: Dagster (Prod)**

All output tables produced by the Waze Speed calculation pip fall under one dataset which is the waze_lookups dataset.

(d) **Output Tables**

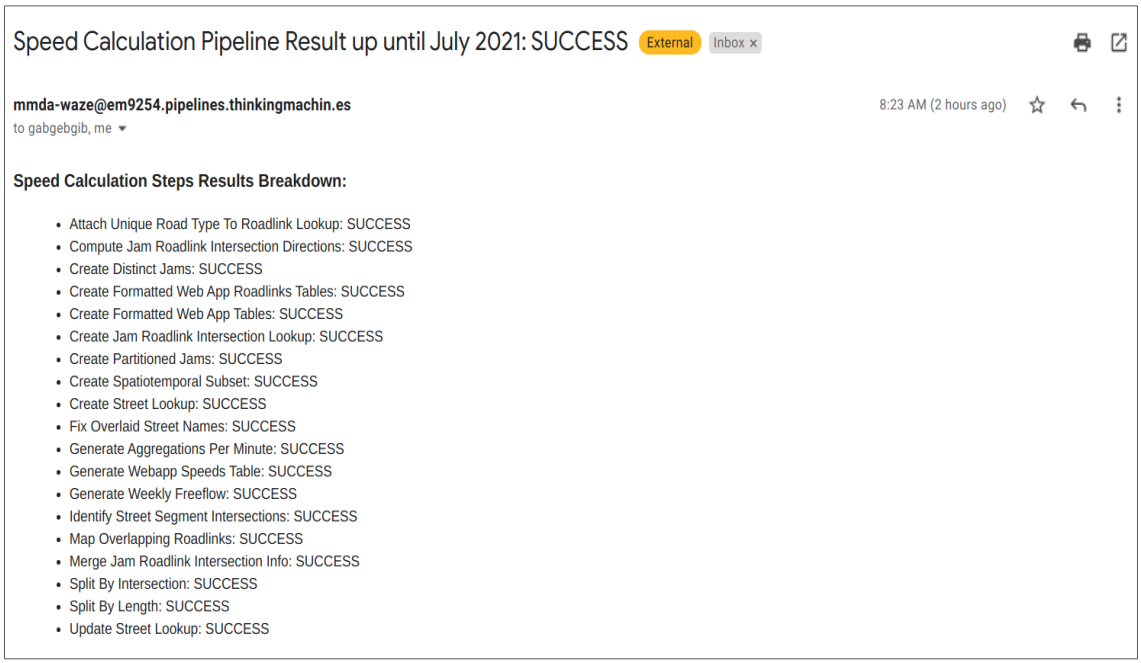
Table 2.17: Output Tables

Pipeline	Dataset	Table
waze_lookup_pipeline	waze_lookups	webapp_table_<date> webapp_table_old_format aggeregates_per_minute all_jams distinct_jam_coordinates free-flow_speeds jam_roadlink_intersection_lookup jam_roadlink_intersection_dir jam_roadlink_intersection_exploded jam_roadlink_intersection_lookup_with_mls jam_roadlink_intersections raw_jams_spatiotemporal_filter

Source: JPT

(e) **Pipeline Notifications**

Every month an email notification will be sent to stakeholders and maintainers of the project showing the results of the Waze Speed Calculation pipeline.



Source: JPT

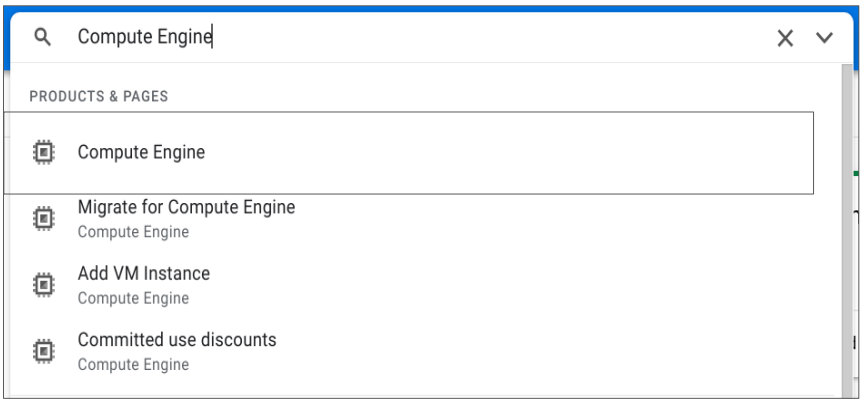
Figure 2.9: Example of a Pipeline Notification

(f) Trigger a Manual Run

Should the clients, stakeholders, or maintainers of the project decide to run the Waze Speed Calculation pipeline manually, it can be done by starting/restarting the dagster VM/Compute Engine instance via the Google Cloud Console.

- Step 1

Look up or search "Compute Engine" in the Google Cloud Console search bar and click the first search result item: Compute Engine.

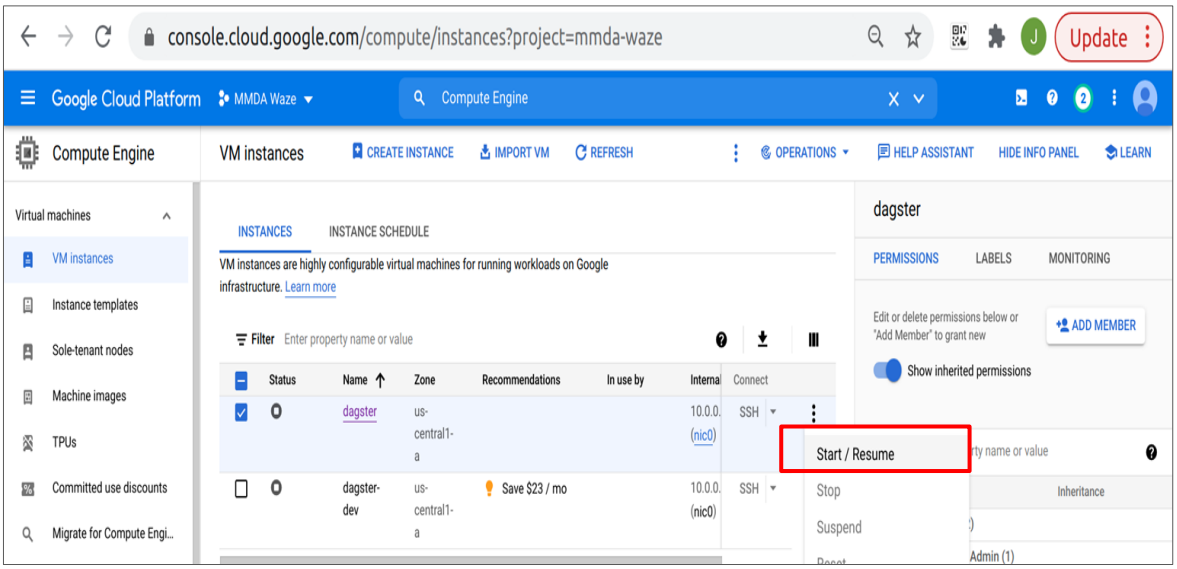


Source: JPT

Figure 2.10: Google Cloud Console Search Bar

- Step 2

Locate the dagster item under the INSTANCES tab and click the More actions icon or the vertical three dots icon on the right side, click Start/Resume if the dagster item is currently stopped denoted by the Status column. If currently running and not stopped, click Stop instead and click Start/Resume again after stopping.



Source: JPT

Figure 2.11: Waze Speed Calculation

The Waze Speed Calculation will now run.

(5) Types of Manual Triggers

Table 2.18: Types of Manual Triggers

VMs	Purpose	VM Details
dagster-monthly	Runs the Waze Speed Calculation pipeline on the previous month's raw Waze traffic data; scheduled to run every first day of the month but can be manually triggered as well	1 vCPU, 3.75 GB memory
dagster-historical	Runs the Waze Speed Calculation pipeline on the raw Waze data from 2018 up until the last day of the previous month; manually triggered	2 vCPUs, 13 GB memory

Source: JPT

(6) Monthly Run

Manually triggering a monthly run is needed if the scheduled monthly run every first day of the month fails due to intermittent and unlikely reasons such as down services, or internet connectivity issues in the Compute Engine instance of the pipeline. If manual intervention from the maintainers of the project is needed to fix unforeseen issues to get the pipeline running again, the monthly run will have to be manually triggered after the issue has been resolved.

Table 2.19: How to Do Monthly Run Manually

Issue	Details	Actions Required
Speed Calculation Fails	Information on the failed task will be elaborated further on the email notification sent to stakeholders after the run has concluded.	Start/Restart the dagster-monthly Compute Engine Instance in the GCP UI to re-trigger the speed calculation for the previous month.

Source: JPT

(7) Full Run

Manually trigger a historical run is needed if the stakeholders decide to update the road links data used for the speed calculation from 2018 up until the current date.

Table 2.20: How to Do Full Run Manually

Issue	Details	Actions Required
Road links Data Change	The roadlinks data in the roadlinks_v6 BigQuery table is based on a file provided by the JICA stakeholders. Should the stakeholders decide to update the roadlinks data used on both the speed calculation and the dashboard web app, maintainers of the project should update the roadlinks_v6 and _roadlink_lookup table accordingly	Contact Thinking Machines and provide the updated roadlinks file. The maintainers of the project should manually update the roadlinks_v6 and _roadlinks_lookup BigQuery tables in the waze_lookup dataset. Other than the BigQuery tables mentioned, the geometries.json file in the JICA Dashboard Web App Github repository should be updated as well. After updating the roadlinks data, start/restart the dagster-historical Compute Engine Instance in the GCP UI to trigger the historical speed calculation.

Source: JPT

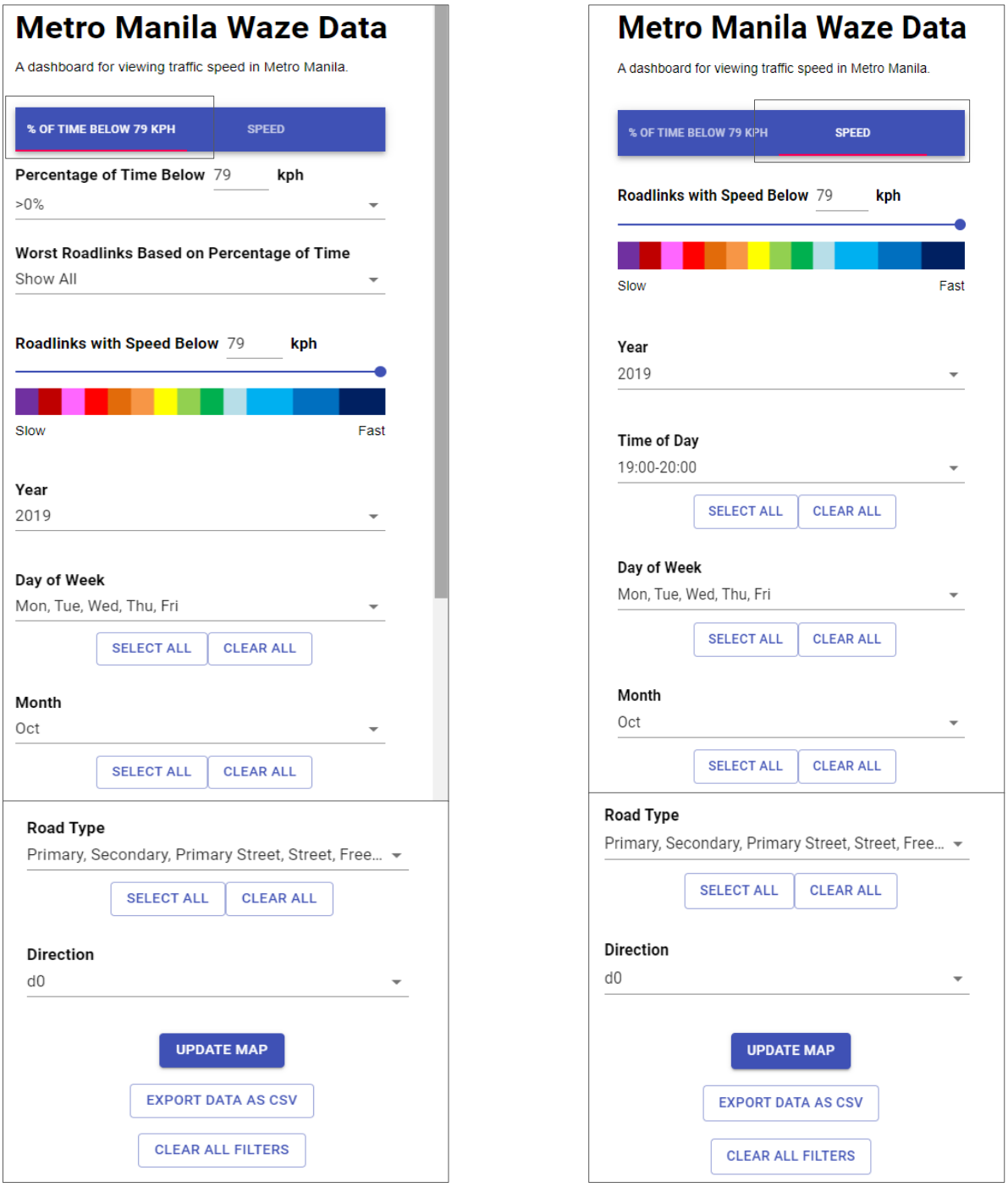
2.4 Dashboard

The Web App Dashboard is intended to visualize jams at a road link level.

Table 2.21: Web App Dashboard Button Details

No	Button/Filter	Details
1	% of Time Below KPH	Only displays the roadlinks that meet the % occurrence
2	Speed	Only displays the roadlinks that are selected in the range
3	Worst Roadlinks Based on Percentage of Time	Narrows down the search to worst roadlinks in terms of jams/delays
4	Roadlinks with Speed Below KPH	Only displays the roadlinks that are selected in the range
5	Color Bar	Color symbols of how fast/slow a roadlink is. This is affected by the roadlink speed filter
6	Time of Day	(Only at the speed filters) Select from hourly times of day
7	Year	Select the year
8	Day of Week	Select the day of the week
9	Month	Select the month of the year
10	Road Type	Select the road type as determined by the JICA (previously determined by Waze data, but due to randomness of the raw data labeling, this was made consistent by JICA)
11	Direction	d0 - East Bound / North Bound d1 - West Bound / South Bound
12	Update Map	Displays the queried results
13	Export Data as CSV	Download as a csv file the data shown on the dashboard based on the filters selected
14	Clear all Filters	Restores all filters to default

Source: JPT



Source: JPT

Figure 2.12: Select Button / Filter in Dashboard

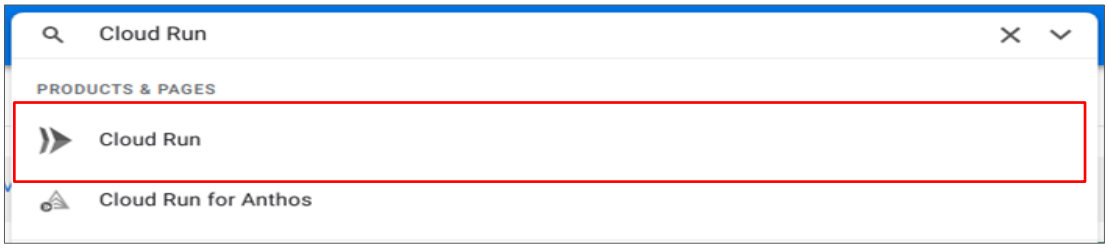
2.5 Access Management

(1) Updating Dashboard User Access

In order to add or remove emails with access to the Web App Dashboard, the developer must redeploy the mmda-waze-jica-dashboard-<environment> service in Cloud Run.

(a) **Step 1**

Look up or search "Cloud Run" in the Google Cloud Console search bar and click the first search result item: Cloud Run.

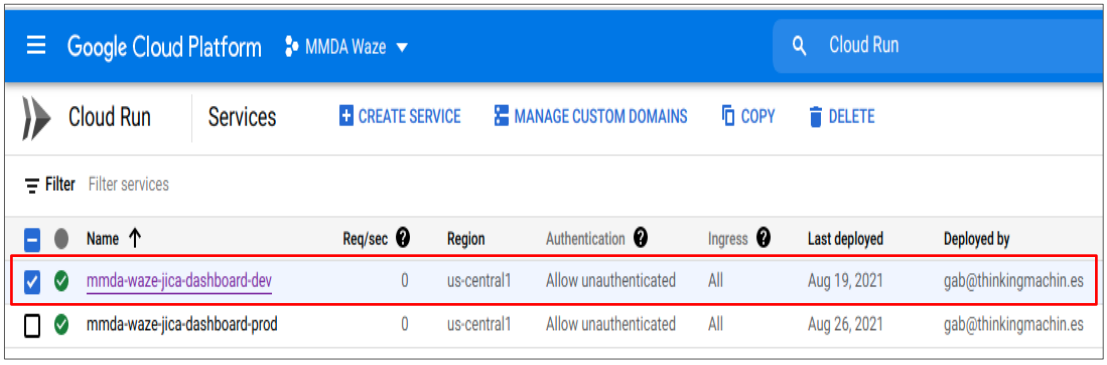


Source: JPT

Figure 2.13: Cloud Run

(b) **Step 2**

Locate and click the Cloud Run service you want to redeploy; for example, the mmda-waze-jica-dashboard-dev service.

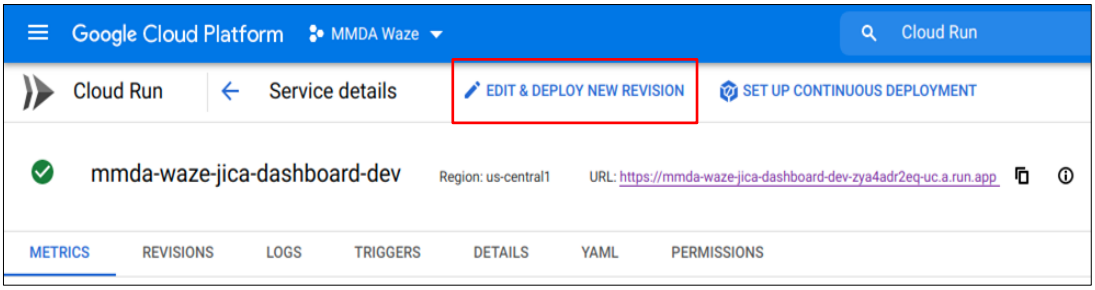


Source: JPT

Figure 2.14: Selecting Cloud Run Service

(c) **Step 3**

After clicking the Cloud Run service of your choice; the user will be redirected to the Cloud Run Service details page; click the EDIT & DEPLOY NEW REVISION button.

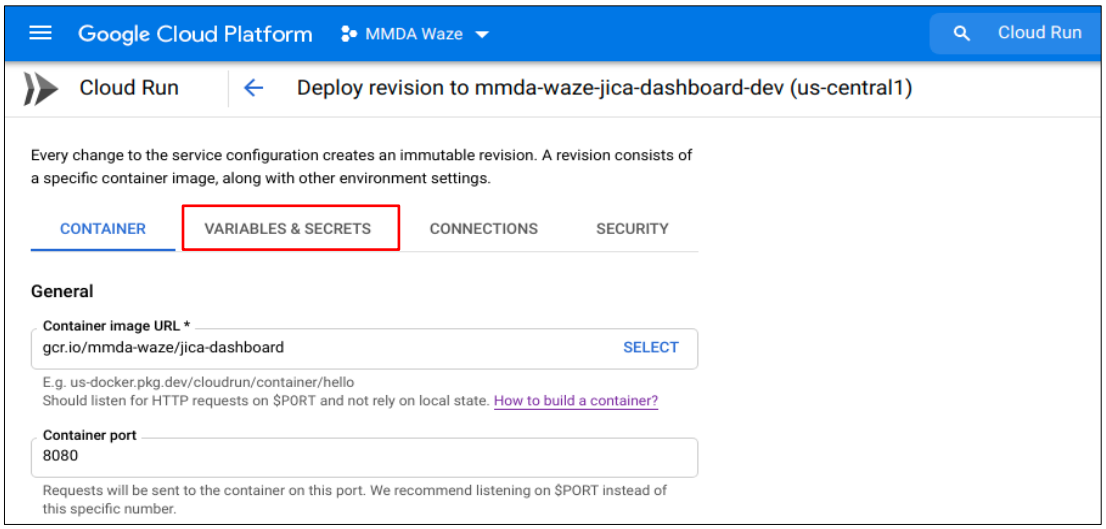


Source: JPT

Figure 2.15: Edit and Deploy New Revision Button

(d) **Step 4**

In the Deploy revision page of the mmda-waze-jica-dashboard-<environment> service, click the VARIABLES AND SECRETS tab

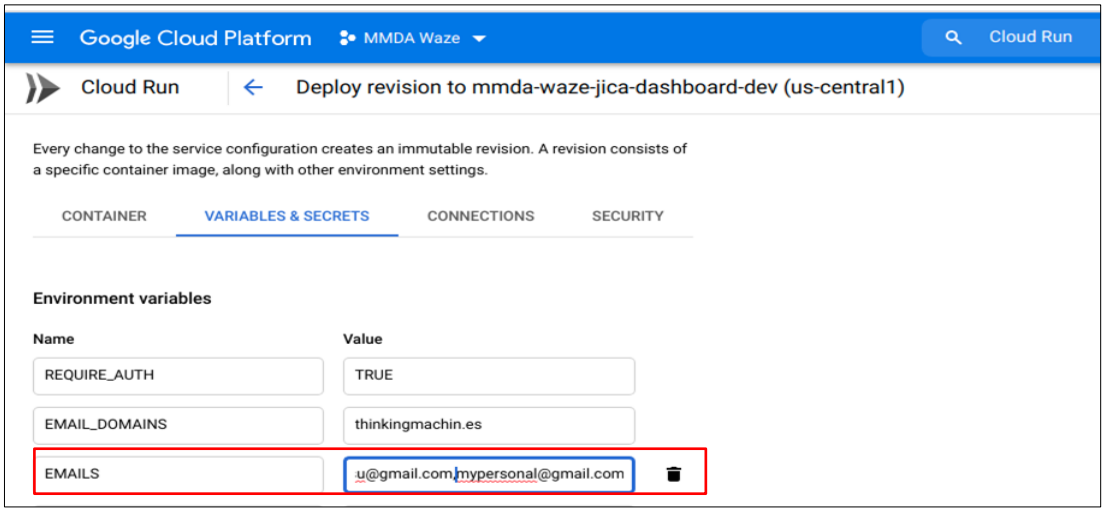


Source: JPT

Figure 2.16: Variables and Secrets Tab

(e) **Step 5**

Locate the Environment variables section under the VARIABLES & SECRETS tab, and update the value of the EMAILS variable; either append a new email address separated by a comma sign, or remove an old email address.

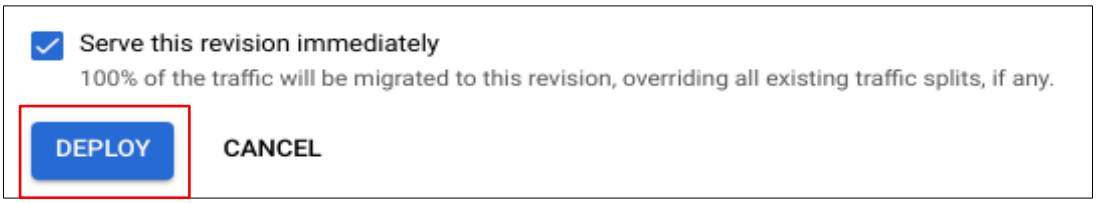


Source: JPT

Figure 2.17: Environment Variables

(f) **Step 6**

Click the DEPLOY button at the bottommost part of the Deploy revision screen.

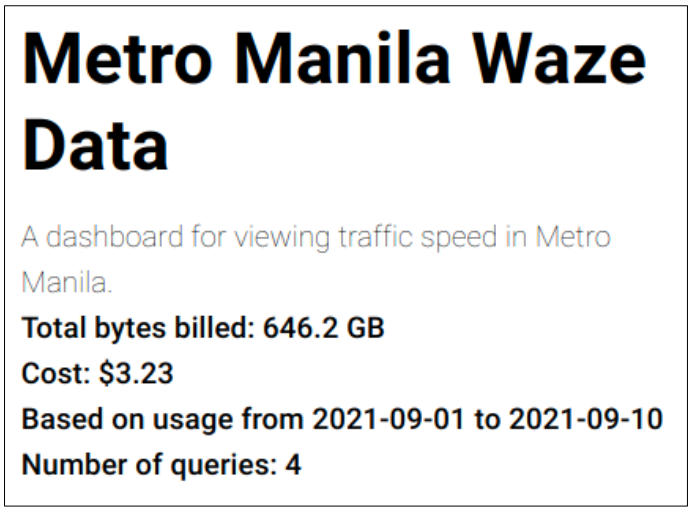


Source: JPT

Figure 2.18: Deploy Button

(2) Updating Access to the Web App Cost Metrics

Other than controlling access to the Web App Dashboard service itself, we can also manage users who can view the web app cost metrics for monitoring query usages, quota, and billing.



Source: JPT

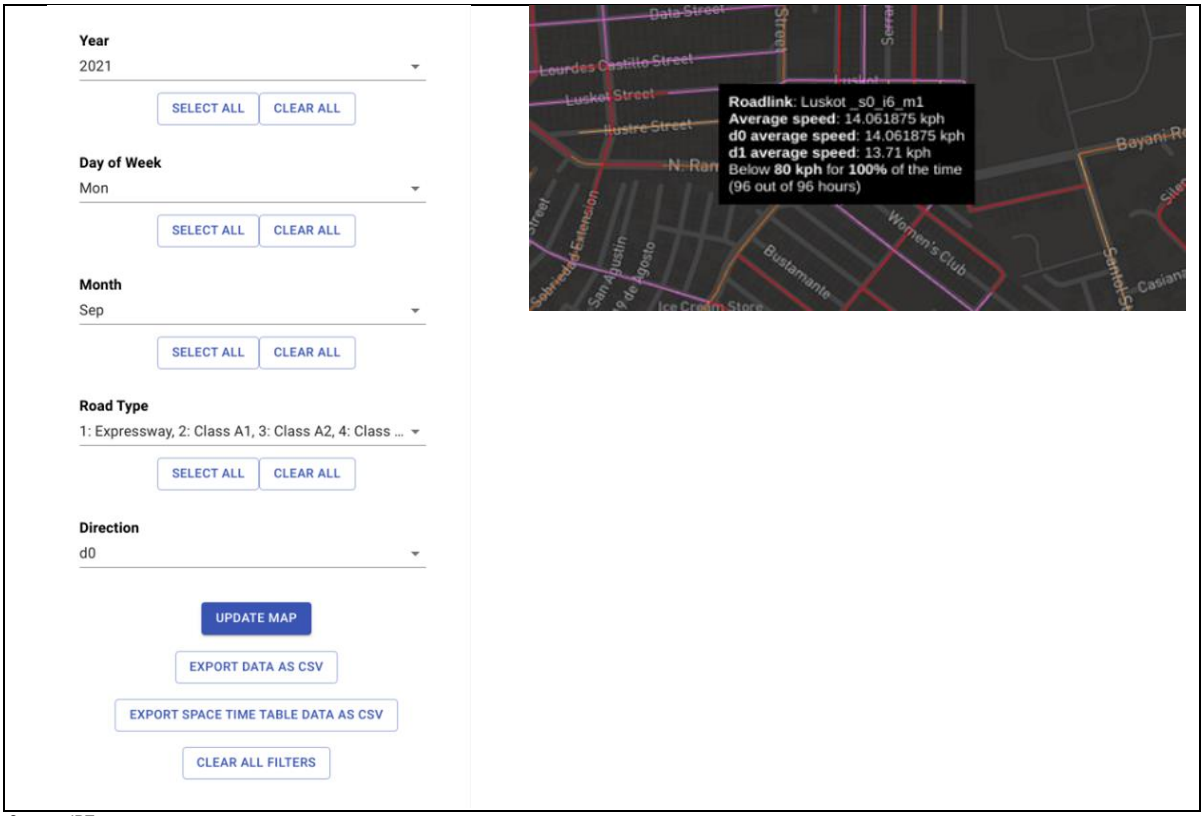
Figure 2.19: Screenshot of Cost Estimation in Dashboard

However, with the current implementation of the web app dashboard from phase one of the project, users with access to this view can only be updated via changes in the web app source code which requires assistance from Thinking Machines.

(3) Dashboard Year, Month, and Day Filters

The combination of values you select in the date filters will determine the roadlinks data to be displayed in the dashboard map view. Specifically, different combinations of filters will result in varying roadlink speeds average in the map view which is shown by the color of the roadlinks/line segments. Clicking the "UPDATE MAP" button in the dashboard computes the average speed of the roadlinks over the selected dates determined by the date filters.

For example, selecting only Mondays from the month of September year 2021 will only compute the average roadlinks speeds over four (4) days or ninety-six (96) hours since there are only four Mondays in September 2021. In order to verify this, hovering over a displayed roadlink in the map view will show a pop-up displaying the following information with regards to the hovered-over roadlink: name, average speed, average speed in direction d0, average speed in direction d1, and percent of time below N-kph.



Source: JPT

Figure 2.20: Screenshot of Year, Month, and Day Filter in Dashboard

(4) Querying for Merged Tables

```
—----------------------------------------------------------------------------------------------------------------
select New_ID,roadlink_id,a.street_unique,a.direction,roadType,day, time, speed     from
(select street_unique, day, time, speed,direction FROM `mmda-waze.waze_lookups.__webapp_table_old_format` WHERE
date = "2021-11-29") a
left join
(SELECT * from `mmda-waze.waze_lookups.webapp_reference_table`) b
on a.street_unique = b.street_unique
and a.direction=b.direction
order by a.street_unique,a.direction, day, time
—----------------------------------------------------------------------------------------------------------------
Change this value to query a different date.
```

2.6 Known Limitations

These are all the known issues. There may be more issues not yet found.

(1) Slow Dashboard Load Times

Slow loading times may be due to the individual user's internet connectivity, or hardware limitations

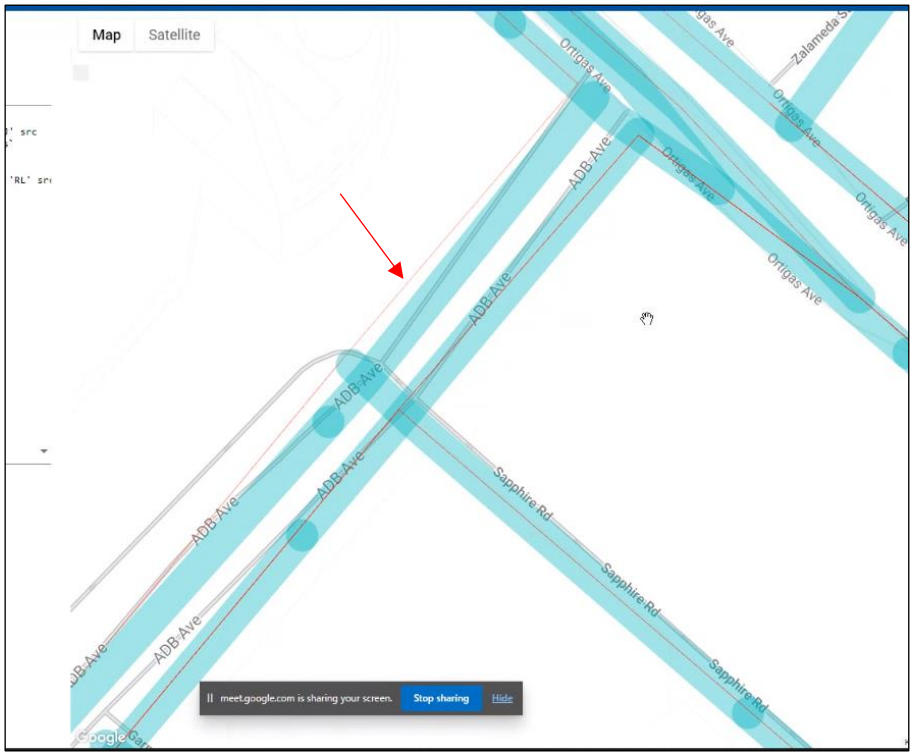
Slow loading times may also be due to Cloud Run's "cold start". If the service is not used for an unspecified amount of time, Google terminates the web app dashboard. Using the web app again after it has been terminated requires the Cloud Run instance to re-download the web app dashboard requirements (docker image) and start it again. Increasing the minimum instances to make a warm start would increase resource costs unnecessarily.

(2) Waze Data Limitations

(a) **Waze GPS Data Changes Every Run**

Challenge:

- The Waze road data (marked by the red lines) is not the same on every run.
- This will not line up with the road links data set by JPT in Road links v6.
- If the road data is not captured at all, the data will assume it is free-flowing.



Source: JPT

Figure 2.21: Example of Waze GPS Data which Does Not Match Road Links

Solution:

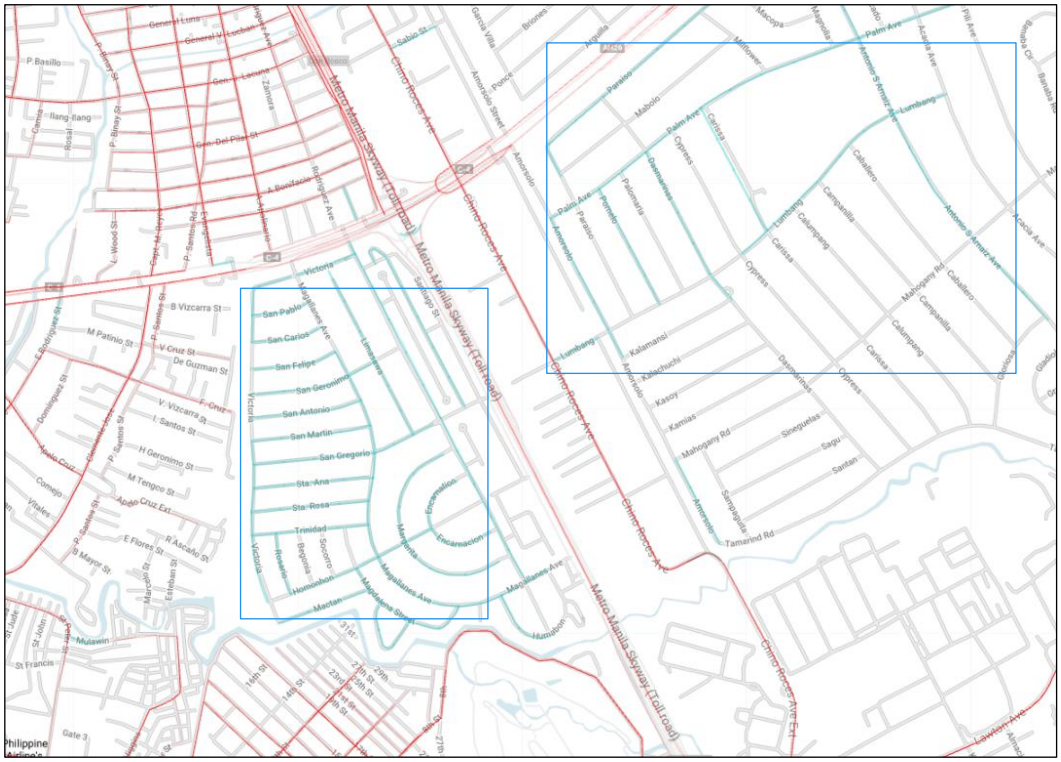
- Buffer zones (marked by the blue highlights) will be created that will detect any Waze road data in the buffer zones like a map matching.

Implications:

- There is a higher chance the Waze road data will be captured.
- The buffer zones are still able to distinguish overlapping road data due to overpasses or fly-overs.
- The buffer zones may inadvertently capture road traffic from other roads that are overlapping or intersecting. This can understate or overstate traffic speed data.

(b) **Some Road Links Do Not Have Any Jams Data**

- Red lines represent all jams from 2020-05 to 2021-07
- Cyan highlights represent road links without any data (e.g. village, military area, etc.)
- 5,000 out of 59,000 road links do not have jam data



Source: JPT

Figure 2.22: Example of Road Links which Has No Waze Data

(c) **When Waze Updates their Underlying Roadmap Location**

Challenge:

- Waze updated its underlying map from the 2018 map which road links v6 is based on.
- This is a special case that cannot be handled by widening the buffer of the road links v6 since the roads are in completely different locations.

Implication:

- Certain road links will not be captured because the Road links v6 location is wrong

Source: JPT

Figure 2.23: Example of New Waze Road Links

(d) **Road Links based on U-turns Cannot Be Captured**

Challenge:

- The methodology for dropping irrelevant intersections is based on the angle between the endpoints of the road link and the intersection.

Implication:

- There is a possibility that the jams of U-turns will not be attributed to the U-turn road link.

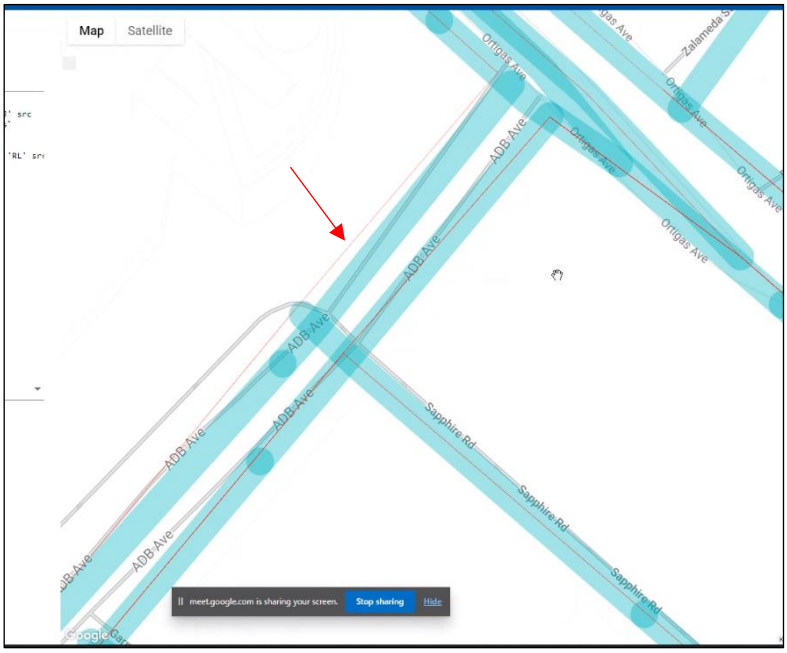
Source: JPT

Figure 2.24: Example of a U-turn which Cannot Be Captured

(e) **Waze Road Data can Shift and Might Not Be Consistent from Run to Run**

Challenge:

- The Waze road data (marked by the red lines) is not the same in every run. This does not line up with the road links data set by JICA in Road links v6.
- If the road data is not captured at all, the data will assume it is free-flowing.



Source: JPT

Figure 2.25: Example of Inconsistent Waze Data

Solution:

- Buffer zones (marked by the blue highlights) will be created that will detect any Waze road data.

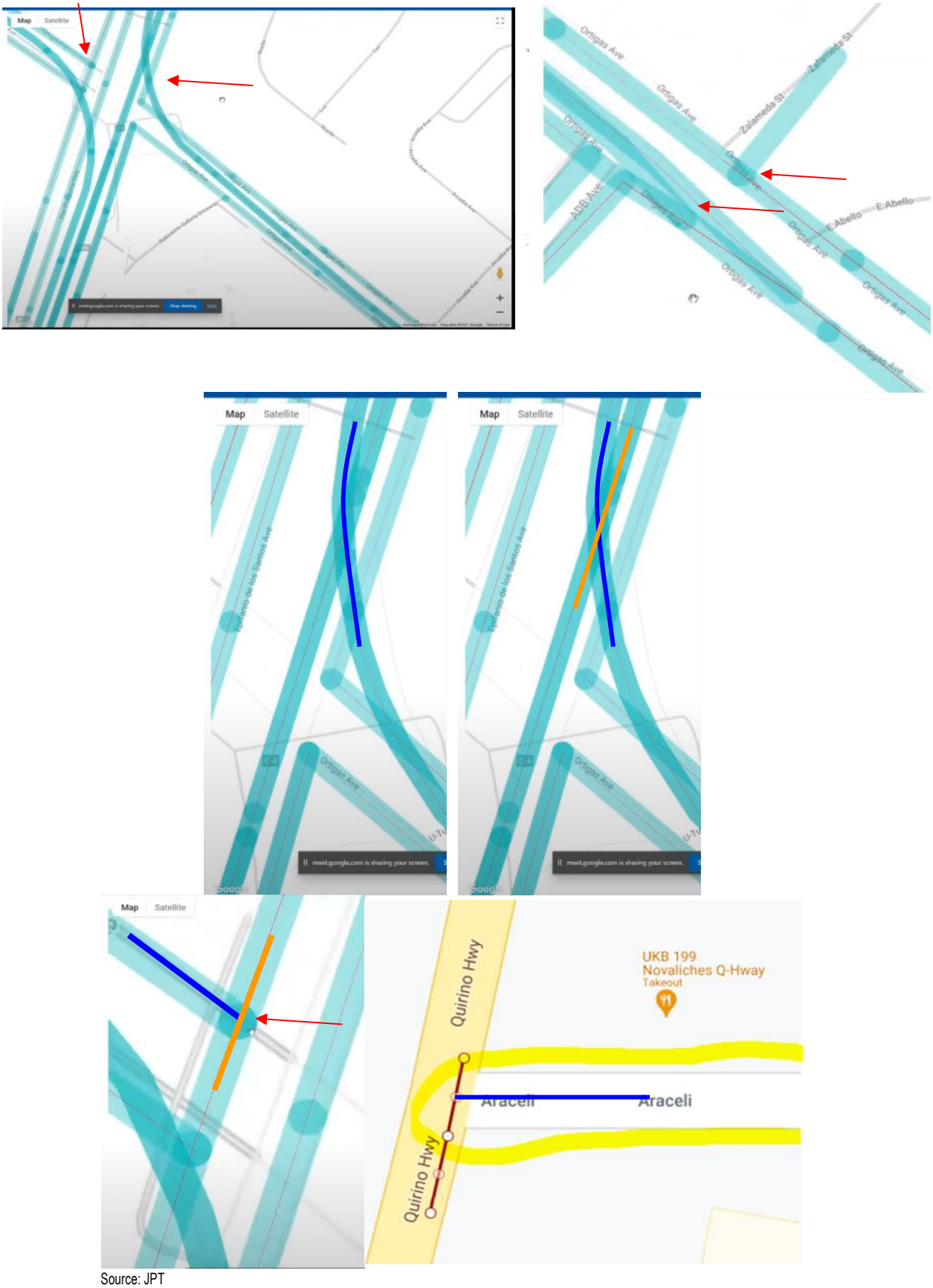
Implication:

- There is a higher chance that the Waze road data will be captured.
- The buffer zones are still able to distinguish overlapping road data due to overpasses or fly-overs.
- The buffer zones may inadvertently capture road traffic from other roads that are overlapping or intersecting. This can understate or overstate traffic speed data.

(f) **Increasing the Buffer Zone Size May Make It Harder to Differentiate the Overlapping and Intersecting Roads**

Challenge:

- Overlapping roads can affect the captured speed data of the roads below and/or above.
- Perpendicular roads may affect the speed of the main roads



Source: JPT

Figure 2.26: Example of Problem Due to Increasing Buffer Size

Solution:

- Create a code wherein the data will not be captured by the road if the angle of two intersecting and overlapping lines is more than 20 degrees.
- This is how we remove roads that are not part of the original road.

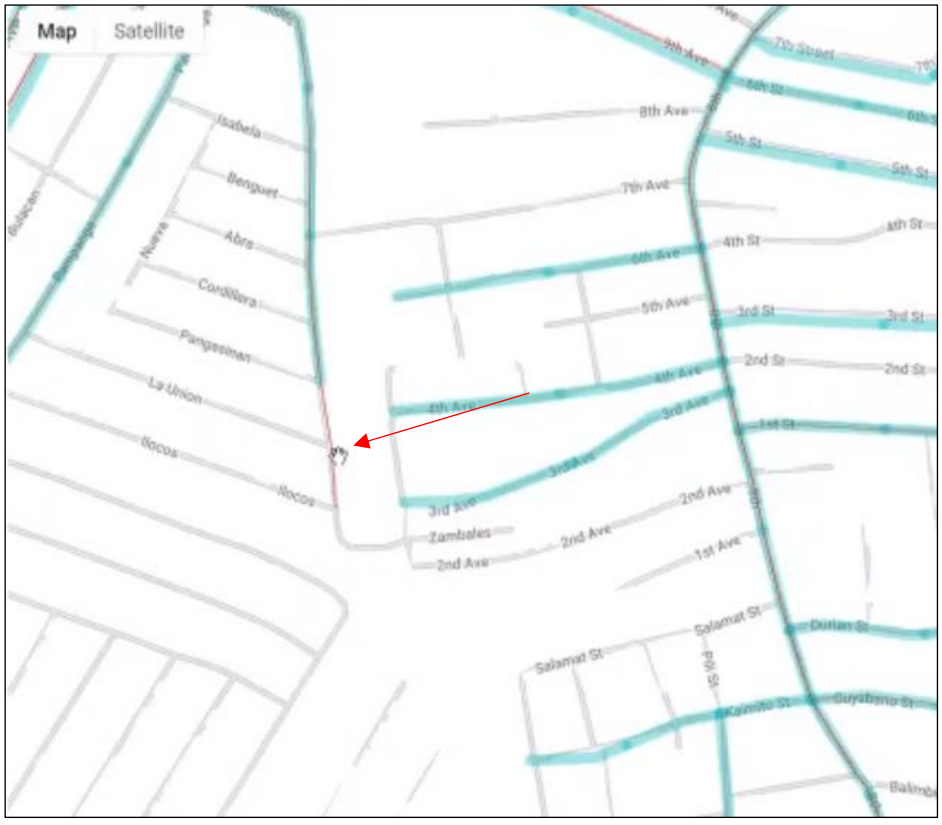
(g) **New Traffic Areas and New Roads will Not Be Captured. This Appears as Red Lines Without Buffer Zones**

Challenge:

- New road data that comes in for streets will not be captured in methodology 2 because road links v6 are fixed.
- This happens when Waze captures new traffic data in areas it did not capture before (i.e., 2018, 2019).
- This is unique to methodology 2 because it is based on road links v6.

Implication

- New road links will not be properly captured.



Source: JPT

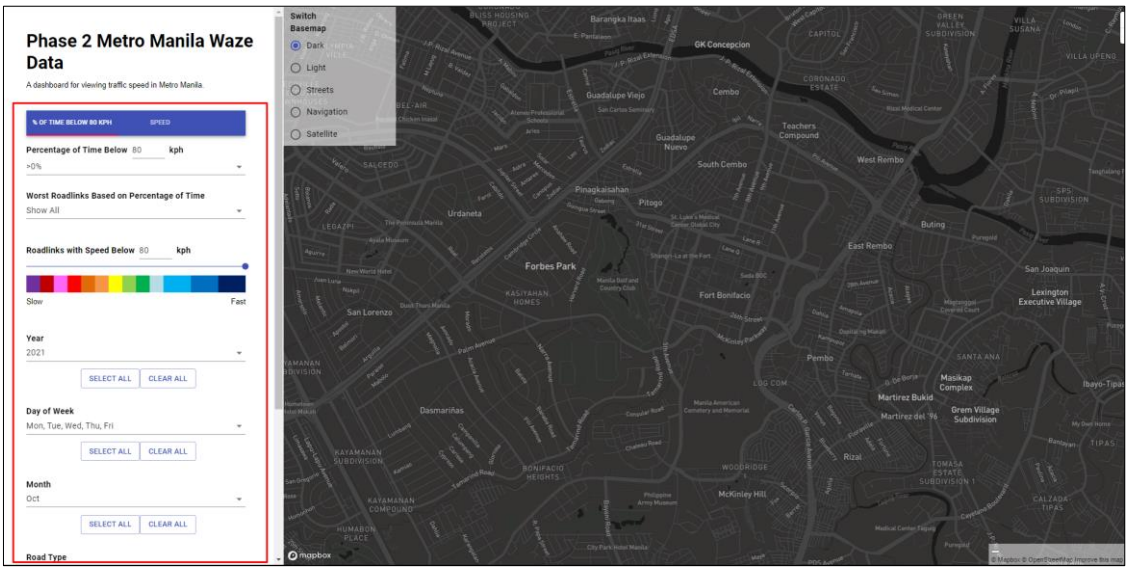
Figure 2.27: Example of New Waze Data on Road Links Not Captured Before

3 USER MANUAL

3.1 Instructions

(a) Go to the Dashboard at this link: https://mmda-waze-jica-dashboard-prod-zya4adr2eq-uc.a.run.app/

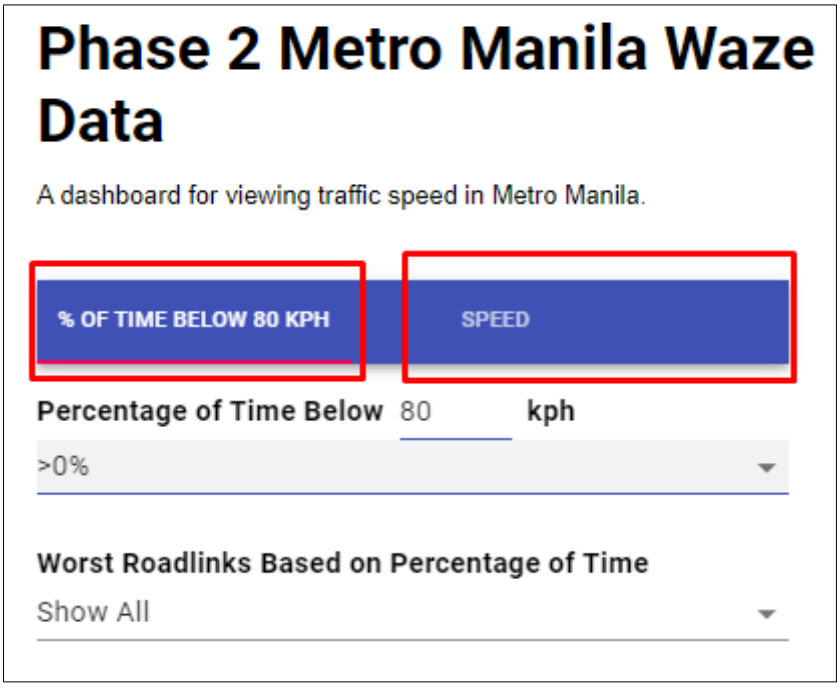
(b) Select the different filters to the left of the Dashboard to change the results shown on the screen.



Source: JPT

Figure 3.1: Waze Data Dashboard

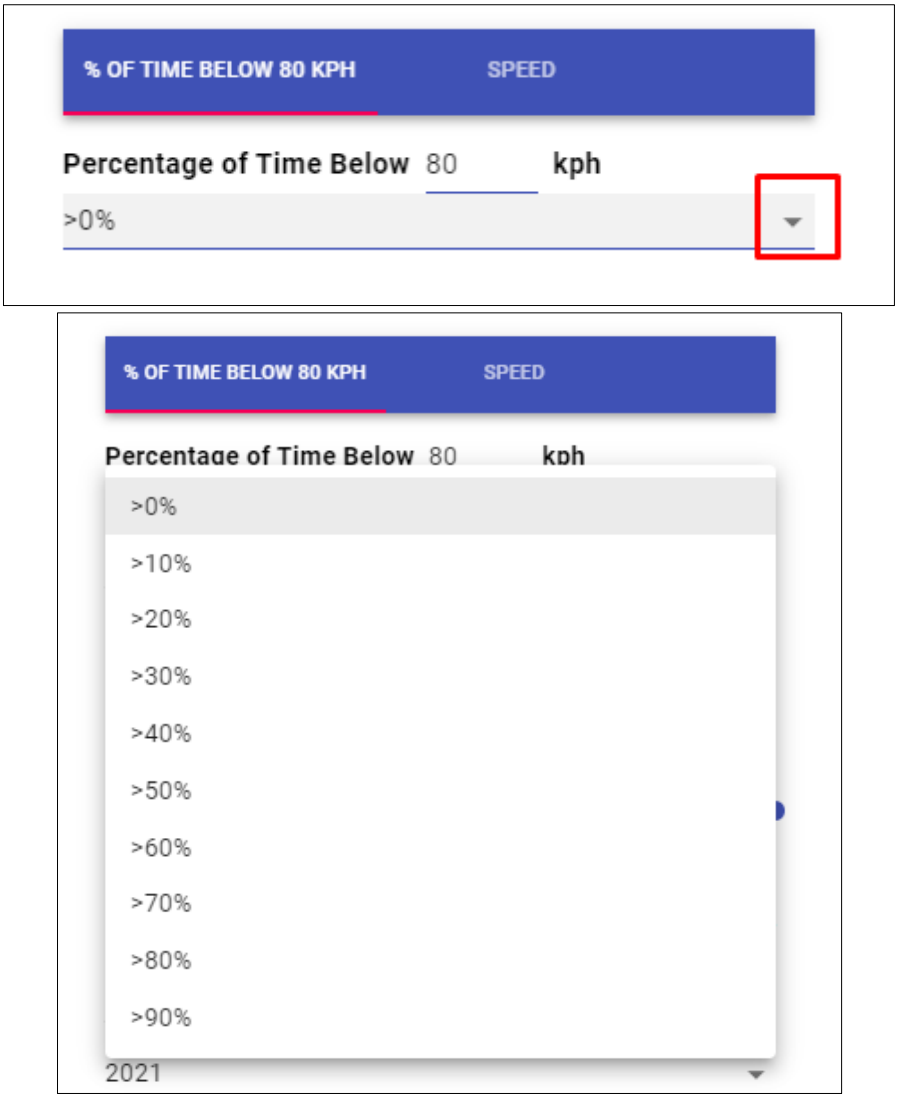
(c) Switch between % of Time below KPH filters and speed filters by clicking on the respective columns.



Source: JPT

Figure 3.2: Data Set Type

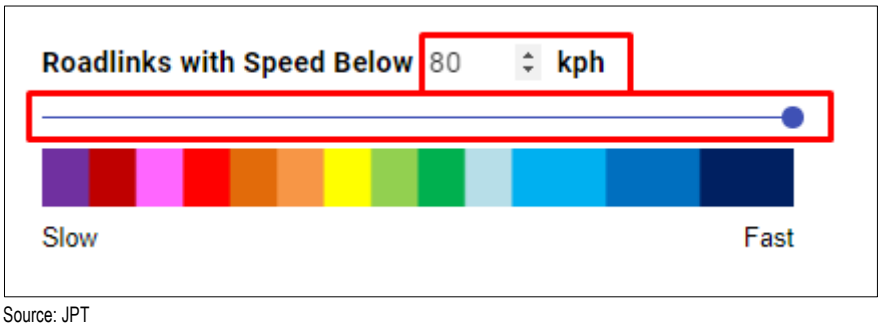
(d) Select a filter by clicking on the drop-down button.



Source: JPT

Figure 3.3: Percentage of Time Below the Speed

(e) Drag Roadlinks with a speed bar to change the values or directly input the values.



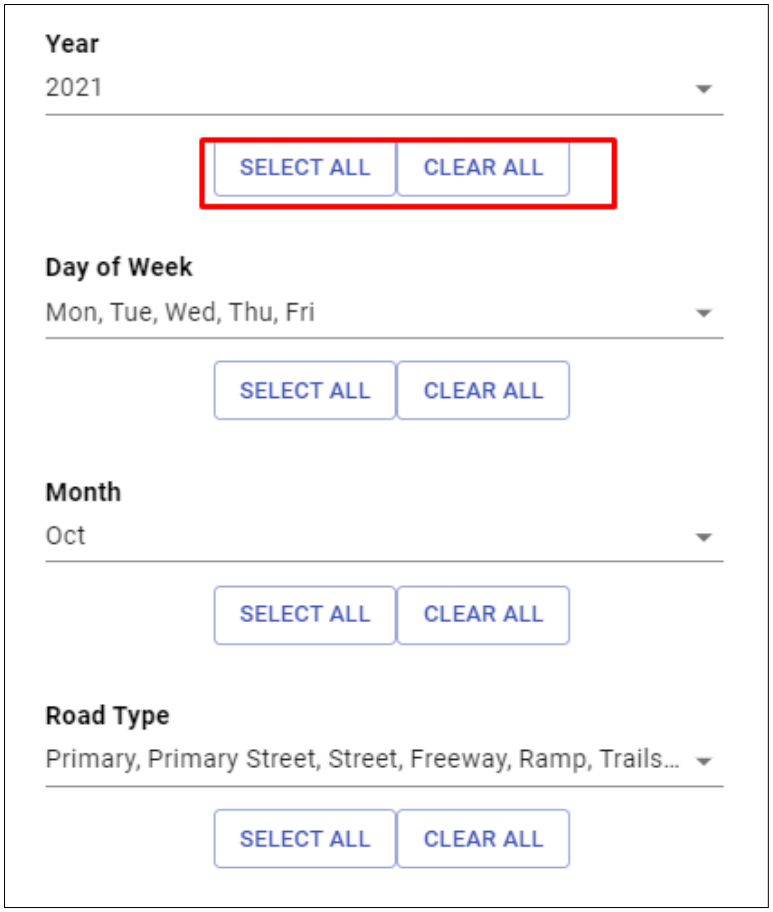
Source: JPT

Figure 3.4: Speed Range

(f) The different colors shown on the map will correspond to the speed of the roadlink.

(g) For some filters, you will be able to 'Select All' the values. This will filter to all the values.

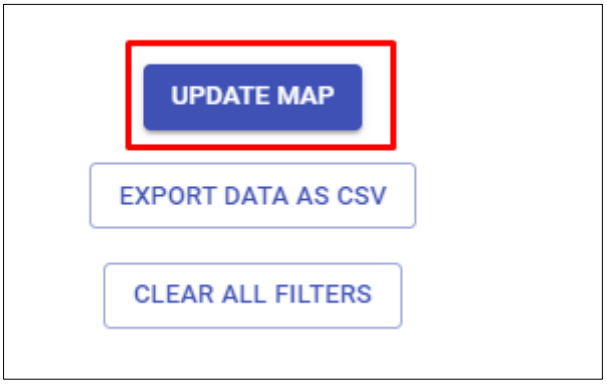
You can also 'Clear All' to unselect all the values.



Source: JPT

Figure 3.5: Selecting Year, Day, Month, and Road Type

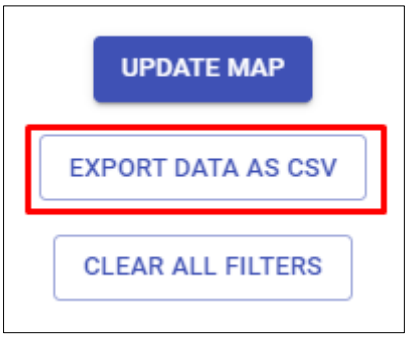
(h) When you have selected the necessary filters, click 'Update Map' to apply the filters on the Map.



Source: JPT

Figure 3.6: Update Map Button

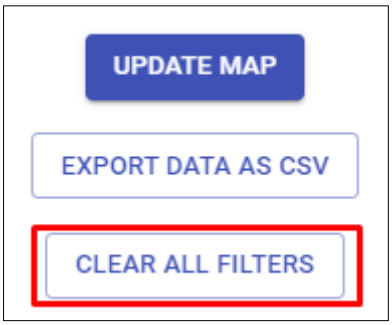
(i) To download the data of the filters selected on the dashboard, click 'Export Data as CSV'.



Source: JPT

Figure 3.7: Export Data As CSV Button

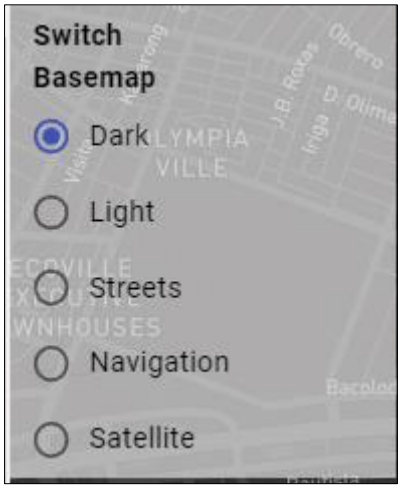
(j) Click on the 'Clear all filters' button to reset all filters back to the default values.



Source: JPT

Figure 3.8: Clear All Filters Button

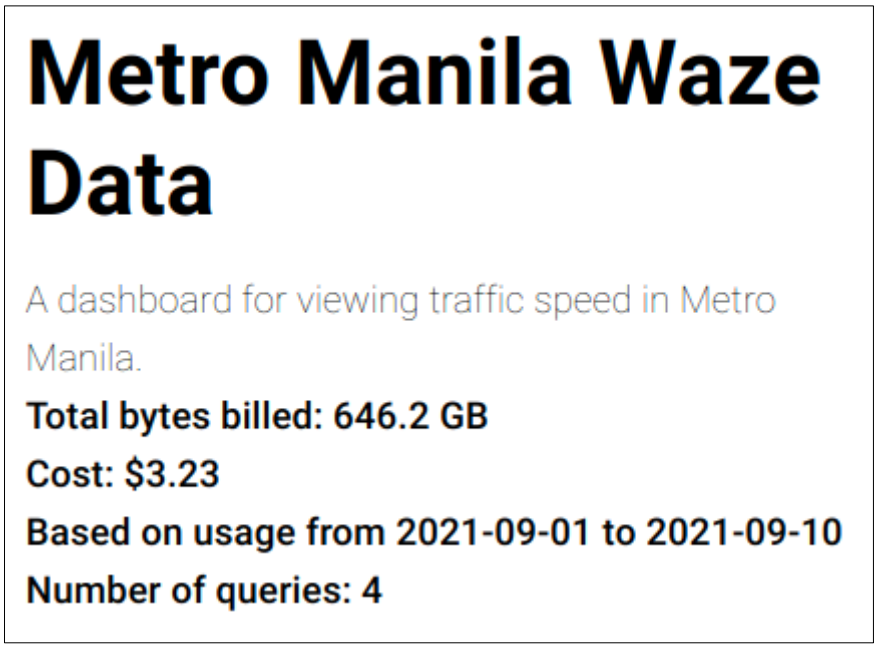
(k) You can adjust the Dashboard visual by changing the 'Switch Basemap'.



Source: JPT

Figure 3.9: Base Map Options

(l) For certain key users, the cost associated with the dashboard will be visible.

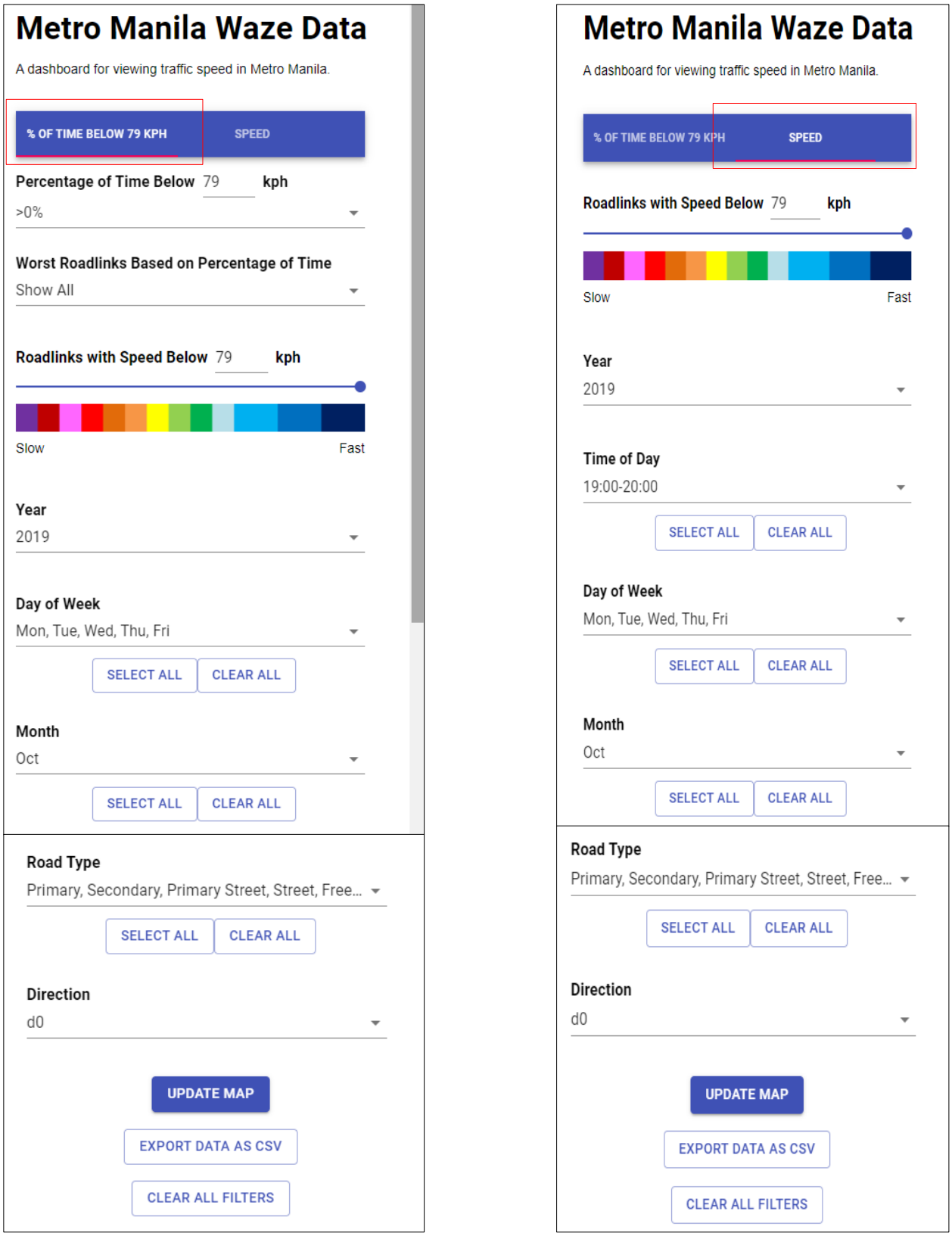


Source: JPT

Figure 3.10: Cost Summary

(m) For more details on the Dashboard and the back-end, refer to the Design and Technical Documentation.

(n) For more details on the data refer to the Data Dictionary and Processing Documentation.



Source: JPT

Figure 3.11: Web App Dashboard

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE PROJECT FOR COMPREHENSIVE TRAFFIC MANAGEMENT PLAN FOR METRO MANILA

TECHNICAL REPORT NO. 4

IDENTIFICATION OF TRAFFIC BOTTLENECKS AND MONITORING

November 2022

ALMEC CORPORATION
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TRANSPORTATION RESEARCH INSTITUTE CO., LTD.

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ABBREVIATIONS

CSV	comma-separated values
CTMP	Comprehensive Traffic Management Plan
DPWH	Department of Public Works and Highways
EDSA	Epifanio delos Santos Avenue
JICA	Japan International Cooperation Agency
JPT	JICA Project Team
LGU	local government unit
LOC	level of congestion
LOS	level of service
MMDA	Metropolitan Manila Development Authority
NCR	National Capital Region
TBN	traffic bottleneck
WKT	well-known text

1 INTRODUCTION

1.1 Objectives

The first activity in identifying traffic bottlenecks (TBNs) and understanding the pre-pandemic traffic situation in Metro Manila is administering questionnaire surveys by MMDA and the 17 NCR LGUs in 2019. Based on the results of the first questionnaire survey, MMDA identified 102 bottlenecks, while the LGUs listed 187 locations, or a total of 289 TBNs, including road segments. However, it should be noted that these bottlenecks were identified subjectively.

For this reason, the objectives of this chapter are to define traffic bottlenecks and identify the major traffic bottlenecks in Metro Manila. By identifying the bottlenecks, the expected outcomes are as follows:

(i) Common understanding among the MMDA and related parties about the trend of traffic congestion in Metro Manila;

(ii) Clear definition of traffic bottlenecks for Metro Manila based on quantitative analysis;

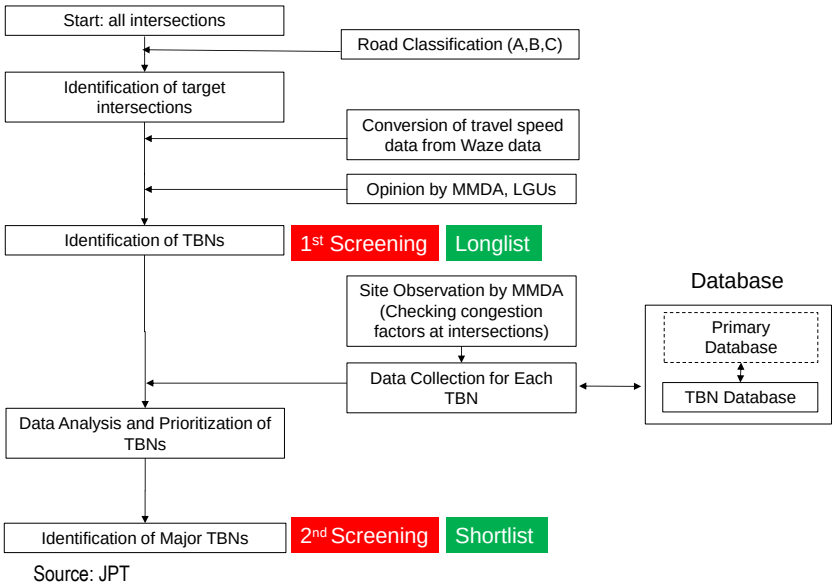
(iii) Longlist of traffic bottlenecks in Metro Manila; and

(iv) Strengthened capacity for identifying traffic bottlenecks using a data-driven methodology.

1.2 Overall Approach

The overall approach to identifying bottlenecks is shown in Figure 1.1. The identified bottlenecks by MMDA and the LGUs were first screened using the Waze travel speed data. TBNs based on Waze travel speed data that were not yet identified by the MMDA and LGUs were added to the potential longlist while TBNs initially determined were retained.

In the second screening, the JPT prepared a datasheet for data collection which will be used for site observation by the traffic enforcers. Then, the TBNs will be classified into intersections, road segments, and areas according to the site conditions. Also, the typology will be made depending on the causes of congestion. Through these steps, the longlist of major TBNs will be finalized.



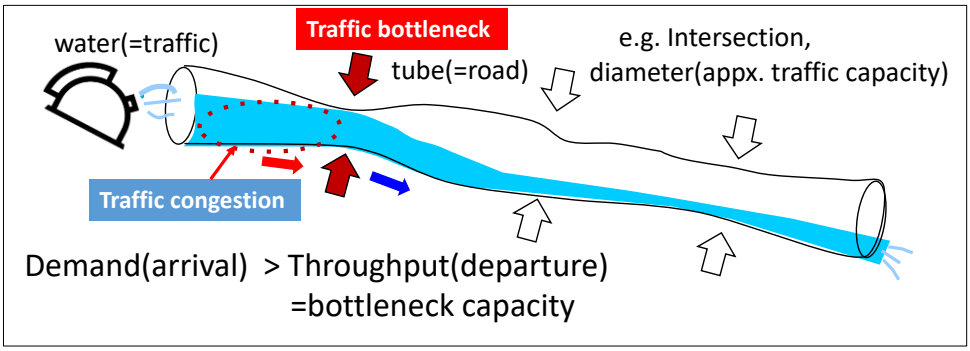
Source: JPT

Figure 1.1: Workflow for Longlisting Major Traffic Bottlenecks

2 DEFINITION OF TRAFFIC CONGESTION AND TRAFFIC BOTTLENECKS

2.1 Basic Traffic Engineering Knowledge of Traffic Congestion

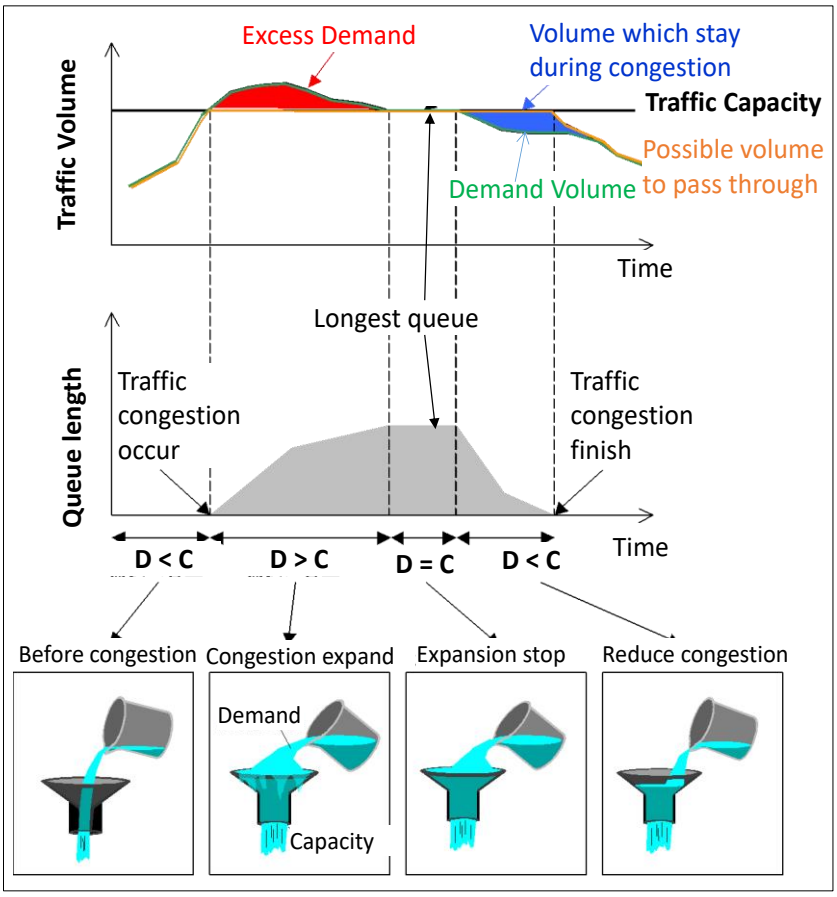
Before defining traffic congestion and bottlenecks, the basic traffic engineering knowledge is described in this section for a better common understanding. Traffic congestion is a phenomenon caused by a pile-up of traffic demands which cannot be accommodated in the network. Meanwhile, a bottleneck is a point in the target area where traffic capacity is the lowest. It commonly becomes the starting point of traffic congestion. Figure 2.1 illustrates the concept of traffic congestion and traffic bottleneck. Traffic flow forms a queue at the upstream section of a bottleneck when traffic demand exceeds the traffic capacity of that bottleneck.



Source: JPT based on material of Takashi Oguchi, Professor of "Traffic Management & Control", the University of Tokyo

Figure 2.1: Concept of Traffic Congestion and Traffic Bottleneck

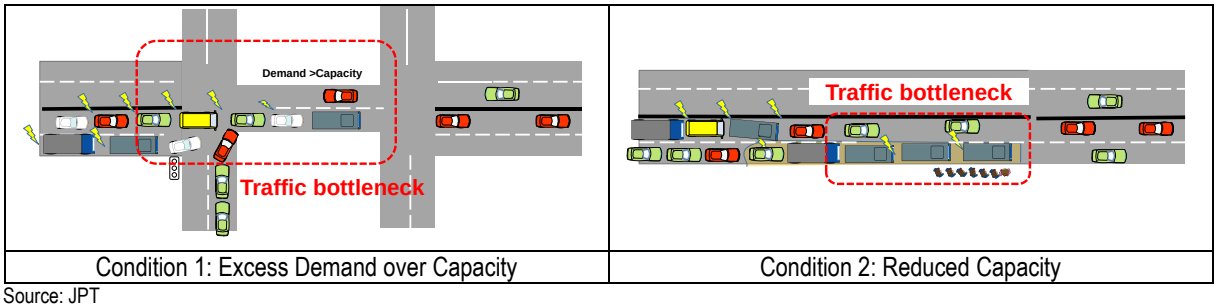
The graph in Figure 2.2 shows the relationship among traffic demand, traffic capacity, and queue length. The horizontal line in the graph represents time, while the vertical line in the first graph is traffic volume. The vertical line in the second graph represents queue length. Traffic congestion starts when traffic demand (traffic volume) exceeds the traffic capacity. When traffic demand exceeds the capacity, traffic congestion continues, and the queue lengthens. Since excess traffic demand accumulates, the longest queue is observed when the excess demand disappears. When traffic demand is lower than capacity, the vehicle queue shortens. Then, when the number of vehicles stuck in traffic congestion is handled, traffic congestion eases.



Source: JPT

Figure 2.2: Relationship among Traffic Demand, Capacity, and Queue Length

There are two conditions when a point or a segment becomes a traffic bottleneck, as illustrated in Figure 2.3. The first is when traffic demand exceeds traffic capacity (excess demand over capacity) due to concentrated traffic caused by narrow road segments, for instance, thereby resulting in traffic congestion. In this case, improvements, such as road widening, grade separation with a flyover, or connection of missing links, are required. The second condition is when the original road capacity is reduced caused of obstructions, such as on-street parking and PUV terminals, resulting in traffic congestion even though traffic demand does not exceed the original traffic capacity. In this case, traffic management measures, such as enforcing parking regulations, are required.



Condition 1: Excess Demand over Capacity	Condition 2: Reduced Capacity

Source: JPT

Figure 2.3: Conditions of Bottlenecks Resulting in Congestion

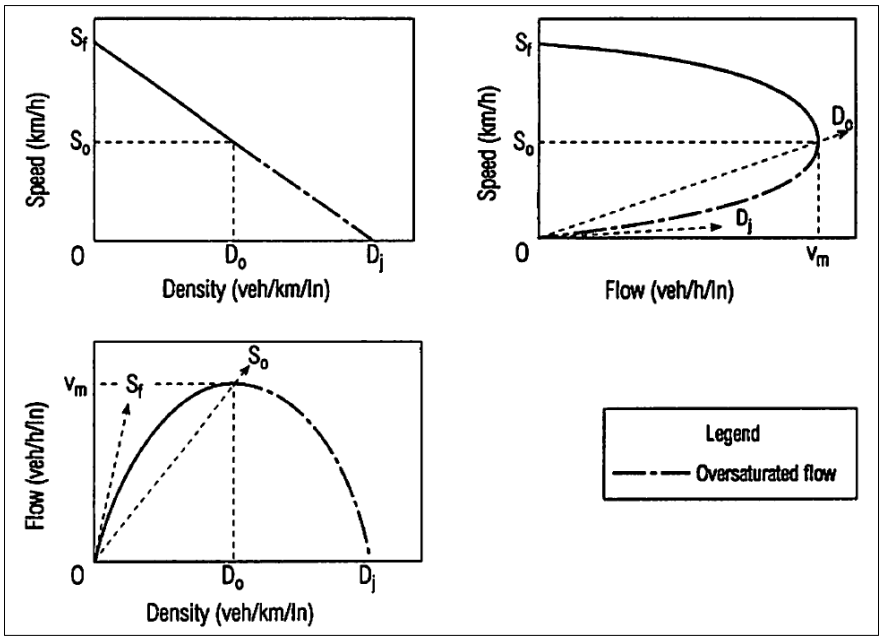
From a traffic engineering perspective, traffic flow is defined by three (3) parameters, i.e., flow, density, and speed, as shown in Table 2.1.

Table 2.1: Three Parameters of Traffic Flow

Parameter	Definition
Flow (traffic volume) Q	the traffic volume or number of vehicles that have passed a certain point
Density k in [vehicle/km]	the number of vehicles that exist in the unit length of road
Speed v in [km/h]	the mean speed of vehicles

Source: JPT

These parameters are interrelated, as shown in Figure 2.4. The maximum traffic capacity of a given section is determined when the traffic flow rate is at its maximum (Q-Max). When the density is greater than that, it becomes a congested flow area where the speed decreases. While it is possible to measure traffic flow rates at individual intersections, speed can also be used as an indicator of traffic conditions and an identifier of a bottleneck. On the other hand, since daily traffic capacity can be reproduced from traffic volume estimates, macro analysis can be utilized to determine the traffic demand.



Source: Highway Capacity Manual 2000.

Figure 2.4: Conditions of Bottlenecks Resulting in Congestion

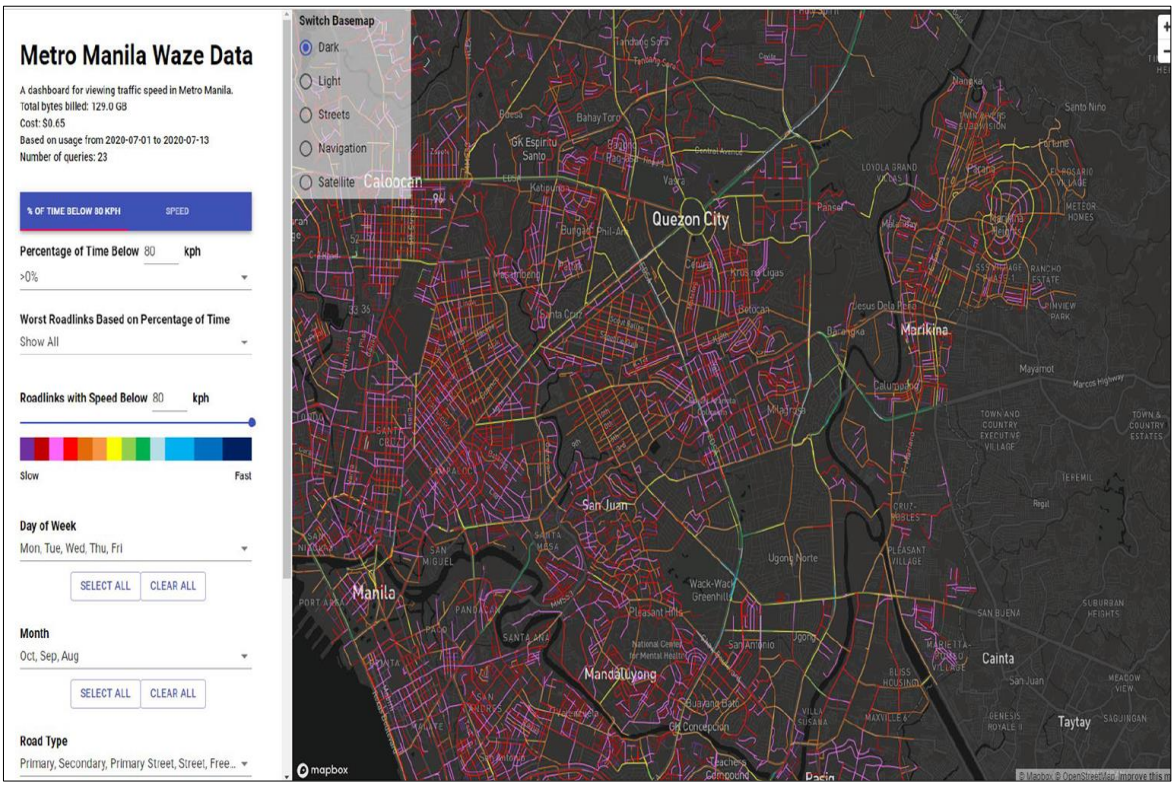
2.2 Definition of Common Criteria of Traffic Congestion and Bottlenecks

(1) Aggregation and Development of Waze Travel Speed Data

Under the Connected Citizens Program, MMDA can obtain travel speed data from Waze, a navigation company. Such data can provide a bird's eye view of the entire Metro Manila. In this CTMP Project, the Waze travel speed data in 2019 was collected and aggregated per 100-meter link. A dashboard web system was developed to visualize the data for any given time, day of the week, month, and by road class. By using this travel speed data from Waze, the traffic situation in Metro Manila was analyzed, and the common criteria for traffic bottlenecks were considered.

(2) Target Intersections

For the identification of TBNs where effective traffic management should be applied, roads were first classified by function, i.e., A, B, C, and D, as shown in Table 2.2. Based on the proposed network classification, target intersections were selected. These are composed of A-A roads, A-B roads, A-C roads, and B-B roads, as shown in Table 2.3. The number of target intersections has a total of 751, and the locations are shown in Figure 2.6.



Source: JPT

Figure 2.5: Developed Dashboard for Travel Speed Data from Waze

Table 2.2: Road Classification for Traffic Management Planning

Road Classification	Definition/Function	Responsibility for Construction	Responsibility for TM
Expressway	A major road with a median strip, access control and a curb shoulder. Toll fee needed.	DPWH, Private	DPWH, Private
Class A	A major road that mainly connects cities, excludes expressways. Refers to the radial and circumferential roads.	DPWH, Private	MMDA, Private

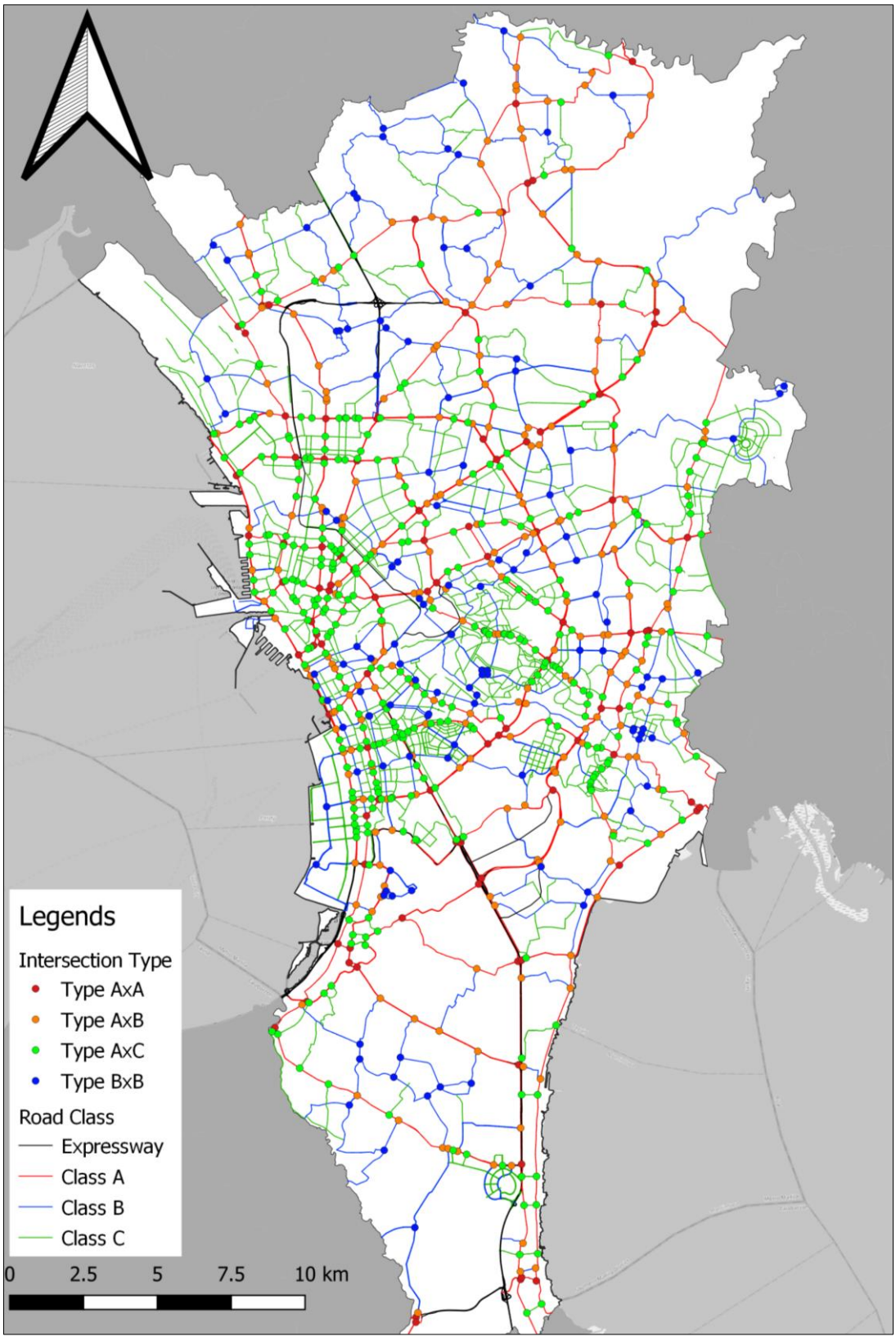
Road Classification	Definition/Function	Responsibility for Construction	Responsibility for TM
Class B	A road that complements Class A roads. An access road to major roads or facilities.	LGUs, Private	MMDA, LGUs, Private
Class C	A road that complements Class B roads, connecting roads in residential subdivisions, and adjacent barangays within a city.	LGUs, Private	LGUs, Private
Class D	The least important road. An access road to facilities within a city. A living road that give priority to pedestrians.	LGUs, Private	LGUs, Private

Source: JPT

Table 2.3: Target Intersections as Traffic Bottlenecks

Class of Intersection		No. of Intersections
1	Class A x Class A	95
2	Class A x Class B	224
3	Class A x Class C	321
4	Class B x Class B	111
Target Intersections in total		751
(Others)		(>10,000)

Source: JPT

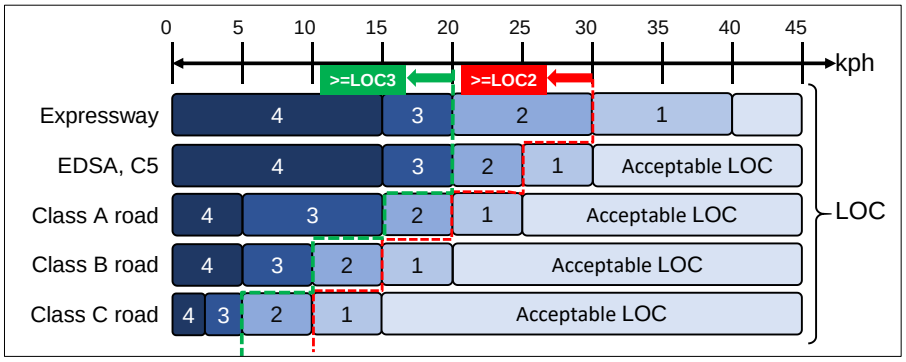


Source: JPT

Figure 2.6: Target Intersections as Potential Traffic Bottlenecks

2.3 Definition of Bottlenecks

The level of service (LOS) is commonly used in traffic analysis to qualitatively examine traffic conditions and travel services. According to the Highway Capacity Manual, LOS is a qualitative measure describing operational conditions within a traffic stream based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. By referring to the LOS, the JPT proposed a new indicator named level of congestion (LOC) to identify traffic bottlenecks. LOCs are determined by travel speed, i.e., when travel speed is low, the LOC is high. Acceptable travel speeds differ depending on the road classification and function. Different thresholds of LOC were proposed for each road class, as shown in Figure 2.7. For Epifanio de los Santos Avenue (EDSA) and Circumferential Road 5 (C-5), which are classified as Class A roads, access roads connecting to them are relatively few compared to other Class A roads. Road users expect higher travel speeds when using them, so a different threshold from that of Class A roads was applied to EDSA and C-5. In determining the LOC of an intersection, the travel speed of inflow traffic on each leg of the intersection was used as a basis.

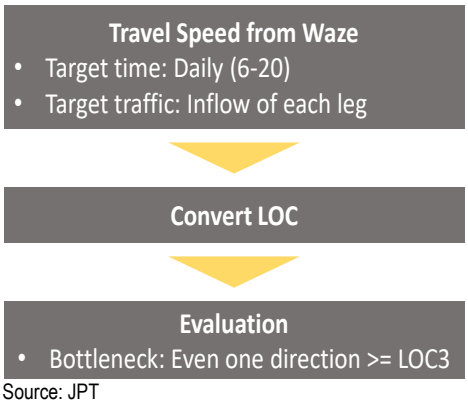


Source: JPT

Figure 2.7: Level of Congestion by Road Class

Based on the new indicator, LOC, the target intersections were evaluated (Figure 2.8). An intersection's LOC was determined using the 2019 average travel speed data obtained from Waze, which covers weekdays from 6:00AM to 8:00PM, for inflow traffic on each leg of an intersection. An intersection was regarded as a TBN when its LOC in at least one direction is 3 or more.

In summary, a TBN is defined as "an intersection/point whose inflow traffic in at least one direction has an LOC of 3 or more." Based on this definition, the 751 target intersections were narrowed down to 164 TBNs (Table 2.4 and Figure 2.9).



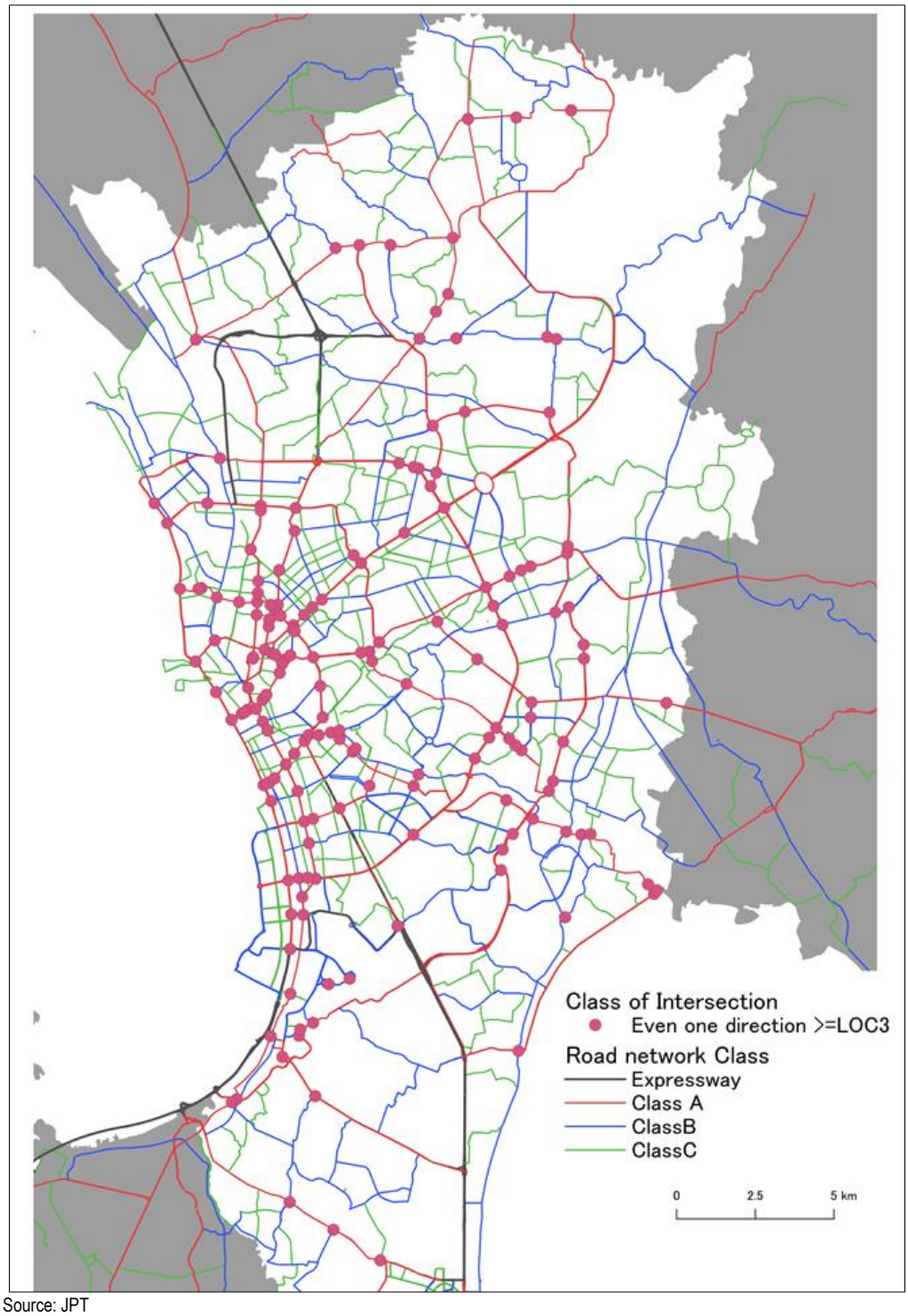
Source: JPT

Figure 2.8: Flow of Identifying TBNs

Table 2.4: Number of Traffic Bottlenecks Based on Waze Data

Class		No. of Intersections	
		Target	TBN (LOC = >3)
1	A x A	95	50
2	A x B	224	58
3	A x C	321	50
4	B x B	111	6
Total		751	164 (33%)

Source: JPT



Source: JPT

Figure 2.9: Traffic Bottlenecks based on LOC >=3

(1) Checking and Adding of TBNs Identified by MMDA and LGUs

As mentioned earlier, questionnaire surveys were distributed to MMDA offices and 17 LGUs in Metro Manila in 2019 to identify traffic bottlenecks. In the process, MMDA and the LGUs subjectively identified traffic bottlenecks. Table 2.5 breaks down the target intersections into those identified by MMDA and the LGUs in the questionnaire surveys. The 109 intersections identified by MMDA and LGUs are included in the 751 target intersections. Furthermore, the bottlenecks identified by MMDA and LGUs include 10 non-intersections such as U-turn slots or merging points.

Table 2.5: Breakdown of Target Intersections by Government Office

Class of Intersection		Number of Intersections/TBNs	
		Target	MMDA + LGUs
1	A x A	95	36
2	A x B	224	41
3	A x C	321	30
4	B x B	111	2
Total		751	109
Line		-	15

Source: JPT

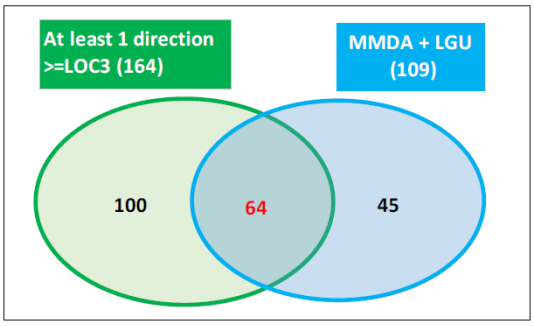
Next, the 164 TBNs identified based on Waze travel speed data, and 109 TBNs from MMDA and LGUs were compared to sort out overlapping points, as summarized in Table 2.6 and shown in Figure 2.10. Out of the 109 TBNs identified by both MMDA and LGUs, 64 overlap with those identified based on Waze travel speed data, while 45 locations do not overlap. Since the 45 locations of non-overlapping TBNs are possible TBNs, they were added into TBNs as well.

Table 2.6: TBNs based on LOC and Government Office

Intersection Type	Initially Identified TBN			No. of Overlapping TBNs (>=LOC3 & MMDA + LGU	No. of Non-overlapping TBNs	
	Total	TBN with >= LOC3	TBN Identified by MMDA + LGU		>= LOC3	MMDA + LGU
A x A	61	50	36	25	25	11
A x B	75	58	41	24	34	17
A x C	66	50	30	14	36	16
B x B	7	6	2	1	5	1
Total	209	164	109	64	100	45

Source: JPT.

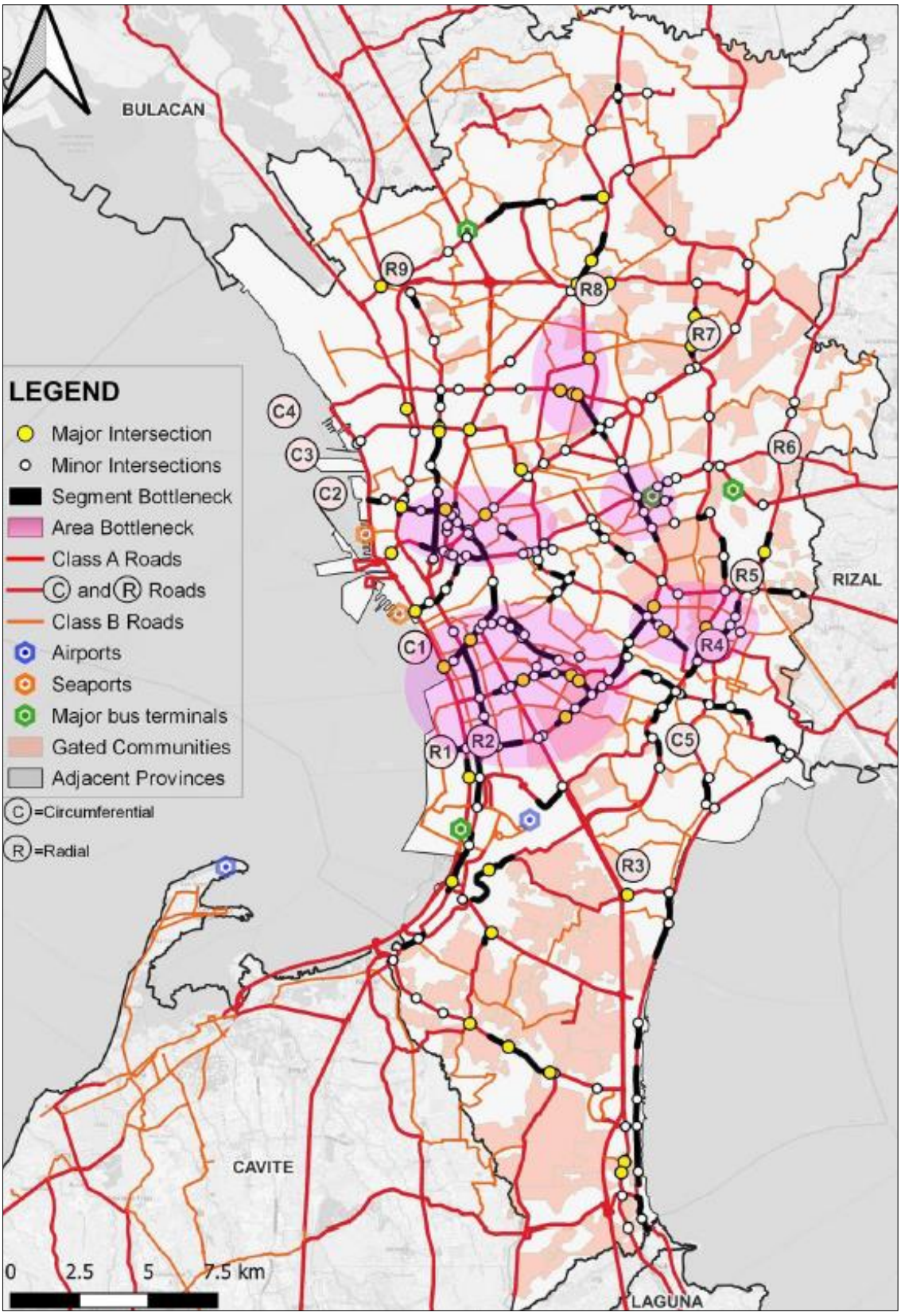
In conclusion, the total number of TBNs is 209 points, 164 TBNs were identified using Waze travel speed data and 109 TBNs were determined by the MMDA/LGUs. An overlap of 64 TBNs were existing on the list of both MMDA/LGU and LOC based method.



Source: JPT

Figure 2.10: TBNs Identified based on LOC and Government Office

Of the 209 bottlenecks identified based on travel speed and observation by MMDA and LGU counterparts, 42 locations were deemed as serious bottlenecks facing severe congestion. They are shown in Figure 2.11.



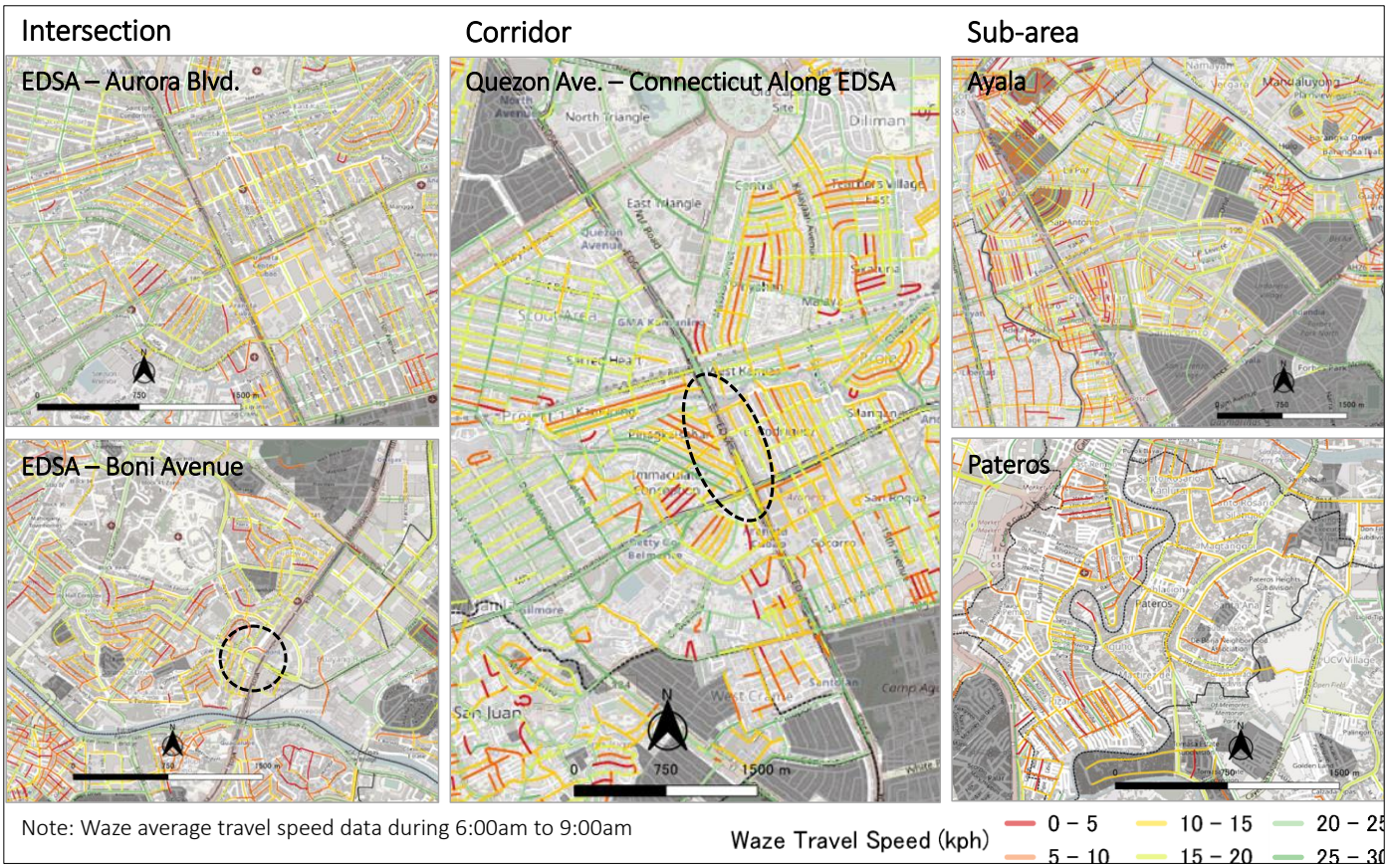
Source: JPT

Figure 2.11: Location of Identified TBNs

3 SHARED UNDERSTANDING OF TRAFFIC CONGESTION AND BOTTLENECKS

3.1 Traffic Situation in Metro Manila

Figure 3.1 illustrates the traffic situation in Metro Manila before the COVID-19 pandemic. This was based on Waze travel speed data. As observed in the figure, a single bottleneck at an intersection extends to the segments along the corridor until the surrounding area as congestion becomes more severe.



Source: JPT

Figure 3.1: Pre-pandemic Traffic Situation in Metro Manila based on Waze Data

3.2 Traffic Conditions in TBNs

As mentioned earlier, the TBNs were identified using two approaches: by LOC based on Waze travel speed data and by questionnaire surveys administered by MMDA and the LGUs. This section spells out the traffic condition.

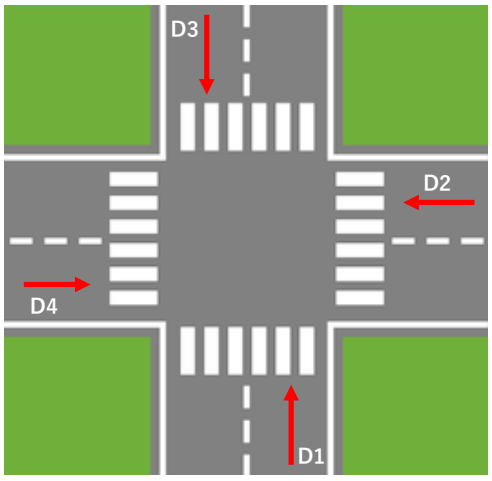
(1) Overlapping Points (Class A x Class A)

Among the TBNs identified by MMDA and the LGUs, those that were judged as TBNs with LOCs of greater than 3 and are overlapping with Waze travel speed data were included in the TBNs. Table 3.1 shows the detailed information about selected overlapping points regarding their traffic condition. These points are found to be low-speed sections at least in the inflow direction of a major road.

Table 3.1: Traffic Conditions in Overlapping AxA Bottlenecks

Intersection Name	EDSA–Shaw Boulevard	Lacson Ave.–Laong Laan St.
Location	Mandaluyong	Manila
Map		
Class	A x A	A x A
MMDA or LGU	TBN identified by MMDA	TBN identified by LGUs
LOC	TBN identified by LOC (>= LOC3)	TBN identified by LOC (>= LOC3)
LOC of Each Inflow Direction	D1: 15.2km/h: LOC3 (EDSA) D2: 8.9km/h: LOC3 (Class A) D3: 16.0km/h: LOC3 (EDSA) D4: 10.5km/h: LOC3 (Class A)	D1: 11.8km/h: LOC3 (Class A) D2: - D3: 10.5km/h: LOC3 (Class A) D4: 23.8km/h: LOC1 (Class A)

Source: JPT



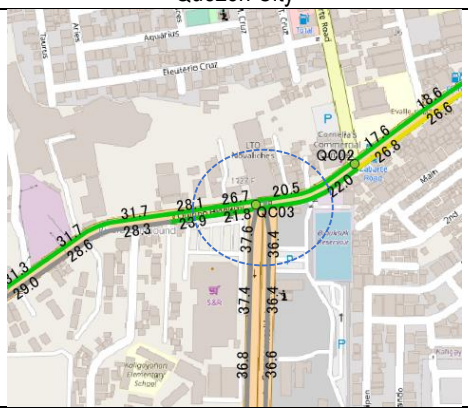
Source: JPT

Figure 3.2: Leg Numbering System

(2) Non-overlapping Points (Class A x Class A)

Among the TBNs identified by MMDA or the LGUs, those that did not fall under LOC 3 to 4 criteria were added to the TBNs as well. Table 3.2 describes the detailed information regarding representative non-overlapping points with their traffic conditions. Most of the non-overlapping TBNs are located along Class A roads, such as, MacArthur Hwy., EDSA, Commonwealth Ave., Ortigas Ave., and Alabang-Zapote Rd. Large variation between travel speed data from 6:00am to 8:00pm from these road sections may be the reason why the average travel speed data resulted to LOC values lower than 3.

Table 3.2: Traffic Conditions in Non-overlapping AxA Bottlenecks

Intersection Name	EDSA–MacArthur Highway	Quirino Highway–Commonwealth Avenue
Location	Caloocan	Quezon City
Map		
Class	A x A	A x A
MMDA or LGU	TBN identified by MMDA and LGUs	TBN identified by LGUs
LOC	Not TBN identified by LOC (>= LOC3)	Not TBN identified by LOC (>= LOC3)
LOC of Each Inflow Direction	D2: 21.6km/h: LOC2 (EDSA) R1_3: 32.2km/h: LOC0 (EDSA) R2_1: 29.2km/h: LOC0 (Class A) D1: 18.0km/h: LOC2 (Class A)	D4: 26.7km/h: LOC0 (Class A) D2: 21.6km/h: LOC1 (Class A) D3: - D1: 36.5km/h: LOC0 (Class A)

Source: JPT

(3) Non-intersections along Class A Roads

The U-turn slots and merging points which MMDA or the LGUs identified as traffic bottlenecks are located on Class A roads, as shown in Table 3.3. These segments should be checked and added to the TBNs, as well.

Table 3.3: Non-intersections along Class A Roads

Name	EDSA, Santolan Crame U-turn slot	EDSA SM North Annex - U-turn Slot Corregidor – U-turn Slot
Map		
Class	A	A
MMDA or LGU	TBN identified by MMDA	TBN identified by MMDA

Source: JPT

3.3 Classification of Traffic Bottlenecks

Classifying the identified TBNs will create appropriate measures against traffic congestion. For instance, if several TBNs are on the same road and adjacent to each other, grouping them would suggest a holistic solution that would be more effective to the entire corridor. As mentioned earlier, there are two conditions when a point or a section becomes a TBN: excess demand over capacity and reduced capacity. Moreover, the severity and direction of traffic congestion or the queue length may differ depending on site conditions. Therefore, classifying bottlenecks would be essential to make localized measures in tackling congestion.

1) Typology of Traffic Bottlenecks

To determine the major TBNs from the 209 identified TBNs, they were categorized according to intersection type, the severity of congestion, structure and signal type, number of crossing conflicts and legs, and implementation possibility (Table 3.4).

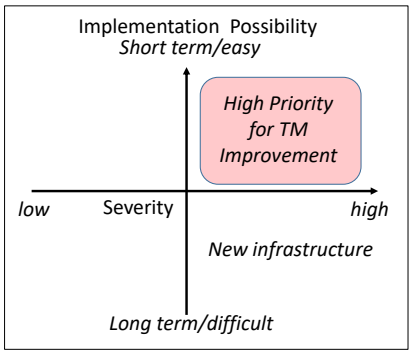
Table 3.4: Traffic Bottleneck Categories

Category	Typology
Intersection Type	✓ Major Corridor: Class A x Class A, B, C ✓ Minor Corridor: Class B x Class B
Severity of Congestion	✓ High congestion level (LOC>=3) ✓ Long queue length in each leg
Structure and Signal Type	✓ Signalized or non-signalized ✓ At-grade or Segregated (Elevated)
Crossing Conflict/No. of Legs	✓ Many conflict locations
Implementation Immediately	✓ Short-term / Easy implementation ✓ Long term / Difficult implementation

Source: JPT

High priority was given to intersections comprising at least one Class A road. Structure and signal type identify signalized and non-signalized intersections, as well as at-grade and segregated (grade-separated) intersections. The number of crossing conflicts in, and legs of, an intersection determines the time to turn to other directions and the probability of a road crash. The more crossing conflicts there are, the higher the probability of being stuck in traffic or causing road crashes, especially if an intersection is non-signalized. Implementation possibility is also considered since priority TBNs need immediate action. Long-term plans may be difficult to execute, since they might require a higher budget, new infrastructures, and land acquisition. Major, or high-priority, TBNs fall under the high severity / short-term implementation criteria, as shown in Figure 3.3.

Meanwhile, the severity of congestion is based on two factors: level of congestion (LOC) and queue length. For LOC, LOC A refers to the initial TBNs selected by MMDA and LGUs. LOC B to D are dependent on the number of approaches or directions with an LOC of 3 or 4 a TBN has.



Source: JPT

Figure 3.3: Criteria for Major TBNs

Table 3.5: Severity of LOC

Severity of LOC	
A	Selected by MMDA/LGUs
B	=1 Direction has >= LOC3
C	>=2 Directions have >= LOC3
D	All Directions have >= LOC3

Source: JPT

Queue length relies on the site observation done in 2021 by MMDA traffic enforcers in the 209 TBNs. In the questionnaire they accomplished, they estimated the queue length per approach of each TBN, indicating “01” for the longest queue and “04“for no queue or less than 100-m queue length. Queue Length 1 means that at least two approaches have moderate queue lengths, while Queue Length 6 means at least one direction has over 500m queue length.

Table 3.6: Severity of Queue Length

Severity of Queue Length	
1	>=2 Direction = 03
2	All Direction = 03
3	=1 Direction = 02
4	>=2 Direction = 02
5	All Direction = 02
6	>=1 Direction = 01

Source: JPT

Where queue length:
01 Heavy: over 500m
02 Moderate: over 300m to 500m
03 Light: over 100m to 300m
04 No Queue or <100m

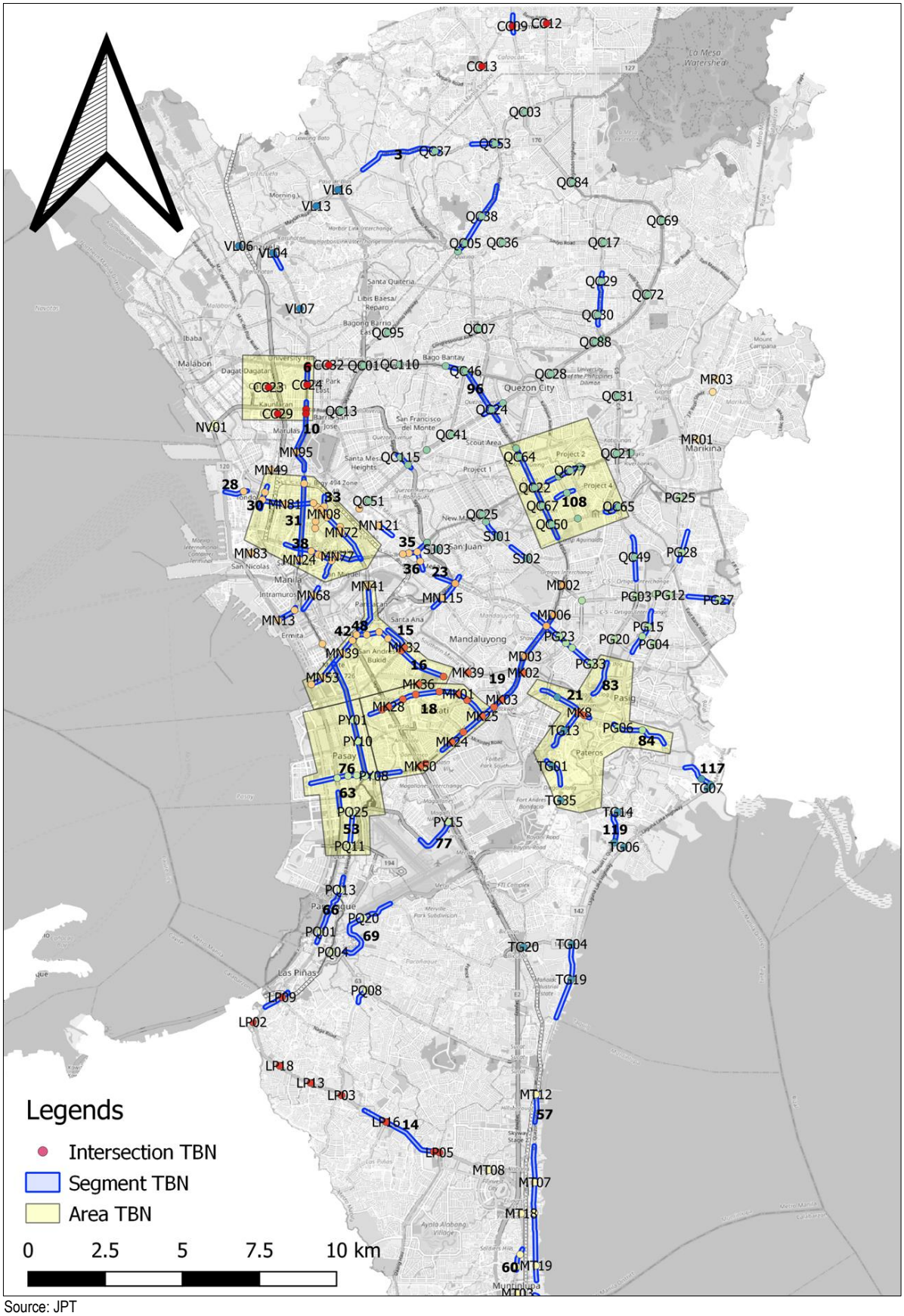
Table 3.7 classifies the long-listed TBNs by intersection type, signalization, and structure. It shows that: (i) 164 (78%) of the 209 long-listed TBNs satisfy the LOC criteria; (ii) 92 (44%) are non-signalized intersections, implying the need for signalization to manage traffic; and (iii) 175 (84%) are at-grade TBNs, implying that traffic congestion can be mitigated by improving at-grade intersections.

Table 3.7: Long-listed Intersection Bottlenecks by Type

Int. Type	>=LOC3	Identified by MMDA/LGUs	Non-signalized	Signalized	At-grade	Segregated
A x A	50	11	26	35	39	22
A x B	58	17	30	45	66	9
A x C	50	16	35	31	64	2
B x B	6	1	1	6	6	1
Subtotal	164	45	92	117	175	34
Total	209		209		209	

Source: JPT

Figure 3.4 shows a map presenting the intersection, segment, and area TBNs.



Source: JPT

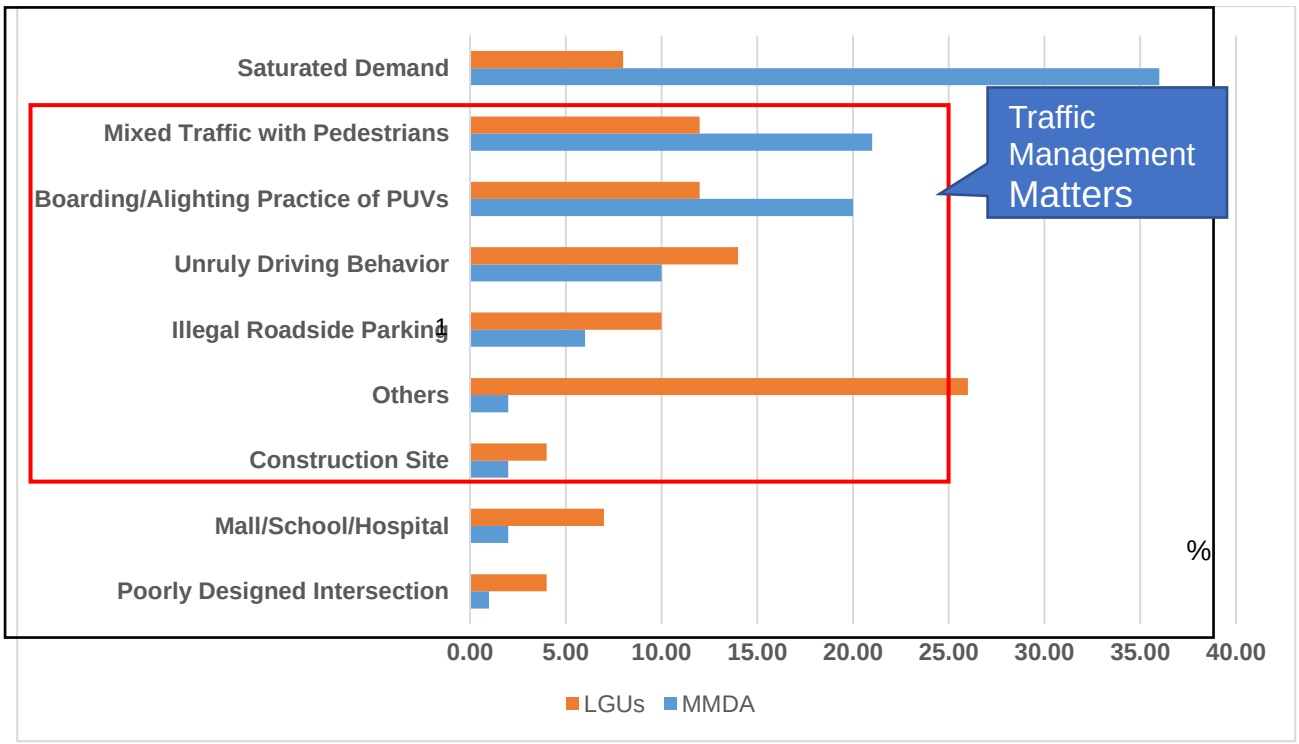
Figure 3.4: Location of Segment Bottlenecks in Metro Manila

4 Causes and Factors of Traffic Congestion

4.1 Congestion Causes according to MMDA and LGUs

Based on the results of the questionnaire surveys conducted among MMDA and LGU CPTs, the major causes of traffic congestion, accounting for 35% for MMDA and 43% for LGUs are: PUJs stopping at intersections, non-compliance with driver rules, and illegal parking, as shown in Figure 4.1.

The questionnaire survey results showed that there are some differences in the causes of traffic congestion as perceived by MMDA and LGU counterparts. The LGU counterparts did not consider excess demand as a top cause. This could be explained by the fact that their jurisdiction mainly covers local roads which have less traffic volume than major roads. Second, the causes identified by MMDA counterparts are attributed to the traffic bottlenecks on major roads, whereas those by LGU counterparts can be associated with traffic bottlenecks on local streets.



[1] "Others" include manual overriding of traffic signals, obstruction by illegal vendors, and poor signal phase timing.
Source: Questionnaires conducted among MMDA and LGU CPTs.

Figure 4.1: Traffic Congestion Causes Identified by MMDA and LGUs

4.2 Factors of Congestion

Factors affecting traffic congestion in Metro Manila were grouped based on local traffic and physical characteristics, among other aspects, as shown in Table 4.1. Based on these, the JPT analyzed each bottleneck from the traffic engineering point of view.

(a) **Road Infrastructure:** In particular, number of lanes (lack of number of lanes, insufficient road width); intersection layout (improper geometric layout, inadequate corner cutting, and improper location of road facilities [pavement markings]); road alignment (sharp curve, gradient change point [sag point], steep slope); tunnels/underpasses (entrance of underpasses).

(b) **Traffic Control and Regulations:** In particular, signal timing (inadequate traffic control with/without traffic signal); poor visibility of traffic signals; left-turning or oncoming vehicles (no left-turn lane, insufficient left-turn lane length, conflict between a left-turning car and an oncoming car); right-turning vehicles (right-turning vehicles blocking those going straight ahead, improper stop line position, improper channelization); and traffic signs (improper traffic sign or installation location). However, it should be noted that for intersections where traffic enforcers intervene, it is difficult to verify whether the signal control was appropriate relative to the traffic conditions since there are no records.

Table 4.1: Factors of Congestion

Aspect		Factor of Congestion
Road Infrastructure	Number of Lanes	Lack of number of lanes
		Insufficient road width
	Intersection Layout	Wrong geometric intersection layout
		Inappropriate for center point of intersection
		Inadequate corner cutting
		Improper location of road facilities (road markings)
	Road Alignment	Sharp curve
		Gradient change point (sag point)
		Steep slope
	Tunnels, Underpass	Entrance of underpass
Traffic Control and Regulation	Signal Timing	Inadequate traffic control (in case of no traffic signal)
		Inadequate traffic signal control (in case of with traffic signal)
		Poor visibility of traffic signal
	Left-turning or oncoming Vehicles	No left-turn lane
		Insufficient left-turn lane length
		Conflict between a left-turning car and an oncoming car
	Right-turning Vehicles	Right-turning vehicles blocking vehicles proceeding straight ahead
		Improper stop line position
		Improper channelization
	Traffic Sign	Improper traffic sign or installation location
Traffic Characteristic	Conflict by Specific Traffic	Speed reduction due to large vehicle
		Motorcycle is obstructed by other modes
		Bike is obstructed by other modes
		Inadequate pedestrian facilities
Environment of Roadside and Intersection	Railway Crossing	Stopping traffic at railway crossing
	Bridge Section	Difference in cross-sectional configuration between the bridge and general sections
		Concentration of traffic on bridges
	Traffic Flow from/to Roadside Land Use, Connecting Streets, etc.	Traffic flow in/out at driveway along roadside shop
		Traffic flow in/out from intersections and narrow streets
		Traffic flow in/out from IC at expressway
	PUJ, PUB	Speed reduction due to PUV stop
		Speed reduction due to PUJ stop
		Lane reduction with dedicated bus and priority lanes
	On-street Parking	Obstruction of travel by on-street parking
Traffic Demand	Exceeding Capacity	Excess traffic capacity at intersections
		Excess traffic capacity at non-intersections
	Concentrated Traffic	Concentration of traffic at a specific time
		Concentration of traffic on roadside facilities at specific times and periods
		Concentration of traffic during specific periods during events or incidents
Others	Construction Work	Lane blockage due to construction
	Clogging of Downstream	Clogging with congestion

Source: JPT.

(c) **Traffic Characteristics:** In particular, disturbance by specific traffic (reduced speed due to large vehicle, motorcycle obstructed by other modes, bike obstructed by other modes, inadequate pedestrian facilities).

(d) **Environment of Roadside and Intersections:** In particular, railway crossing (stopping traffic at railway crossing); bridge section (difference in cross-sectional configuration between the bridge and approach sections, concentration of traffic on bridges); traffic flow from/to roadside land use, connecting streets, etc. (traffic flow in/out at driveway along roadside shop, traffic flow in/out from intersections and narrow streets, traffic flow in/out from IC at expressway); PUJs/PUBs (reduced speed due to PUV stop, lane reduction with dedicated bus and priority lanes); on-street parking (travel obstructed by on-street parking).

(e) **Traffic Demand:** In particular, exceeding capacity (excess traffic demand at intersections, excess demand at non-intersections); concentrated traffic (at specific times, on roadside facilities at specific times and periods, or during events or incidents).

(f) **Others:** In particular, construction work (lane blockage due to construction); clogging downstream.

Based on traffic enforcers' observation, data and information about congestion and its causes for each identified bottleneck were collated into datasheets, as shown in Table 4.2.

The accuracy and consistency of these data were checked by photos taken at the site. Meanwhile, basic information, such as the intersection type (class, signalized, etc.), road inventory (number of lanes, road width, etc.), traffic count data from MMDA, and travel speed data from Waze, was also collected and shown in another datasheet (Table 4.3).

Method of data collection for each Datasheet can be referred to Appendix.

For this CTMP Project, the above-mentioned data helped in determining the intersection type of the bottlenecks and the countermeasures for each factor of congestion. For easy handling and access on demand, this intersection bottleneck database is stored in cloud servers. Microsoft Access can be used to navigate the database. Using a GIS application, the data can be visualized to see the location of intersection bottlenecks in Metro Manila. Together with other databases which the CTMP Project developed, analyzing the traffic situation in the metropolis and choosing TM measures have become more efficient and science-based (Figure 4.2). More detailed information can be referred to Technical Report 08_Manual on Traffic Bottleneck Database.

Table 4.2: Sample of Datasheet 2: Results of Site Observation

Congestion Situation				
	Approach (toward)	**Vehicle Queue Length**	**Spill over from downstream intersection**	**Spill over to upstrea intersection**
D1	Taft South	02 Moderate : over 300m to 500m	Yes	No
D2	Taft North	02 Moderate : over 300m to 500m	No	No
D3	A. Arnaiz West	None	Yes	No
D4	A. Arnaiz East	02 Moderate : over 300m to 500m	Yes	No
D5				

Checklist for Factor of Congestion (intersection)								
1:STRONGLY AGREE, 2:AGREE, 3:DISAGREE								
Factor item	Checkpoint	Factor of Congestion	D1	D2	D3	D4	D5
Road infrastructure	Number of lanes	Lack of number of lanes	1	3	1	1	
		Insufficient road width	2	3	2	2	
	Intersection layout	Wrong geometric intersection layout	3	1	3	3	
		Inadequate corner cutting	1	2	1	1	
		Improper location of road facilities (road markings)	2	3	2	2	
Traffic regulation	Signal timing	Inadequate of traffic signal control	1	1	1	1	
		Bad visibility of traffic signal	1	2	1	1	
	Right-turning or oncoming vehicles	No left-turn lane	1	1	1	1	
		Insufficient left-turn lane length	1	2	1	1	
		Conflict between a left-turning car and an oncoming straight car	1	3	1	1	
	Left-turning vehicles	Right-turning vehicles blocking vehicles proceeding straight ahead	1	1	1	1	
		Improper stop line position	1	2	1	1	
		Improper channelization	1	3	1	1	
Traffic situation	Large vehicle	Speed reduction due to large vehicle	1	1	1	1	
		Obstruction by motorcycles	1	2	1	1	
		Obstruction by bicycles	1	1	1	1	
		Obstruction by pedestrian	1	2	1	1	
Environment of Roadside and intersection	Railway Crossing	Stopping traffic at railway crossing	1	3	1	1	
	Driveway from roadside shop	Traffic flow in/out from intersections and narrow streets	1	1	1	1	
		Traffic flow in/out from IC at expressway	1	2	1	1	
	PUJ, PUV	Speed reduction due to PUV stop	1	3	1	1	
		Speed reduction due to PUJ stop	1	1	1	1	
		Lane reduction with dedicated bus and priority lanes	1	2	2	1	
	On-street parking	Obstruction of travel by on-street parking	1	1	3	1	
Traffic Demand	Over capacity	Excess traffic capacity at intersections	1	1	1	1	
		Excess traffic capacity at non-intersections	1	2	2	1	
	Concentrated traffic	Concentration of traffic at specific time	1	3	1	1	
		Concentration of traffic on roadside facilities at specific times and periods	1	1	1	1	
		Concentration of traffic during specific periods during events or incidents	1	2	1	1	
Others	Construction	Lane blockage due to construction	1	1	1	1	
	Clogging of downstream	Clogging with congestion of downstream	1	2	1	1	
	Free Comment (if any)	Due to traffic accident, tenporaly congestion occurs					

Source: JPT

Table 4.3: Sample of Datasheet 1: Basic Data and Information about Intersection TBNs

Common Information													
CODE	PY04							**Sheet No.**					
REGION	14 NCR	**CITY**	Pasay										
Name of Intersection	EDSA-Taft Ave.						**Administrator (Main Road)**		MMDA				
Latitude / Longitude (Center of Intersection)	14.5375177, 121.0007001												
Intersection Type	A x B			**Structure**					01 At-grade				
Signalization	01 Signalized			**Pedestrian Signal**					00 No				
Station	01 Yes	**Name of Station**							Taft				
Existing Layout (CAD)	URL	https://drive.google.com/drive/folders/10G2optZZAfXIiENqtECyVFYztzfYY5Z1?usp=sharing											
Photo	**Date**	2021/3/16	**Time**	8:00	**URL**	ve/folders/1vXTT281C1Ob2ajQuFtLb							
Google Map (URL)	https://www.google.com/maps/@14.5378334,121.0005801,19.03z?hl=ja												

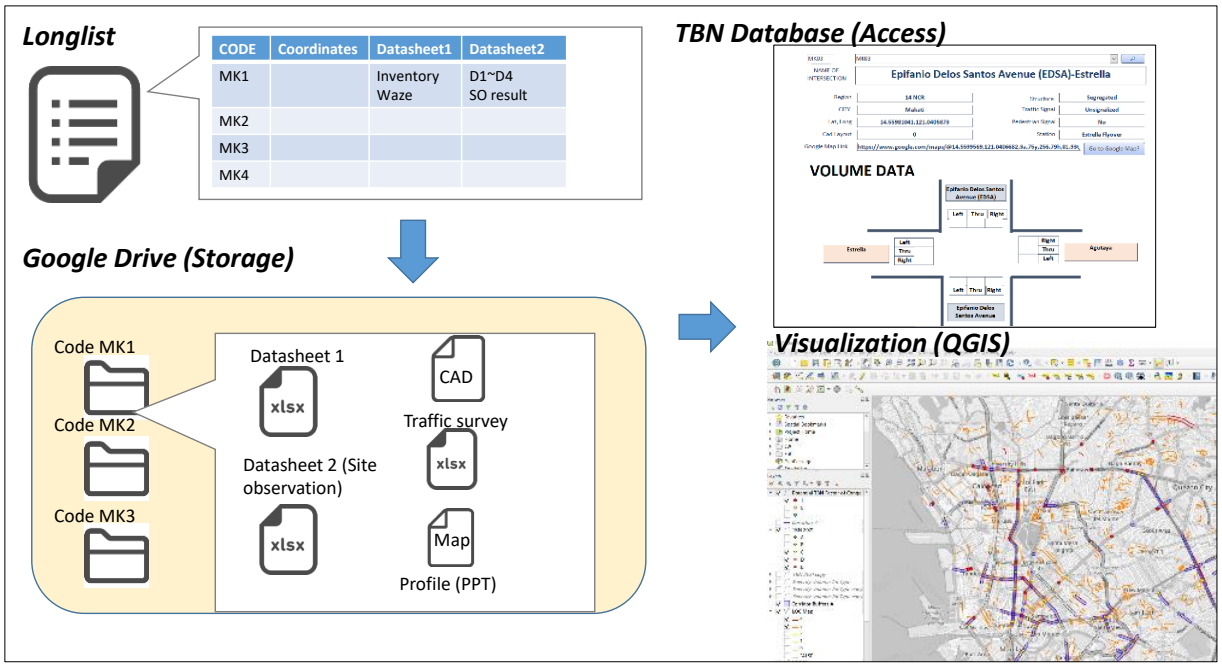
Layout (Inventory)														
	Approach (toward)	**No. of Lane**						**Road Width(m)**						**Data Source**
		Dedicated Left	**Left-Through**	**Through**	**Dedicated Right**	**Right-Through**	**Total**	**Dedicated Left**	**Left-Through**	**Through**	**Dedicated Right**	**Right-Through**	**Total**	
D1	EDSA West	1	0	4	0	1	6	3.5	0.0	14.0	0.0	3.5	21	03 DPWH Atlas
D2	EDSA East	0	0	4	1	0	5	0.0	0.0	13.6	3.4	0.0	17	03 DPWH Atlas
D3	Taft North			3			3						7	03 DPWH Atlas
D4	Taft South			3			3						6.8	03 DPWH Atlas
D5														03 DPWH Atlas

Traffic Volume												
Date of Traffic Volume Survey	Wednesday, March 06, 2019											
Peak Time	From	08:00:00 AM	-	To	09:00:00 AM							
	Approach (toward)	**Class**	**Peak Hour Traffic Volumes (PCUs)**				**Total Volume**	**PUB**	**PUJ**	**PUV**	**PUT%**	
			Left	**Through**	**Right**	**Total**						
D1	EDSA West	A	255	3,840	13	4,108	4,096	135	471	299	22.1%	
D2	EDSA East	A	0	3,163	332	3,495	3,627	81	527	279	24.5%	
D3	Taft North	A	345	30	456	831	917	0	176	56	25.3%	
D4	Taft South	A	12	25	134	171	203	0	44	6	24.6%	
D5											#DIV/0!	
Traffic Volume Survey Data (Excel)	https://drive.google.com/drive/folders/1gOSUI9MSJXEtqUkKahlMjnaRxcj6Mt6f?usp=sharing											

Travel Speed from Waze, LOC						
Source	2019/ Weekday / Daily(6-20)/ Inflow					
	Approach (toward)	**Class**	**In/Out**	**Km/h**	**LOC**	
D1	EDSA West	A	Inflow	13.7	4	
D2	EDSA East	A	Inflow	15.1	3	
D3	Taft North	A	Inflow	13.4	3	
D4	Taft South	A	Inflow	0.0	0	No Data
D5			Inflow			
D1_O	EDSA West	A	Outflow	17.6	3	
D2_O	EDSA East	A	Outflow	22.5	2	
D3_O	Taft North	A	Outflow	0.0	0	No Data
D4_O	Taft South	A	Outflow	19.8	2	
D5_O			Outflow			

Signal Data	
Signal Phase Data	URL
CCTV Data	URL

Source: JPT

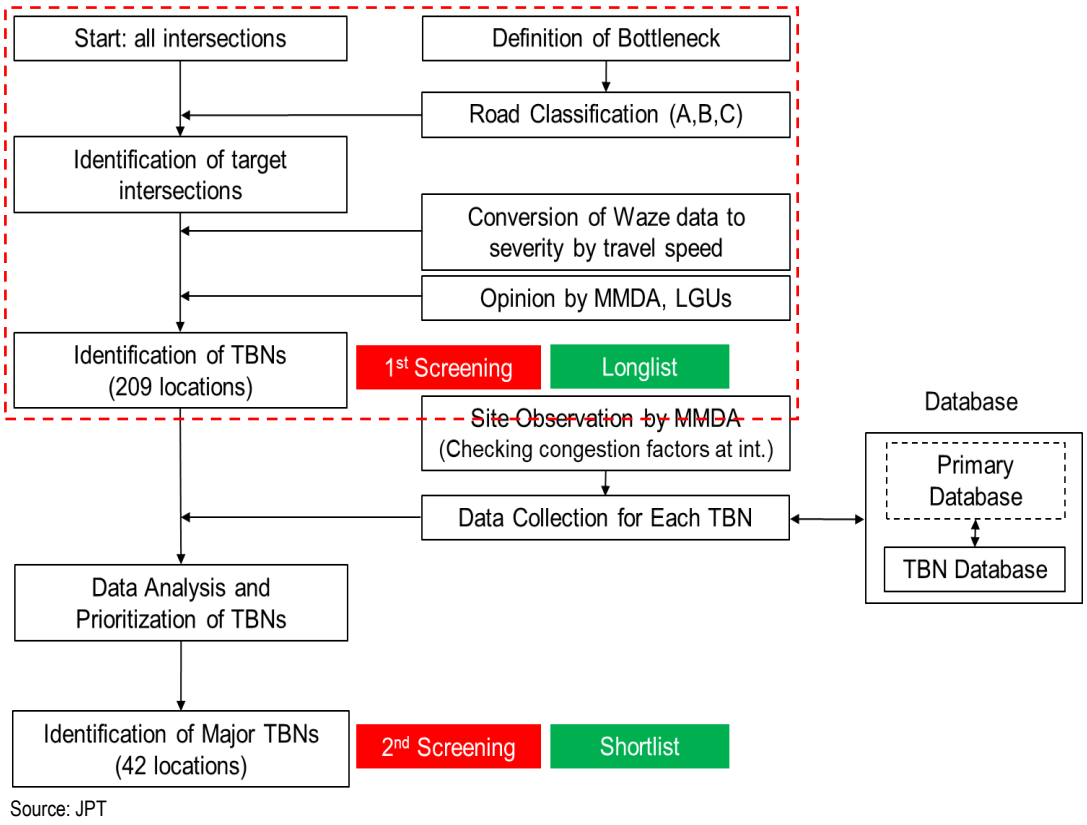


Source: JPT

Figure 4.2: Conceptual Diagram of the Intersection Bottleneck Database

5 MANUAL ON IDENTIFYING TBNS USING WAZE TRAVEL SPEED DATA

The first steps in identifying traffic bottlenecks involve defining the road classification, identifying target intersections (AxA, AxB, AxC, and BxB intersections), converting waze travel speed data from csv file to a map, and applying LOC criteria for intersection, segment, and area TBNs. MMDA and LGUs may also add problematic intersections based on their engineering judgement.



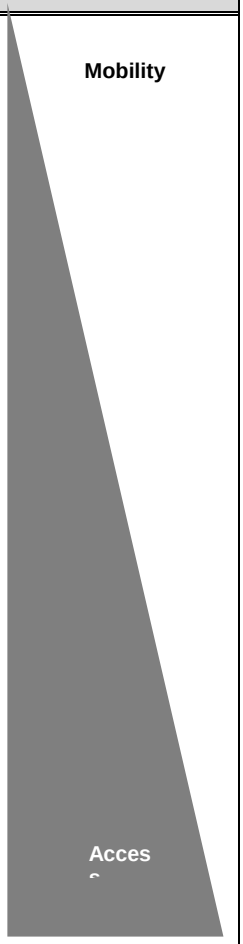
Source: JPT

Figure 5.1: Workflow in Identifying Traffic Bottlenecks

5.1 Road Classification

The JPT, MMDA, and LGU counterpart team defined each road class based on functionality. They specified which roads or establishments each road class connects. Moreover, expressways and major arterial roads provide the most mobility or ability to move, while local streets gives more access given more possible routes.

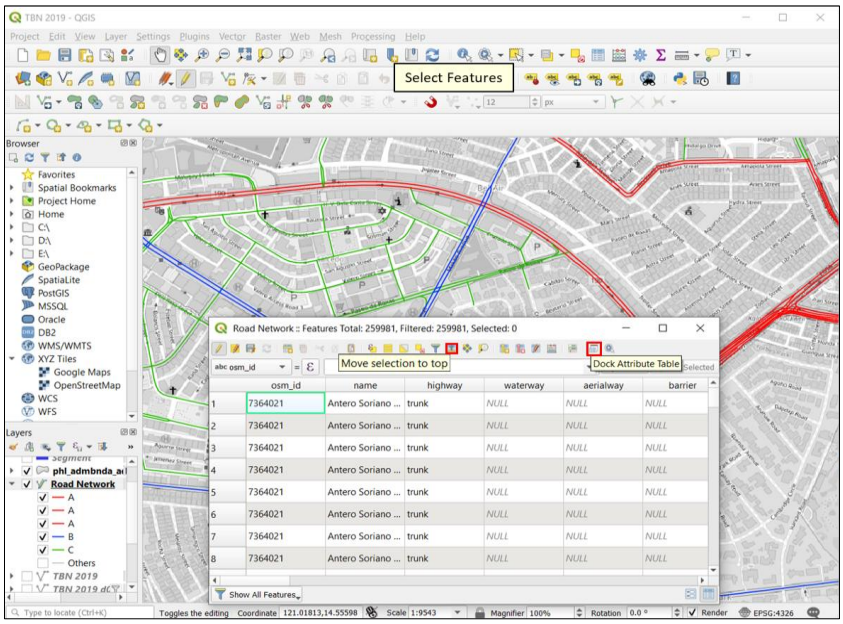
Table 5.1: Road Classification Description

Road Classification		Definition	Function
Expressway and Major Arterials	A	• Controlled access or limited access road with access ramps, lane dividers, etc., for high-speed traffic. • Affect basic urban space & land use. • Backbone serving major traffic flow in Metro Manila such as R1-R10 and C1-C6, and those with the same function as an integrated network.	
Minor Arterials	B	• Provides access to international airports and ports and other major traffic-generating sources. • Articulate primary road network. • Provide major traffic flow with alternate routes. • Affect basic urban space & land use.	
Major Collectors	C	• Connect major traffic-generating sources of LGU to Primary roads. • Connect Barangay centers with LGU/City Hall. • Serve main traffic within LGUs.	
Minor Collectors	D	• Connect barangay with other barangays. • Road that connects main socio-economic activity facilities/areas such as schools, hospitals, markets, etc. for the residents in LGUs and provides good access to primary/secondary roads. • Roads that serve main traffic circulation within LGUs.	
Local Streets	E	• Roads that complete destination trips, connected to other roads but do not belong to the classes above. • Living roads that prioritize pedestrians. • Roads that mostly serve intra-barangay traffic, gated villages, etc.	

Source: JPT

The following steps show how to edit the road classification of links from the Road Network database.

(a) Open the attribute table and click “Dock Attribute Table” and “Move selection to top”.



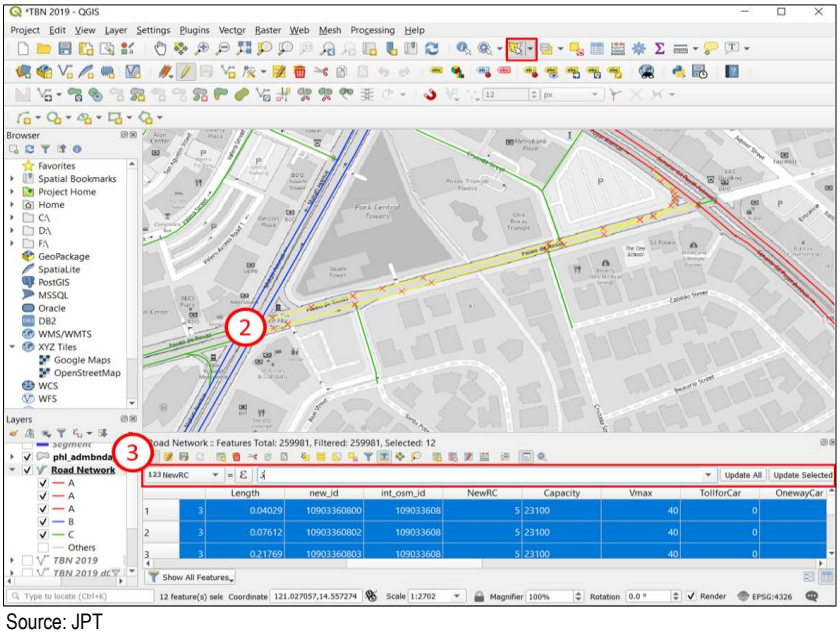
Source: JPT

Figure 5.2: Road Network Attribute Table

(b) Select the links that need to be updated.

(c) Select “NewRC” field and type the new value.

- 1 = Expressway (black)
- 2,3 = A (red)
- 4 = B (blue)
- 5 = C (green)
- 9 = Others (grey)



Source: JPT

Figure 5.3: Updating Road Links

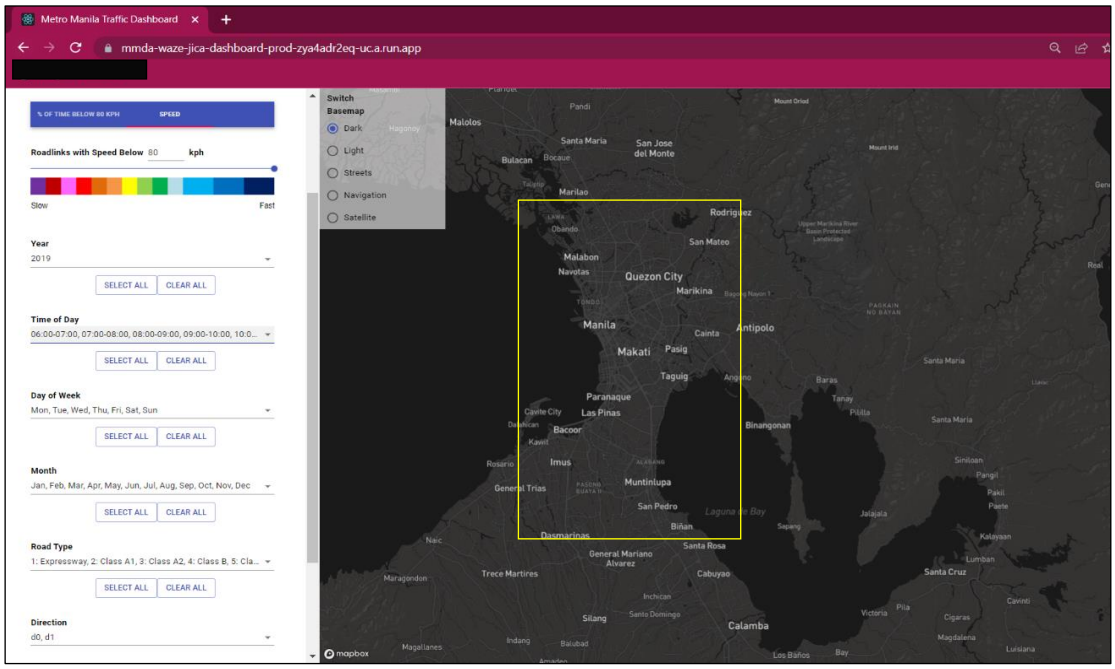
And click the “Update Selected”. The link will change it’s color depending on the new assigned class.

5.2 Waze Data Dashboard

This section explains the elements found in the Waze Data Dashboard, as well as how to export network and space-time table data.

(a) Access Metro Manila Waze Data dashboard by going to https://mmda-waze-jica-dashboard-prod-zya4adr2eq-uc.a.run.app/.

(b) Zoom the map such that whole Metro Manila can be seen in the screen.



Source: JPT

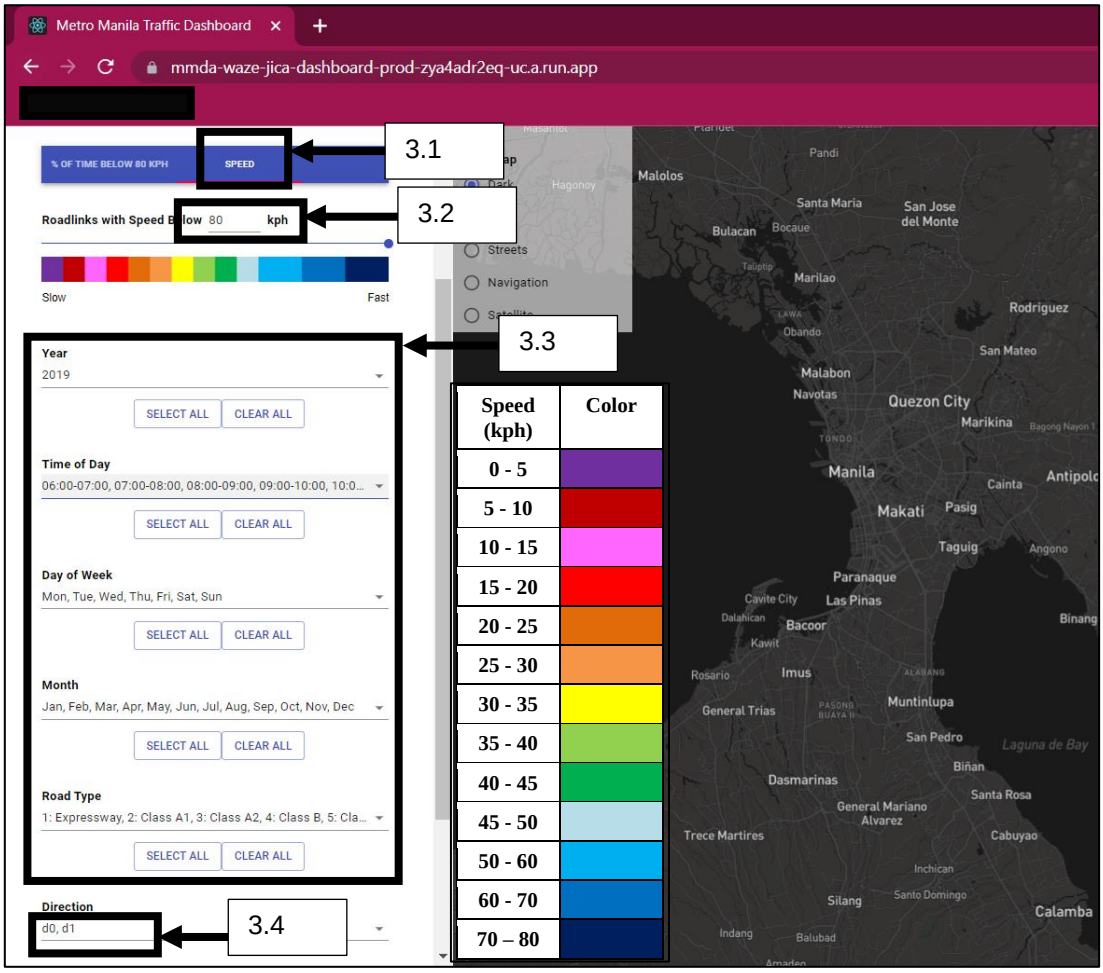
Figure 5.4: Waze Data Dashboard

(c) Set the filters to the left of the dashboard to change the results shown in the map or export the needed data.

- Switch the analysis method to “Speed.”
- Select 80kph. The colors shown in the map will correspond to the speed of the road link.
- For some filters, you will be able to “Select All” the values. This will average the data called by the filter. You can also “Clear All” to unselect the values.

  For the traffic bottleneck identification in CTMP, ALL day of week, month, road type, and direction were selected for the year 2019. Time of day values were from 6:00 am to 8:00 pm.

  Filtered values related to time of day, day of week, and month may be changed in future studies depending on the scope the strategies/plans to be implemented.
- Road links with a likely cardinal direction of either East or North will show up under the “d0” filter, while those that are either West or South will show up under “d1.”

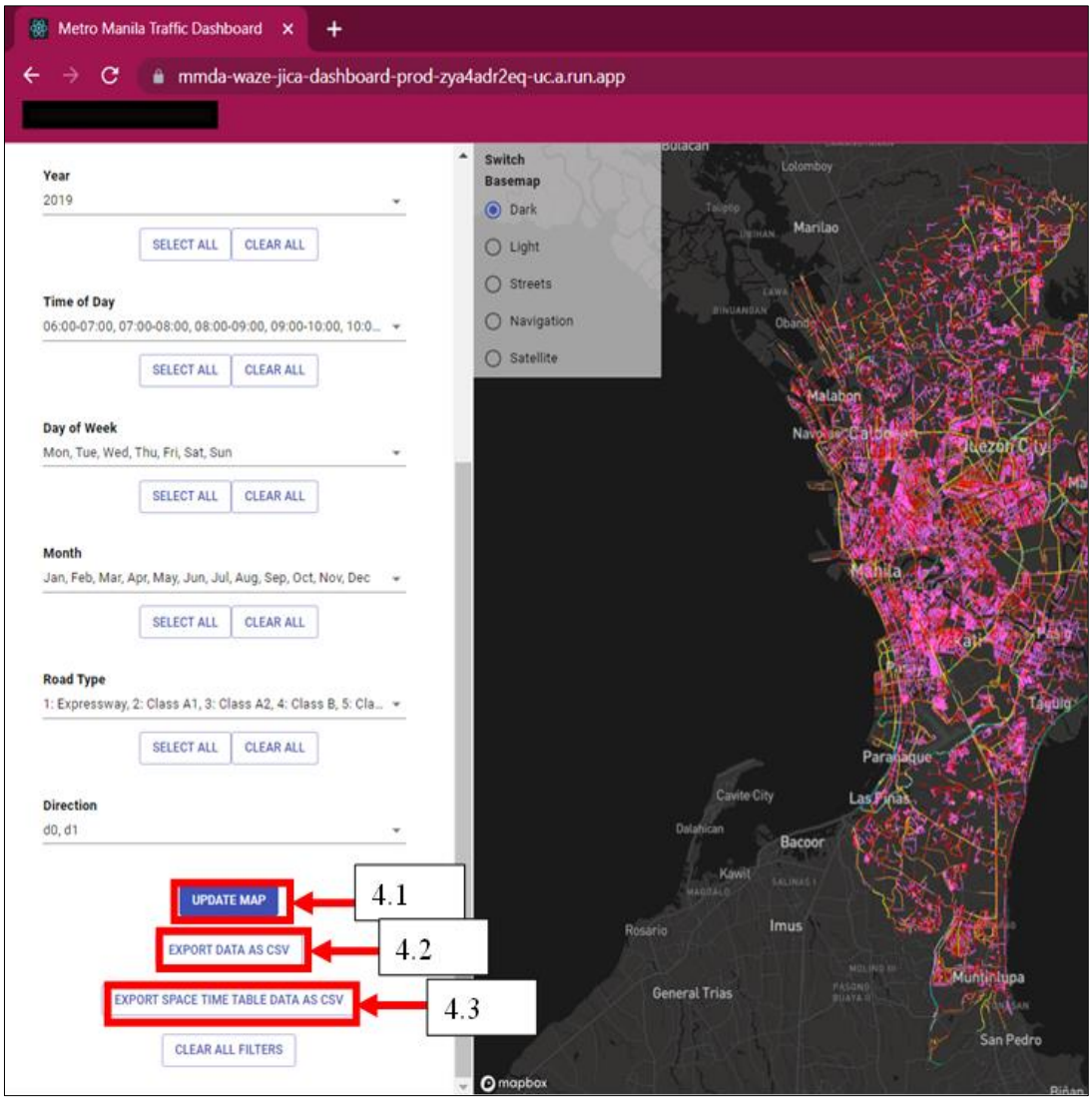


Source: JPT

Figure 5.5: Components of the Waze Data Dashboard

(d) Show updated map or export needed data.

- When needed filters are selected, click “Update Map” to apply the filters on the map.
- Export road network attribute by clicking “Export data as CSV.” The attribute contains street name, average speed, road type, and well-known text (WKT) among others. WKT is important in plotting the links in a GIS software.
- Export space-time for circumferential and radial roads by clicking “Export
- Space Time Table Data as CSV.”



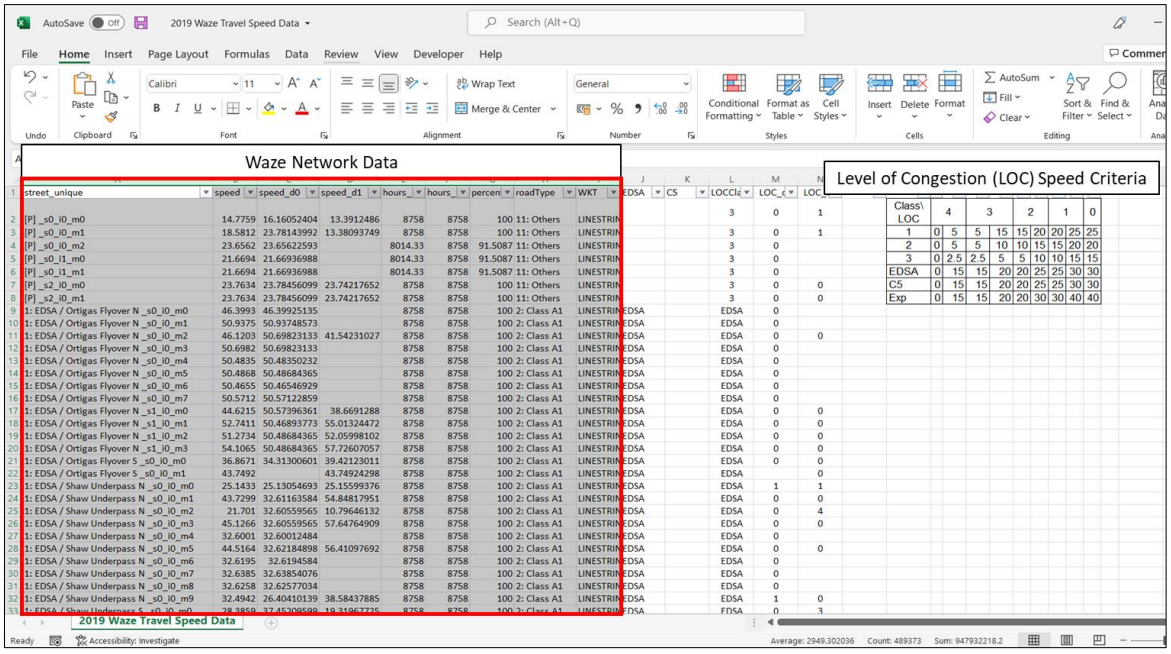
Source: JPT

Figure 5.6: Exporting Data from Waze Data

5.3 Creating Level of Congestion Map

From the exported network data, the comma-separated values (CSV) file can be converted into a map. The following steps show how to compute for the level of congestion and to present the links in the map.

(a) Paste the exported "Waze Network data" in the template provided. The template will determine road class based on the Level of Congestion (LOC) speed criteria set by the JICA project team. LOC of d1 and d0 shall be automatically computed by using the average speed (speed_d0, speed_d1) and road class (LOCClass) of each link.



Source: JPT

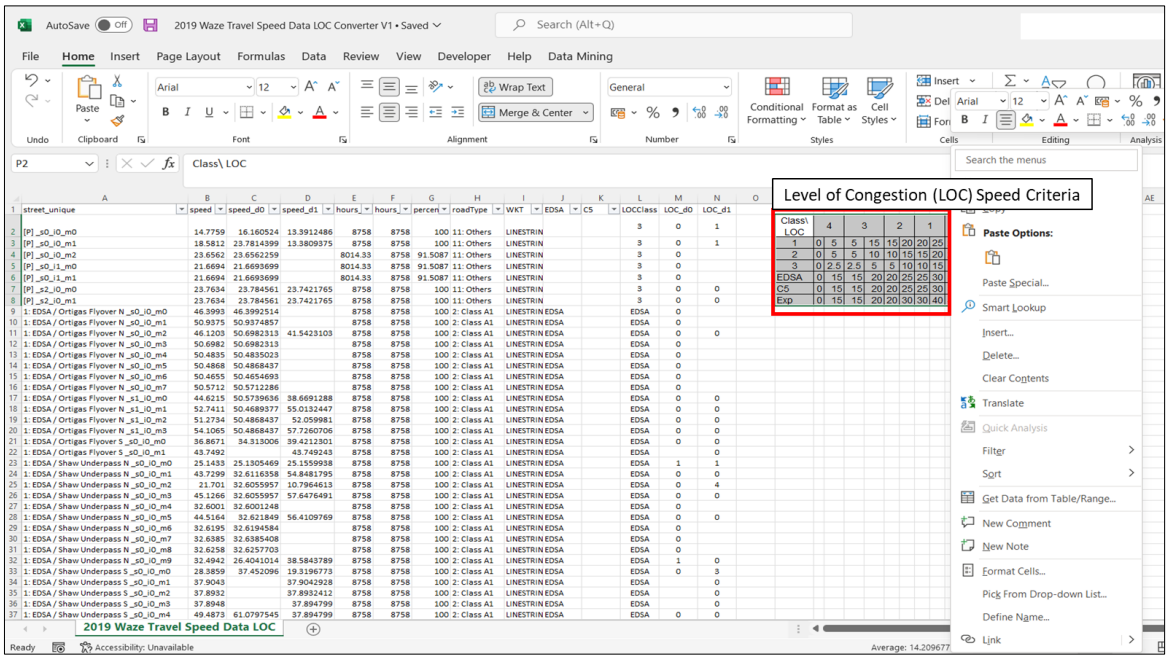
Figure 5.7: Waze Data Converter

(b) Save the file as "2019 Waze Travel Speed Data LOC Converter V1.csv".

Source: JPT

Figure 5.8: Save As File Type

(c) Open "2019 Waze Travel Speed Data LOC Converter V1.csv" and Delete the Level of Congestion (LOC) speed criteria.

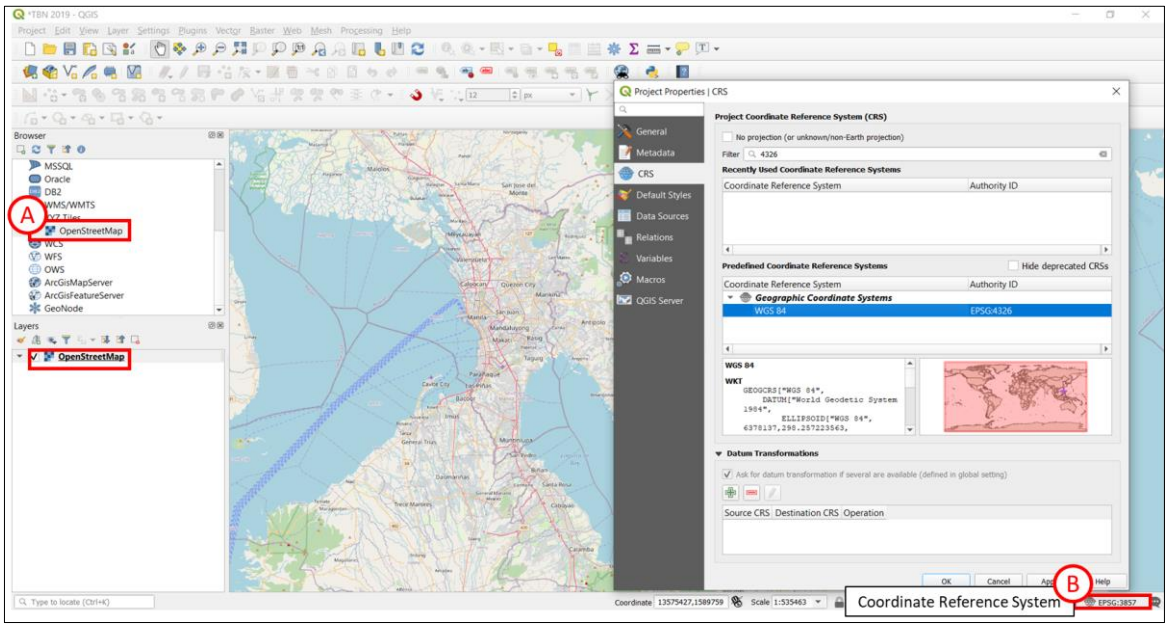


Source: JPT

Figure 5.9: Level of Congestion Speed Criteria

(d) Open QGIS and create a new .qgz file.

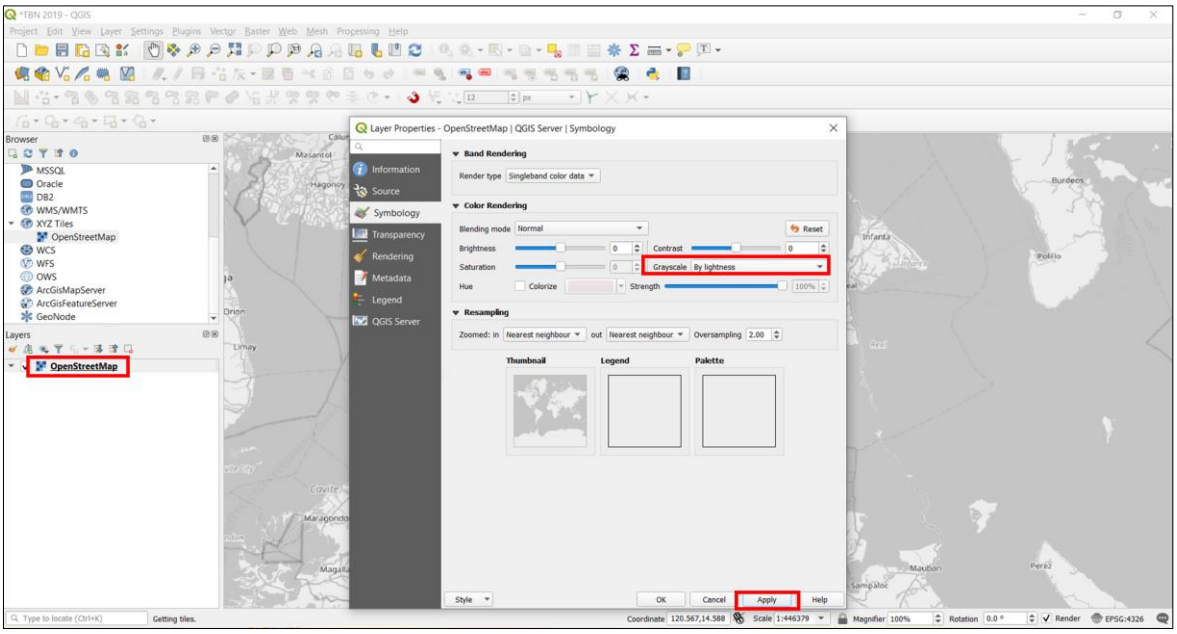
(e) A: Drag "OpenStreetMap" from Browser to Layers. B: Set Coordinate Reference System to "EPSG:4326".



Source: JPT

Figure 5.10: Coordinate Reference System

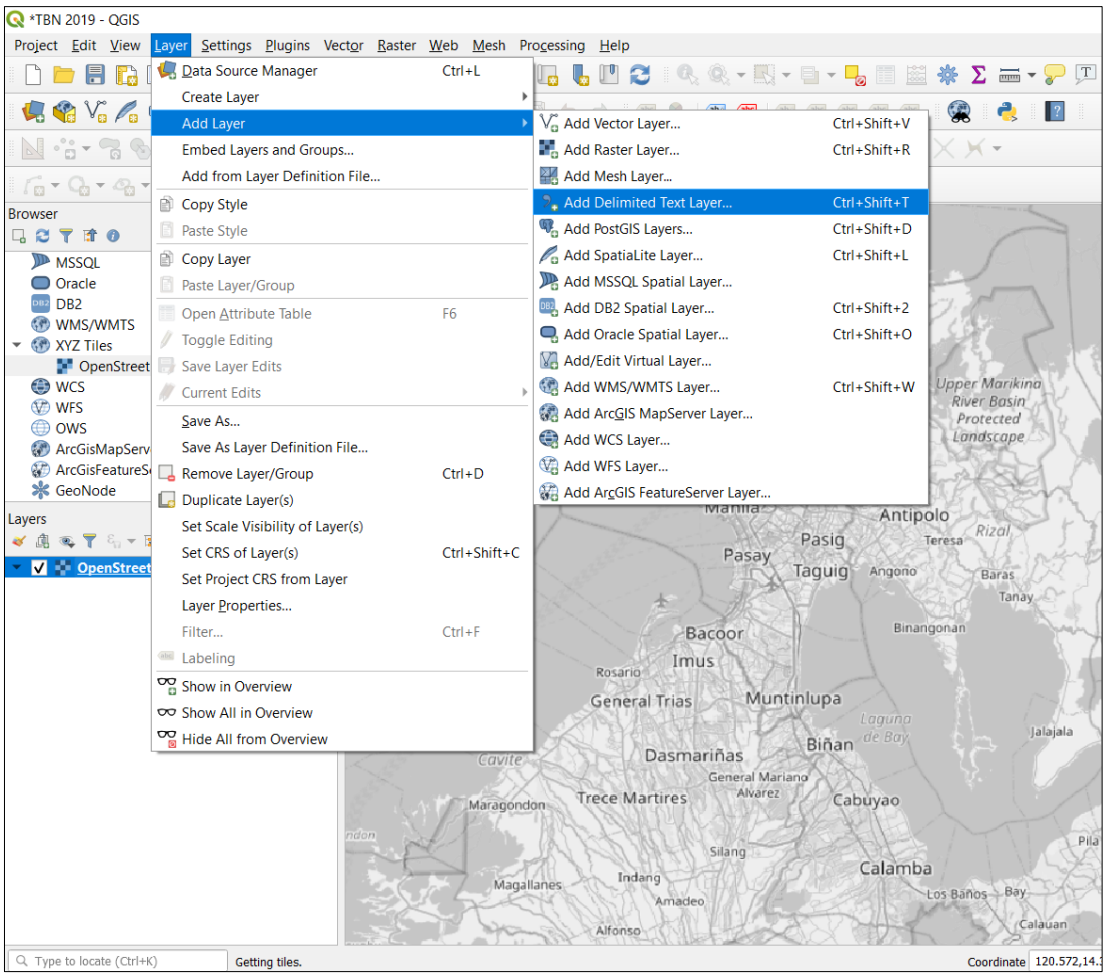
(f) Right click OpenStreetMap (OSM) and click "Properties". Set Grayscale to "By Lightness" and "Apply".



Source: JPT

Figure 5.11: Map Set to Grayscale

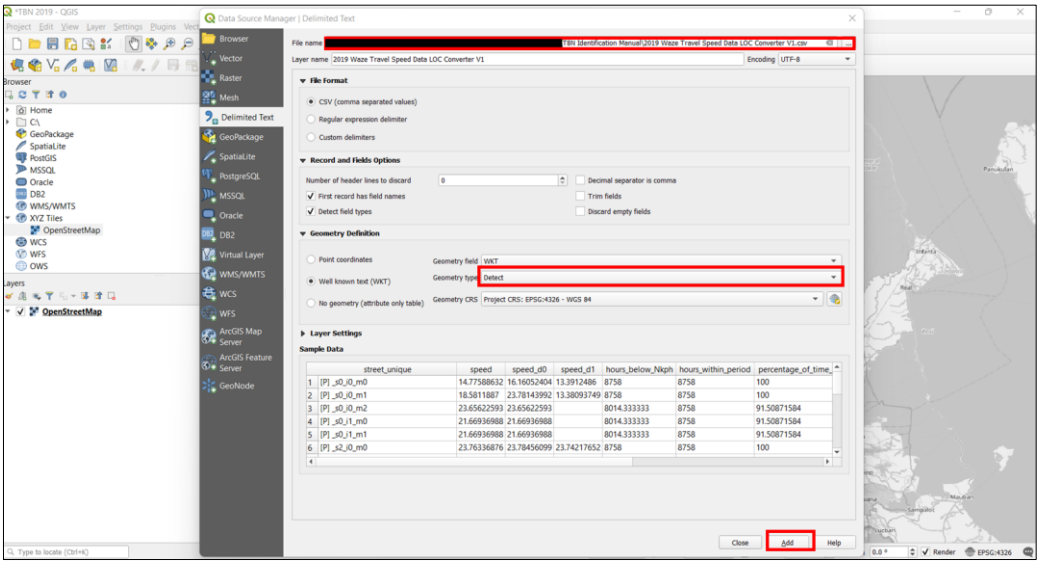
(g) Import Waze travel speed data by clicking on “Layer” -> “Add Layer” -> “Add Delimited Text Layer”.



Source: JPT

Figure 5.12: Add Delimited Text Layer

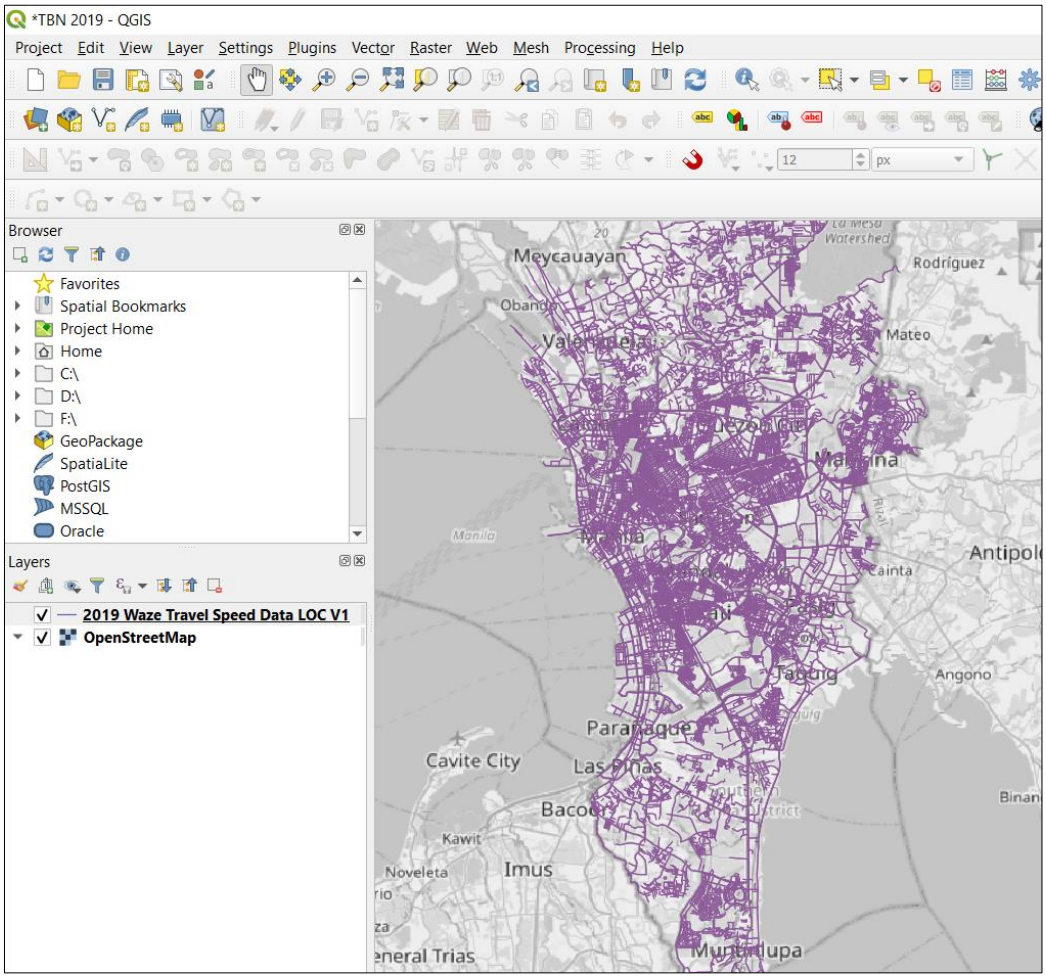
(h) Load “2019 Waze Travel Speed Data LOC V1”. Geometry field will automatically detect the WKT column of the csv file. Select “Detect” for Geometry type. Press “Add”.



Source: JPT

Figure 5.13: Load Delimited Text

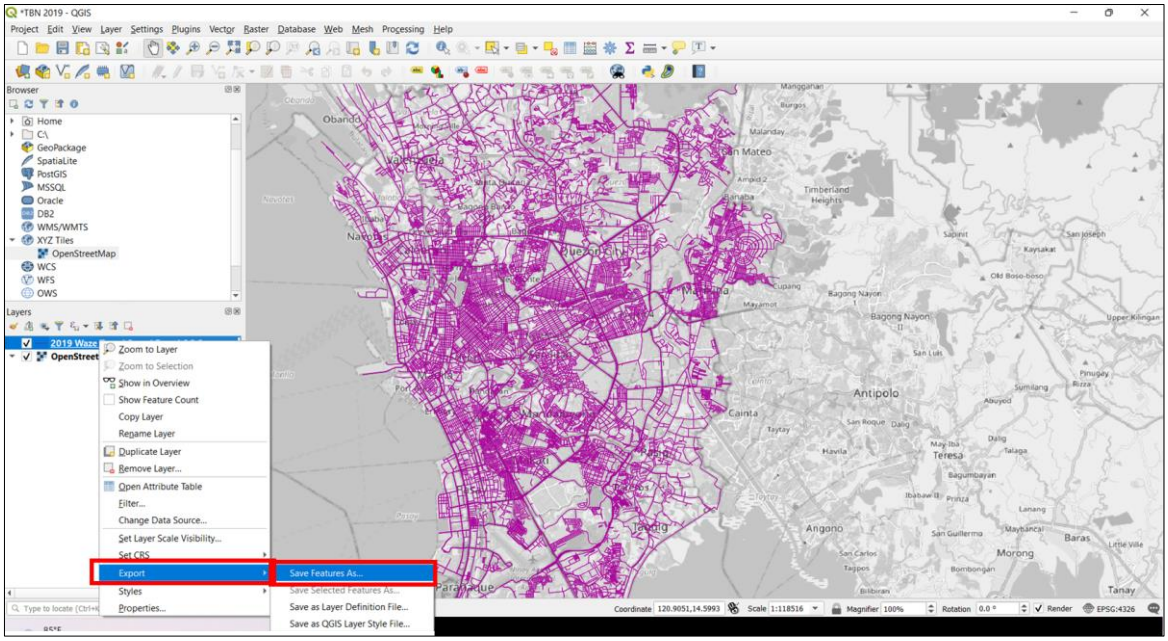
(i) In this updated map, the links are not yet categorized.



Source: JPT

Figure 5.14: LOC Road Network

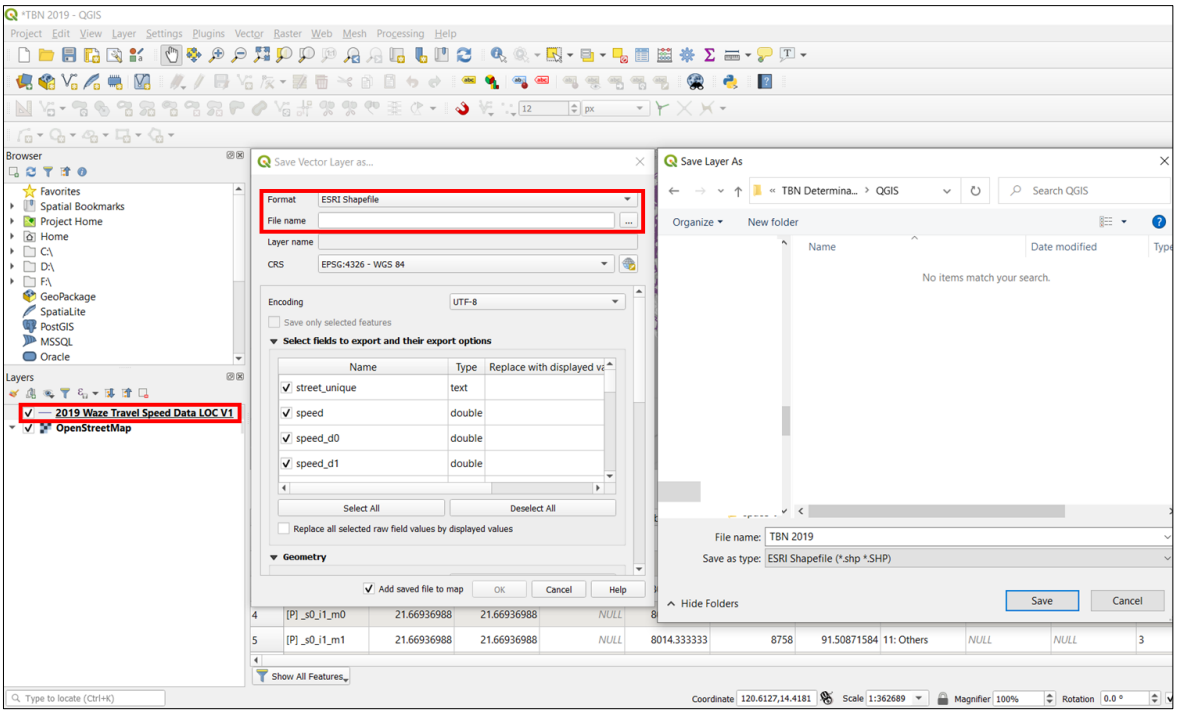
- Right click the layer. Click “Export.” Click “Save Features As”



Source: JPT

Figure 5.15: Export LOC Map as Shape File

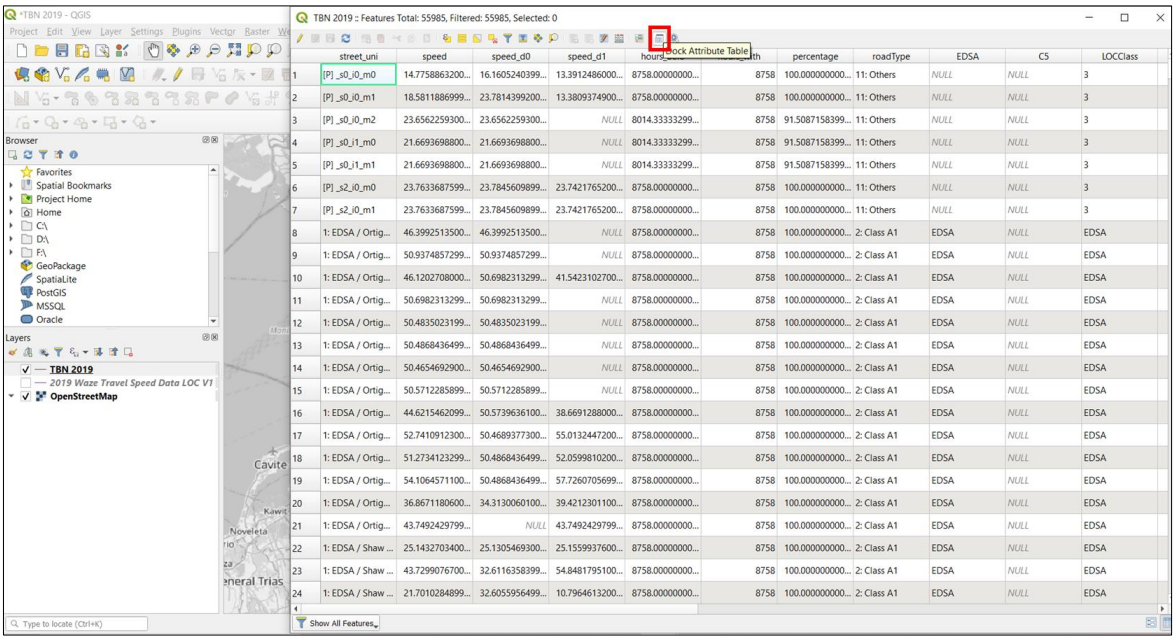
- Set Format to “ESRI Shapefile” and save the shape file in a folder as “TBN 2019”.



Source: JPT

Figure 5.16: LOC Map as Shape File

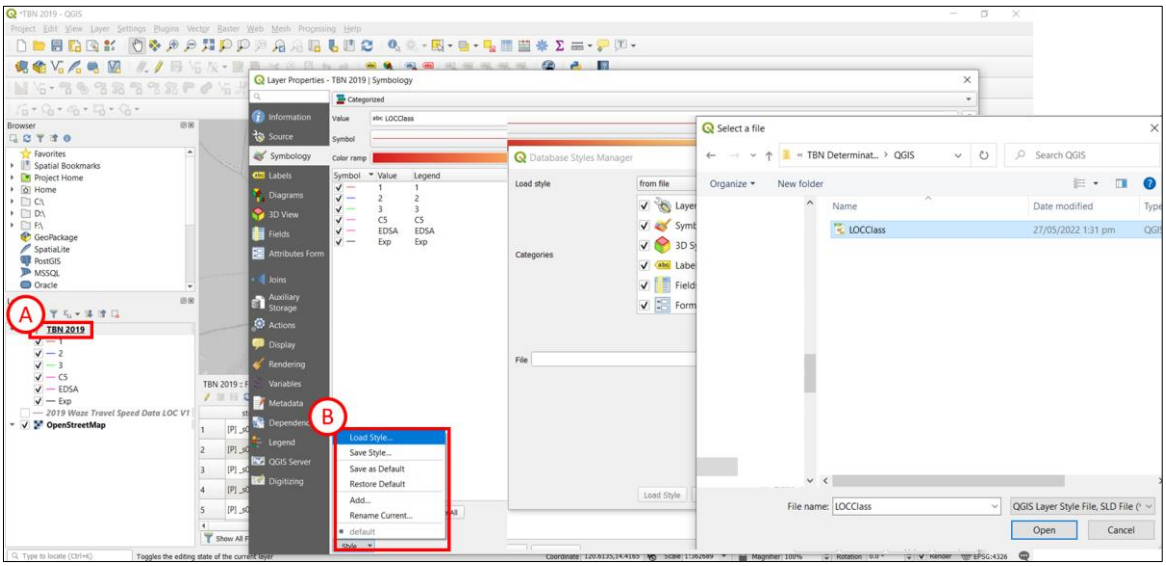
(j) 10. Right click “TBN 2019” and click “Open Attribute Table”. Click “Dock Attribute Table”.



Source: JPT

Figure 5.17: LOC Map Attribute Table

(k) A: Right click “TBN 2019” and click “Properties”. B: On the lower left, click “Style” and load “LOCClass”. Legends for different road classes will show on the map in different colors.

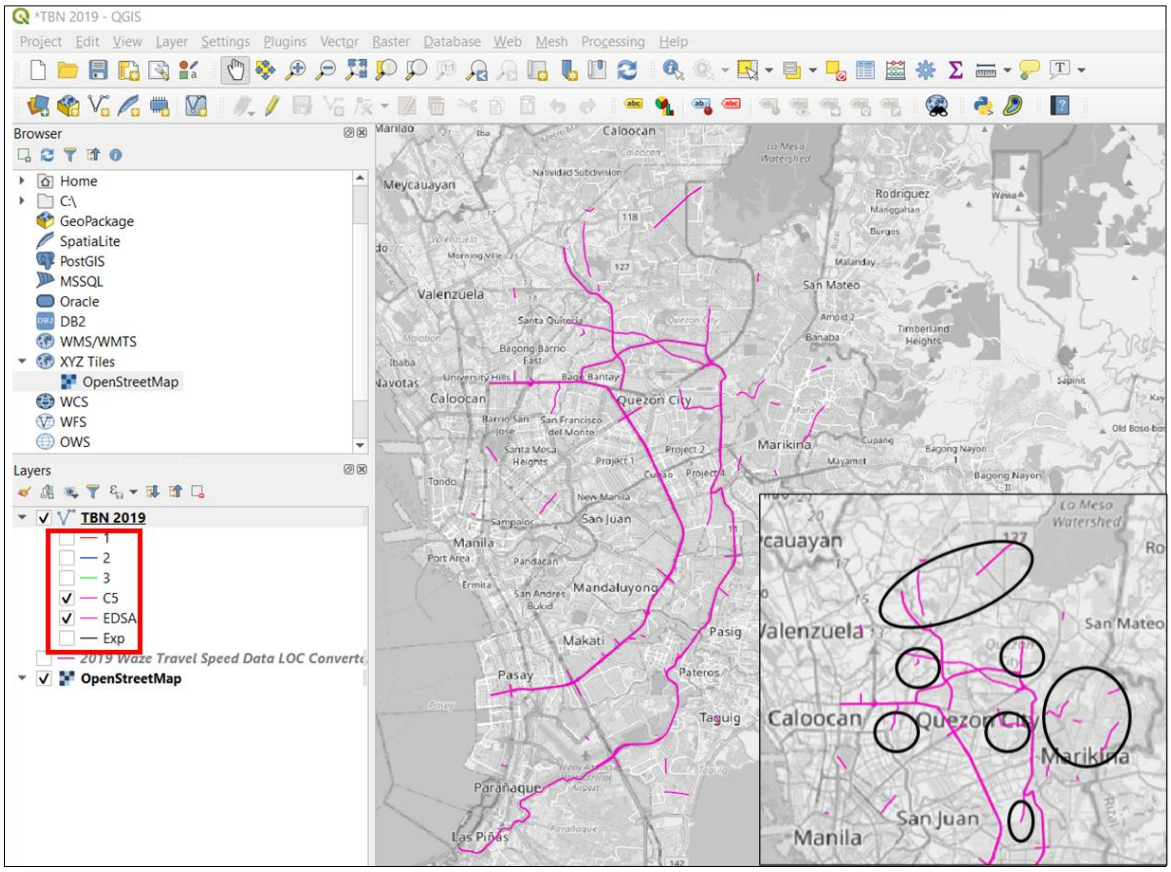


Source: JPT

Figure 5.18: LOC Map Load Style

(l) Links classified as EDSA and C5 should be sense-checked in the map because the formula in the excel file has limitations on detecting those links.

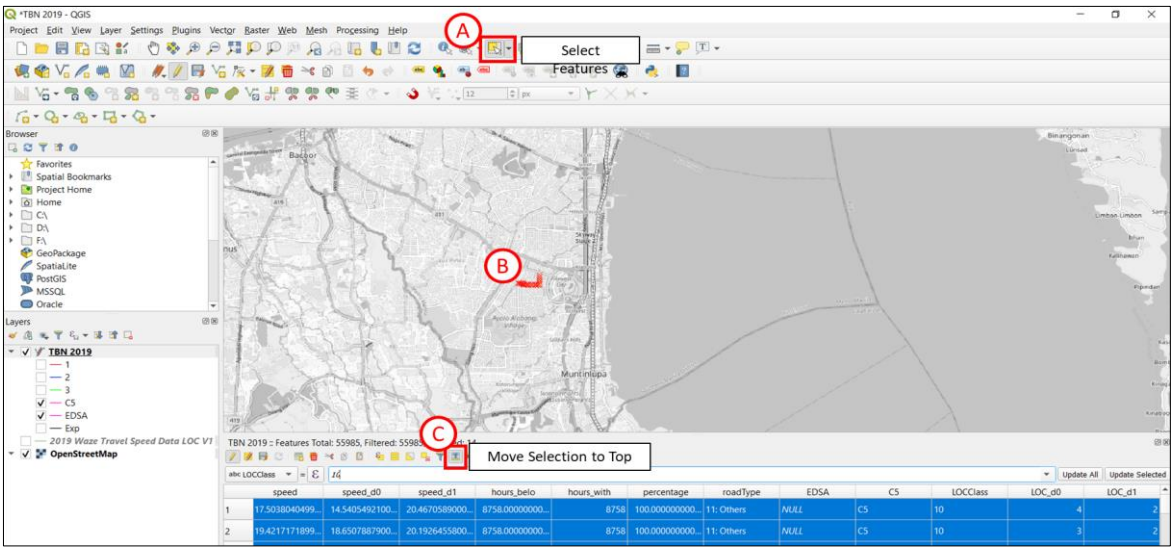
Uncheck 1, 2, 3, and Exp from “TBN 2019” layer. Uncheck also the 2019 Waze Travel Speed Data LOC Converter V1. Links that does not belong to EDSA and C5 should be re-classified.



Source: JPT

Figure 5.19: Raw Data on C5 and EDSA links

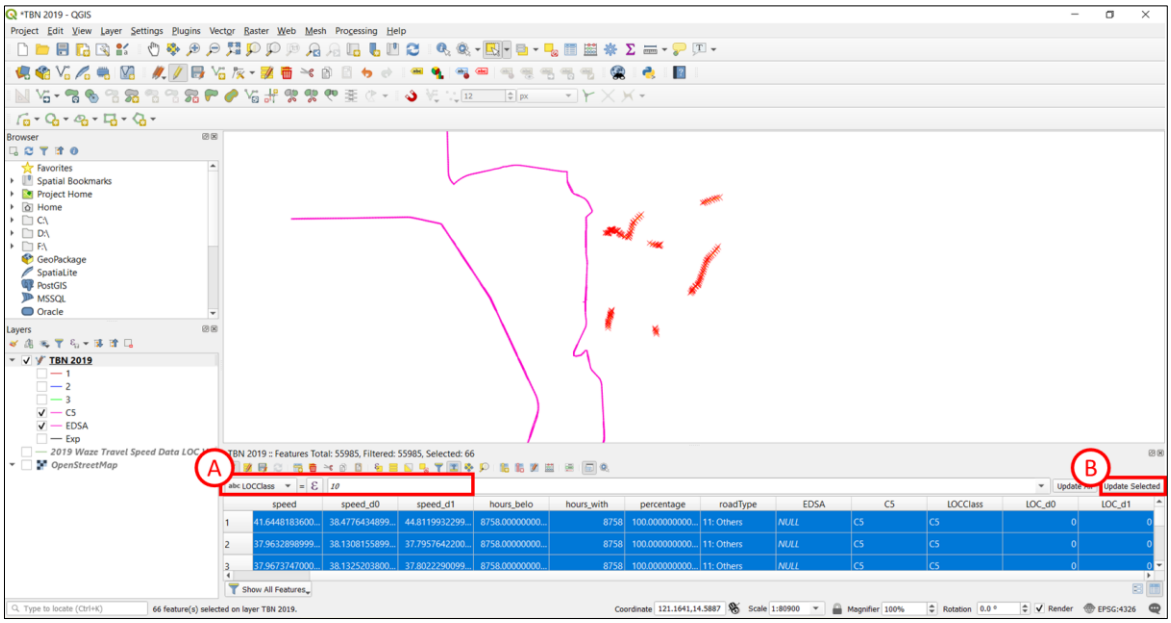
(m) A: Use “Select Features” and select links outside EDSA and C5. B: Select links. C: Click “Move Selection to Top”.



Source: JPT

Figure 5.20: Cleaning EDSA and C5 Data

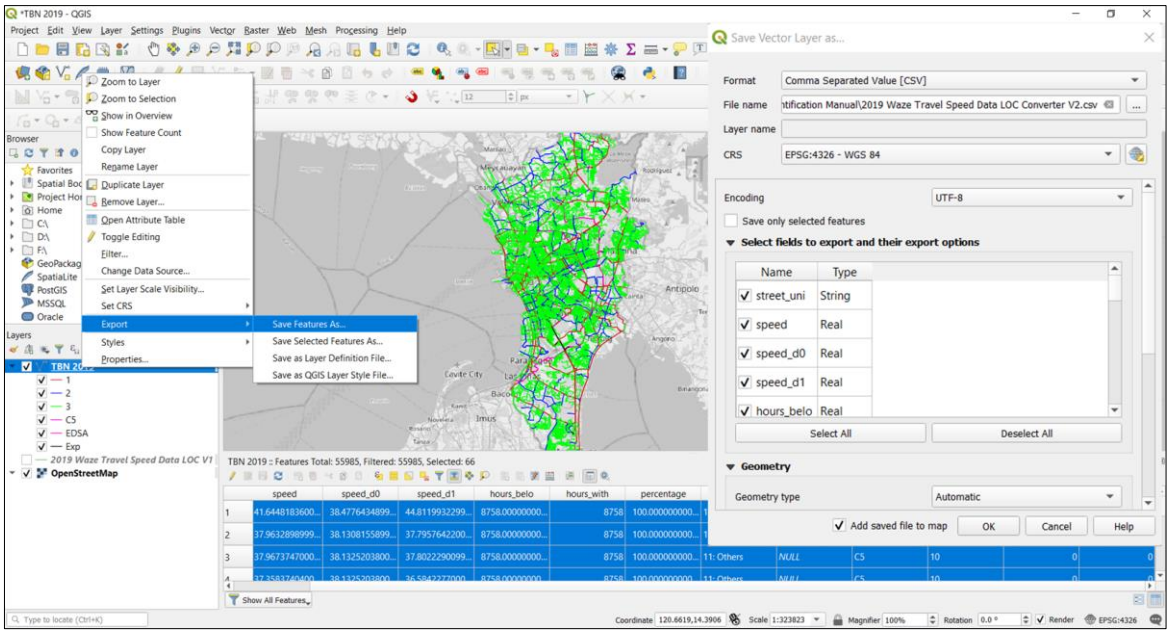
(n) To change the LOCClass, selected links should be marked first. Label the links outside EDSA and C5 with a different number by selecting LOCClass. A: Type any number besides 1 to 3. For instance, “10”. B: And Click “Update Selected”.



Source: JPT

Figure 5.21: Reclassifying Links

(o) Export TBN 2019 as .csv file and label it as “2019 Waze Travel Speed Data LOC Converter V2”.

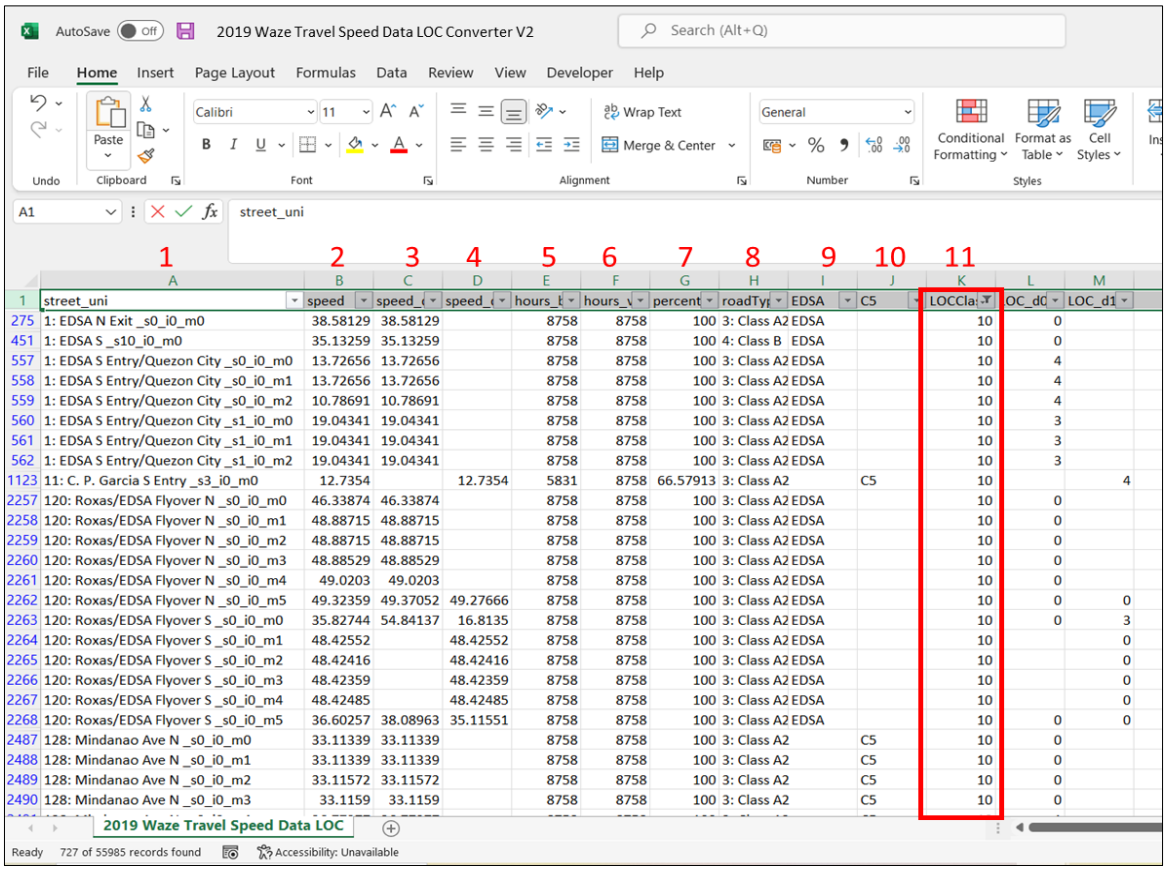


Source: JPT

Figure 5.22: Exporting Cleaned LOC Map

In this example, 2019 Waze Travel Speed Data LOC Converter V2 have links with “LOCClass=10”. These links were previously automatically classified as EDSA or C5 in the excel file and were labeled “10” in QGIS attribute table.

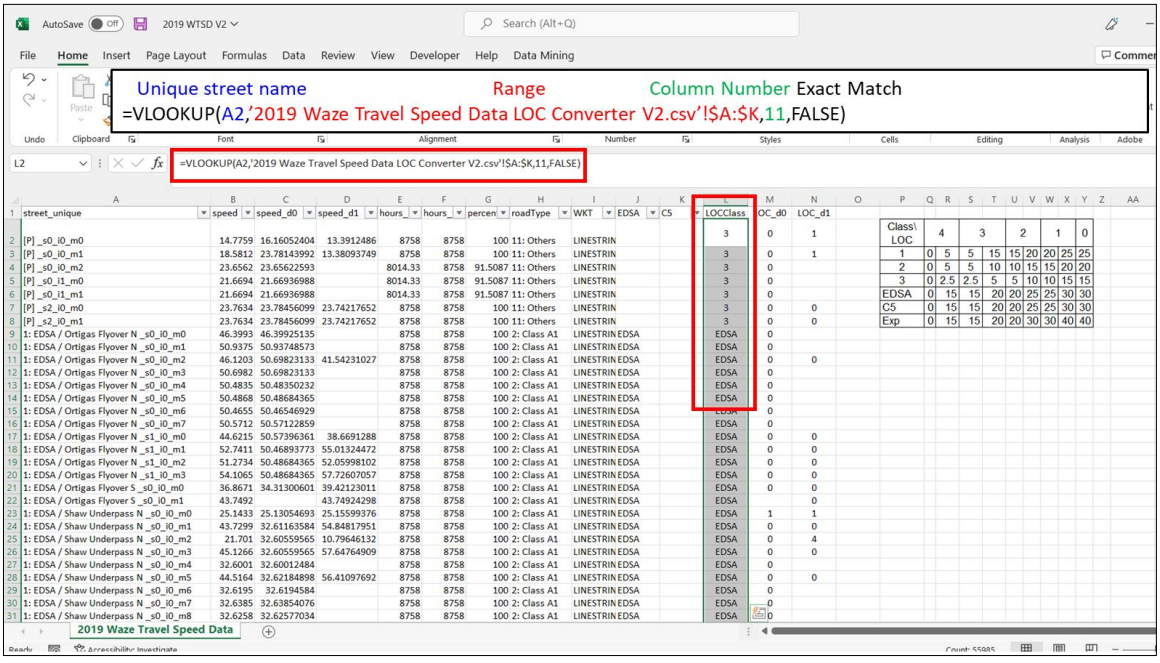
These links should be re-classified as either 1, 2, 3, or Exp (based on the road type column).



Source: JPT

Figure 5.23: Attribute Table as CSV

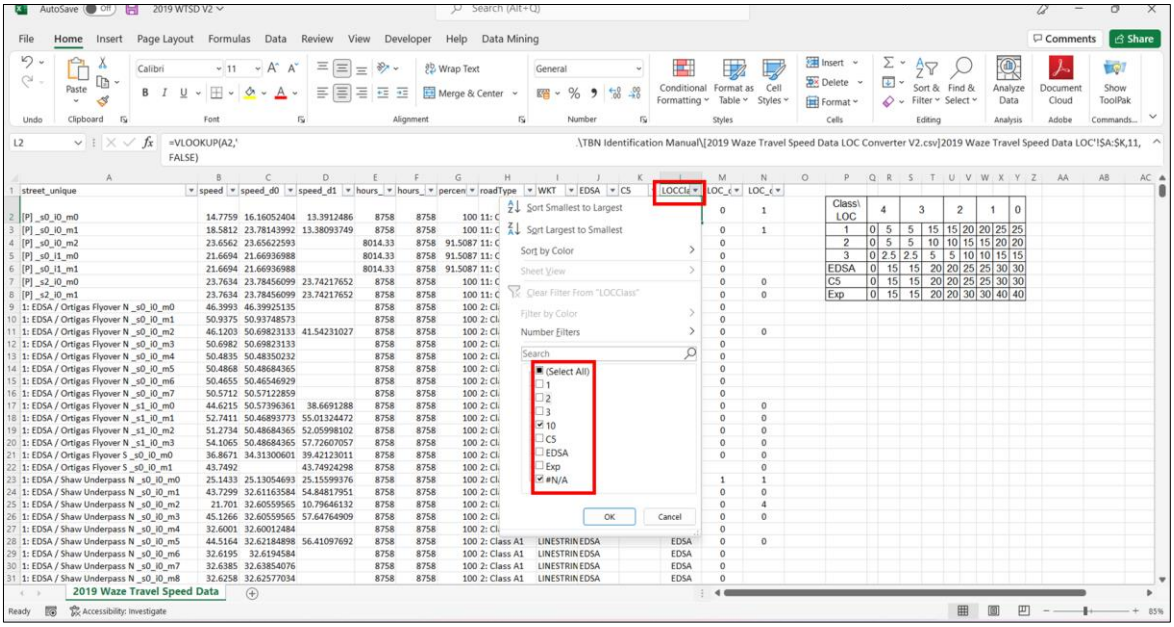
(p) Make a duplicate of "2019 Waze Travel Speed Data LOC Converter" and rename it to "2019 WTSD V2". Use Vlookup function for LOCClass column from "2019 Waze Travel Speed Data LOCV2".



Source: JPT

Figure 5.24: VLOOKUP Formula

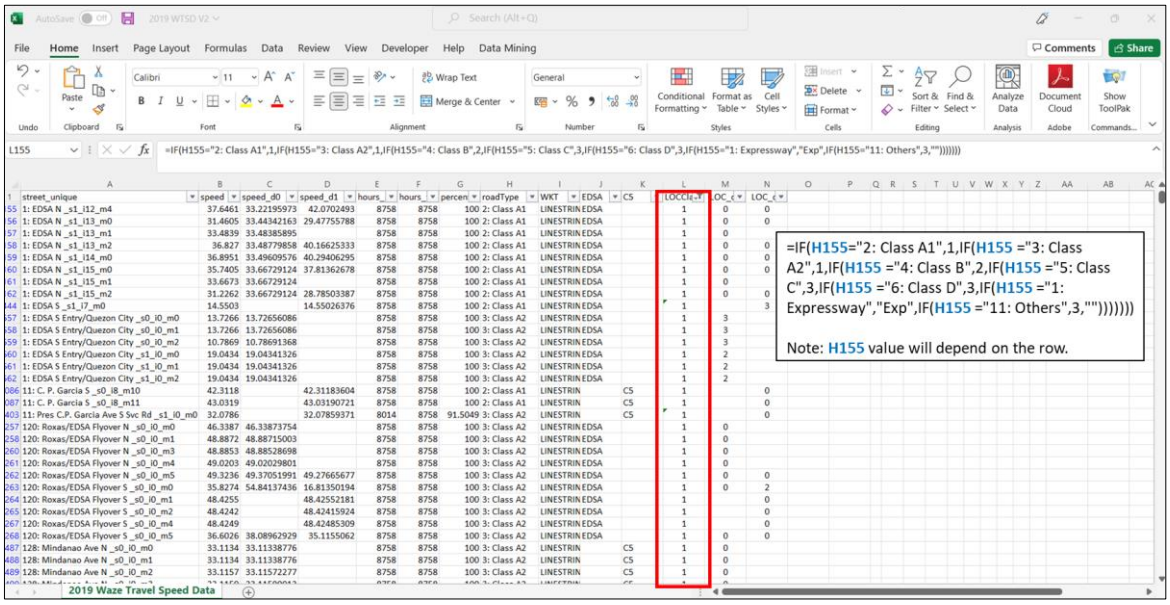
(q) Filter "LOCClass" = 10 and #N/A.



Source: JPT

Figure 5.25: Filtering Reclassified Links

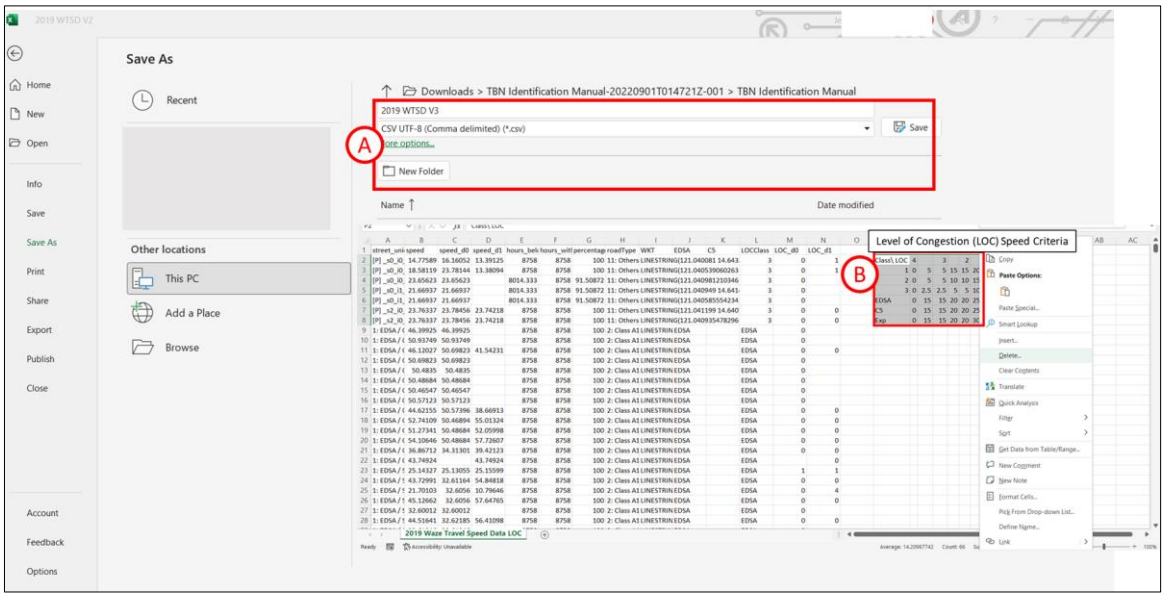
(r) LOCClass = 10 should be changed to the default "LOCClass" value based on "roadType". Copy the formula and select the cell along "roadType" (Column H).



Source: JPT

Figure 5.26: Finalizing Road Class of Unclassified Links

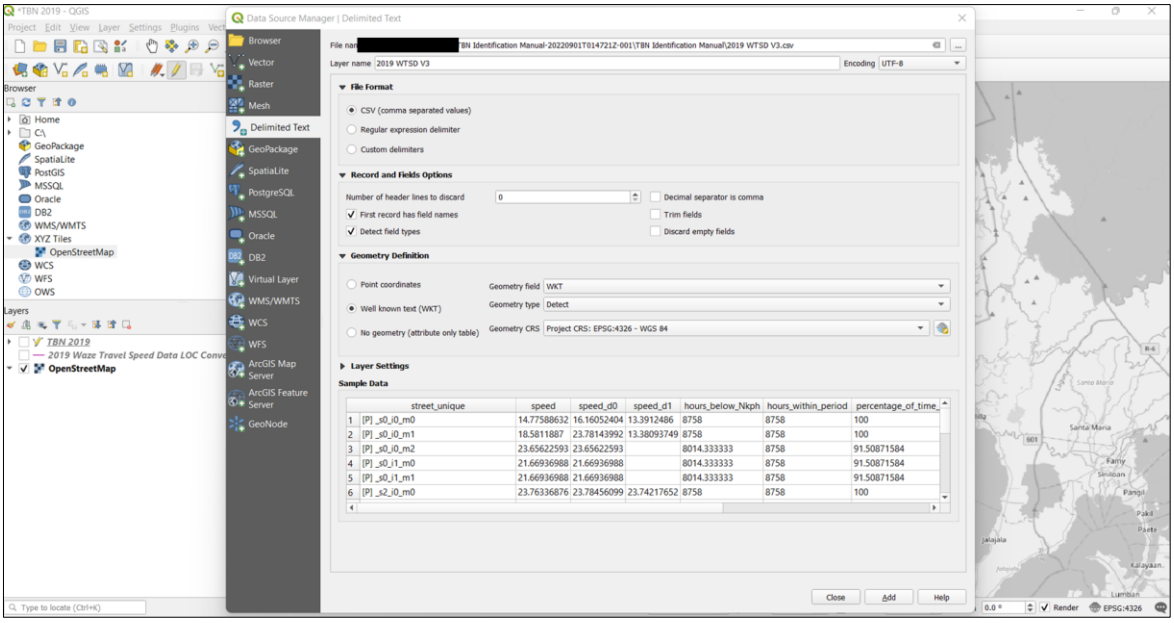
(s) A: Save the new version as .csv file. B: Delete the Level of Congestion (LOC) speed criteria and click save.



Source: JPT

Figure 5.27: Deleting LOC Criteria on CSV File

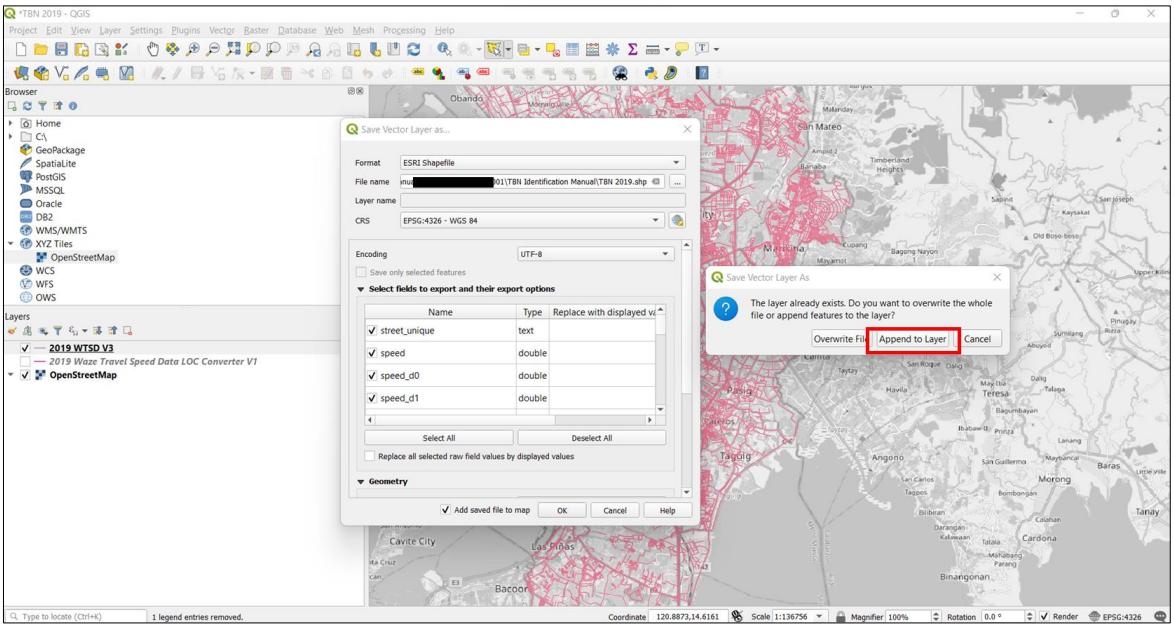
(t) Load the new version of Waze Travel Speed Data. Click “Layer” -> “Add Layer” -> “Add Delimited Text Layer”. Select the .csv file.



Source: JPT

Figure 5.28: Adding Delimited Text File of Sense Checked Data

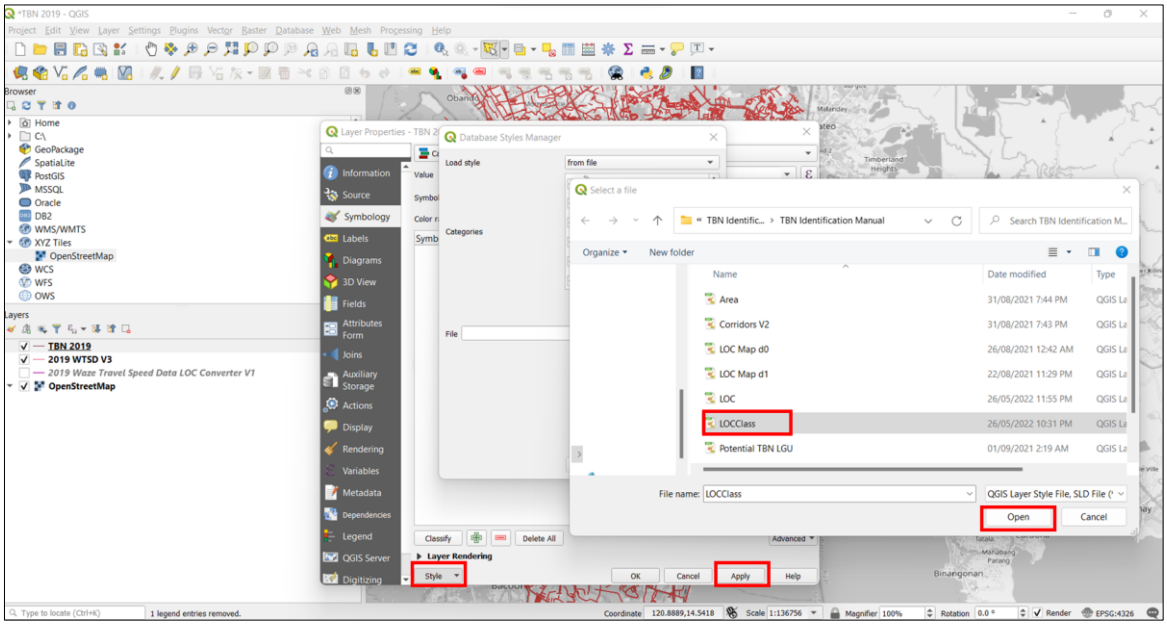
(u) Convert the map to .shp file. Right click on the Waze travel speed data and click “Export” -> “Save Feature as”. Set Format to “ESRI Shapefile” and save the shape file in a folder.



Source: JPT

Figure 5.29: Append to Layer

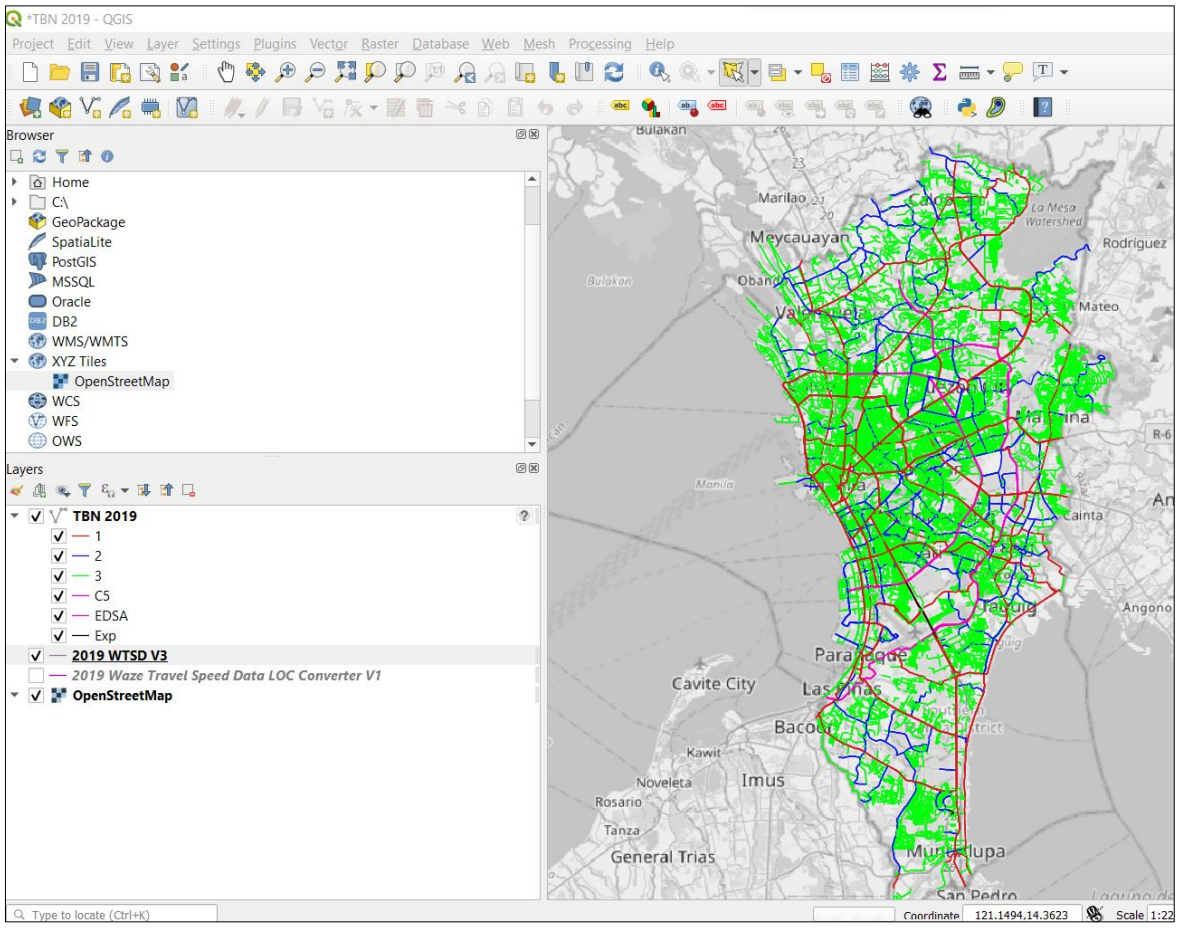
(v) Select “Style” and load “LOCClass”.



Source: JPT

Figure 5.30: Load LOC Class Style

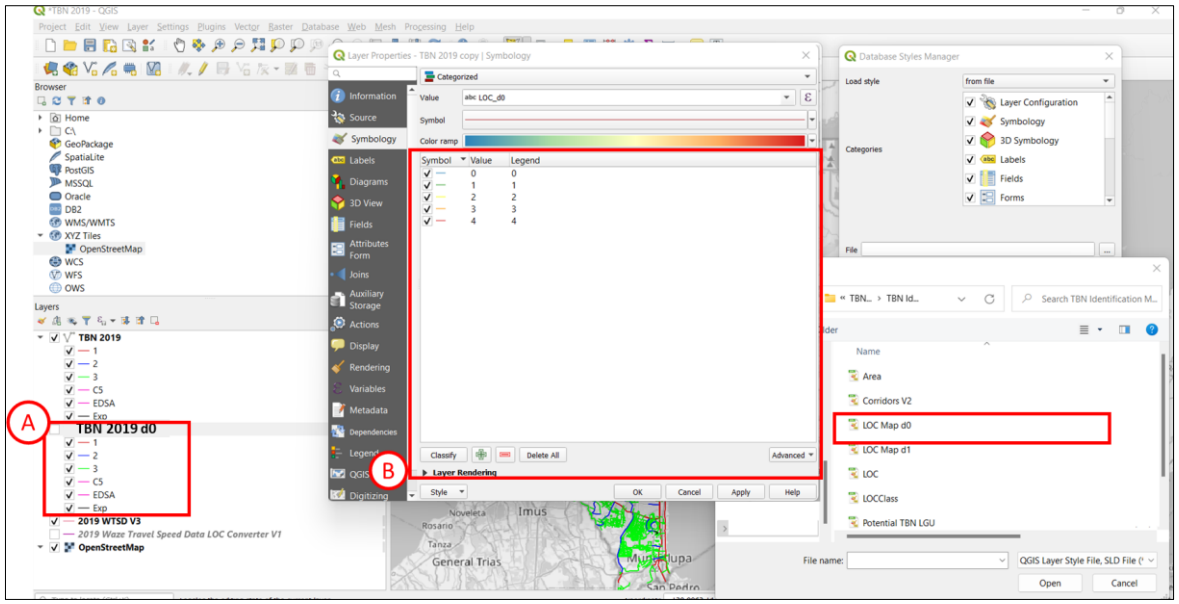
Below is a map showing the road classification with different LOC criteria.



Source: JPT

Figure 5.31: Road Classification of the LOC Map

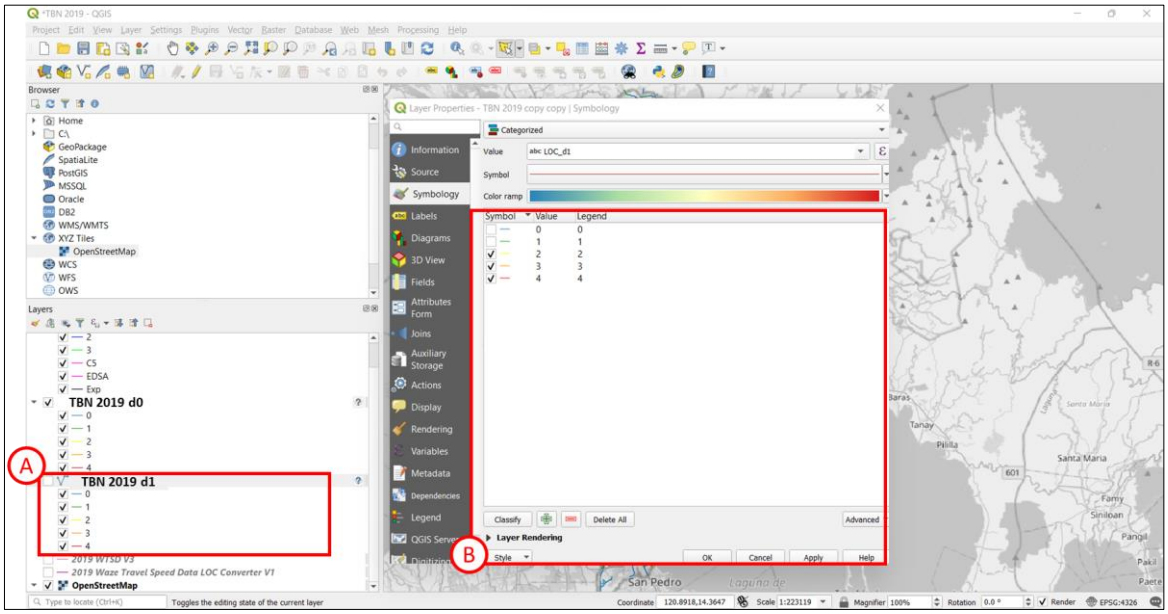
(w) A: Duplicate the updated “TBN 2019” and rename as “TBN 2019 d0”. B: Load “LOC Map d0” style.



Source: JPT

Figure 5.32: Load LOC Map d0

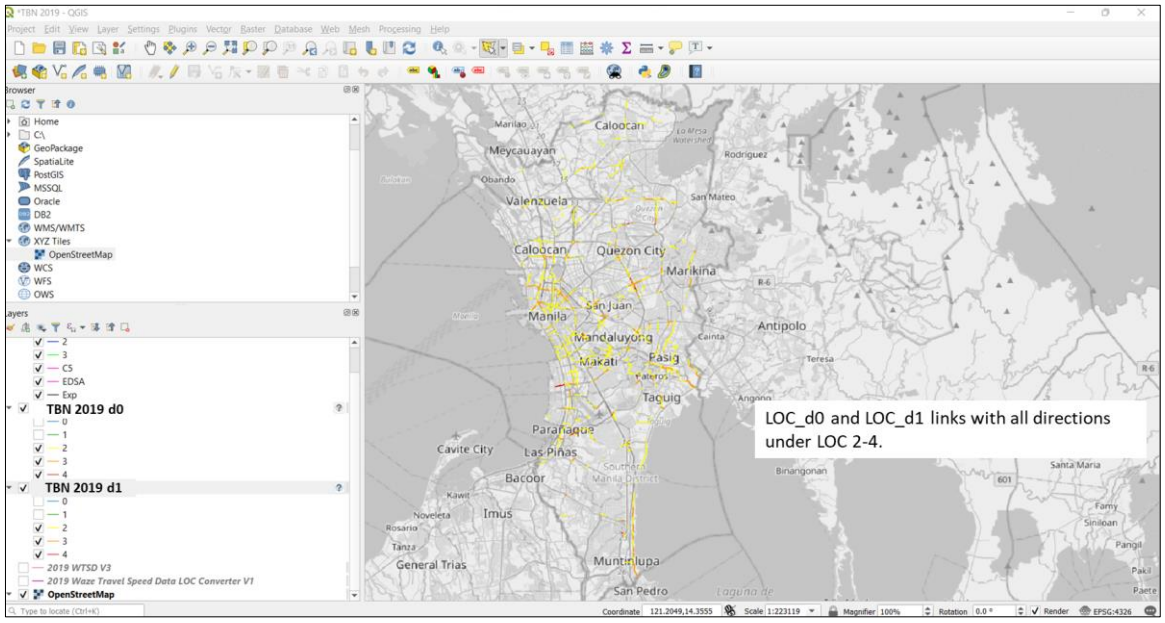
(x) A: Duplicate the updated “TBN 2019” and rename as “TBN 2019 d1”. B: Load “LOC Map d1” style.



Source: JPT

Figure 5.33: Load TBN 2019 d1 Style

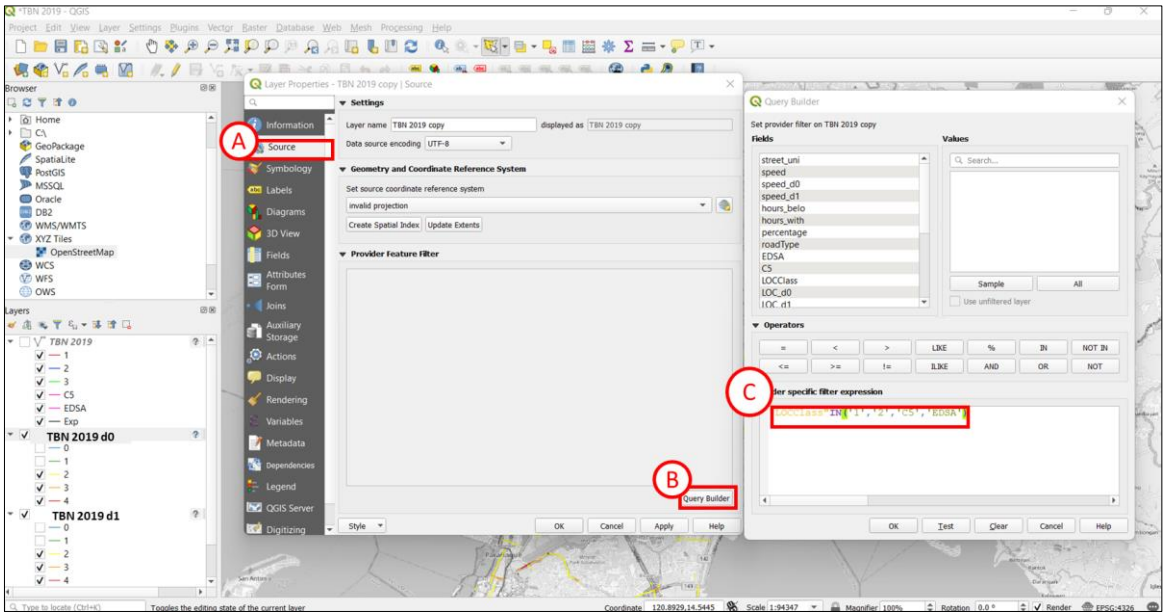
(y) Filter “TBN 2019” duplicates based on desired values.



Source: JPT

Figure 5.34: Road Network Under LOC 2 to 4

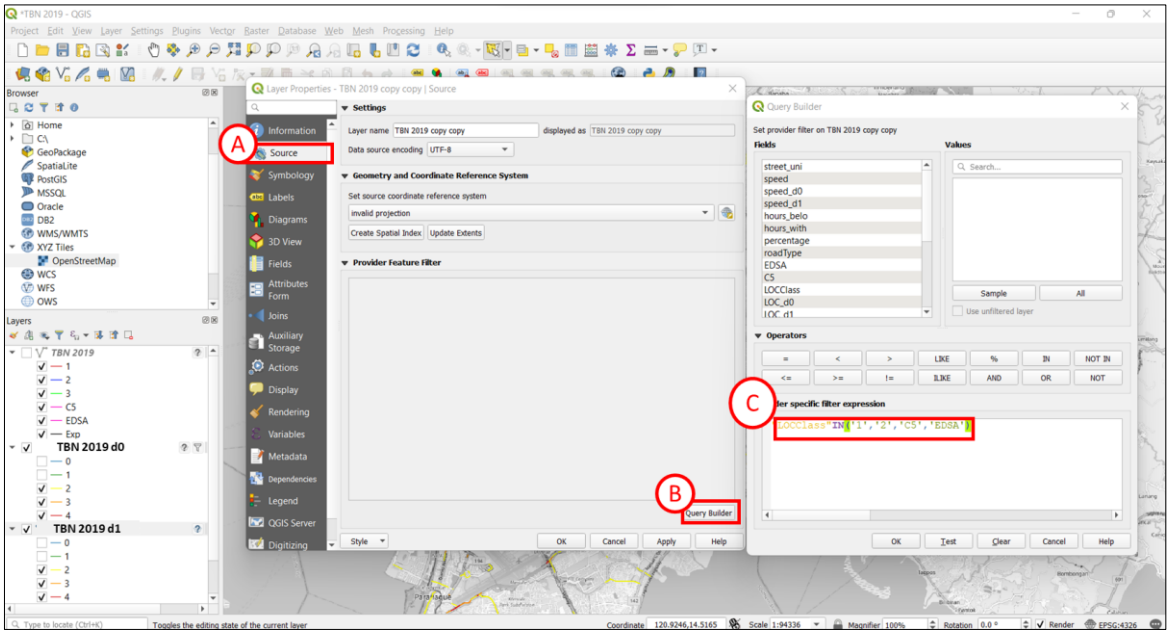
(z) To be able to prioritize intersections along major roads, “LOCClass” should be further filtered into Class A and B. A: Open properties of “TBN 2019 d0” and select “Source”. B: Click “Query Builder”. C: Type “LOCClass” IN (‘1’,’2’,’C5’,’EDSA’) and press “OK”.



Source: JPT

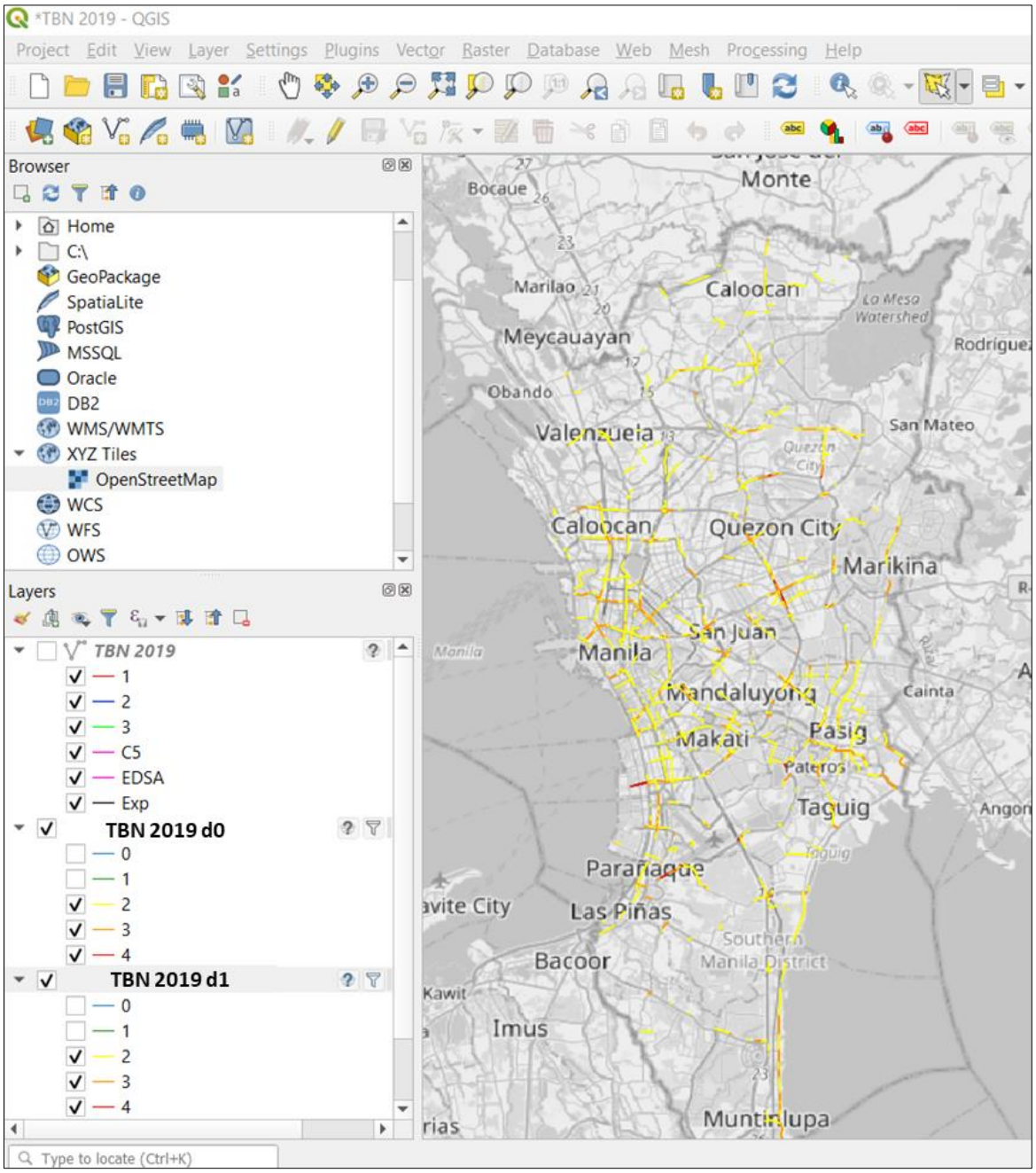
Figure 5.35: Filtering Class A to Class B Road Links for d1

- To be able to prioritize intersections along major roads, “LOCClass” should be further filtered into Class A and B. A: Open properties of “TBN 2019 d1” duplicates and select “Source”. B: Click “Query Builder”. C: Type “LOCClass” IN (‘1’,’2’,’C5’,’EDSA’) and press “OK”.



Source: JPT

Figure 5.36: Filtering Class A to Class B Road Links for d0



Source: JPT

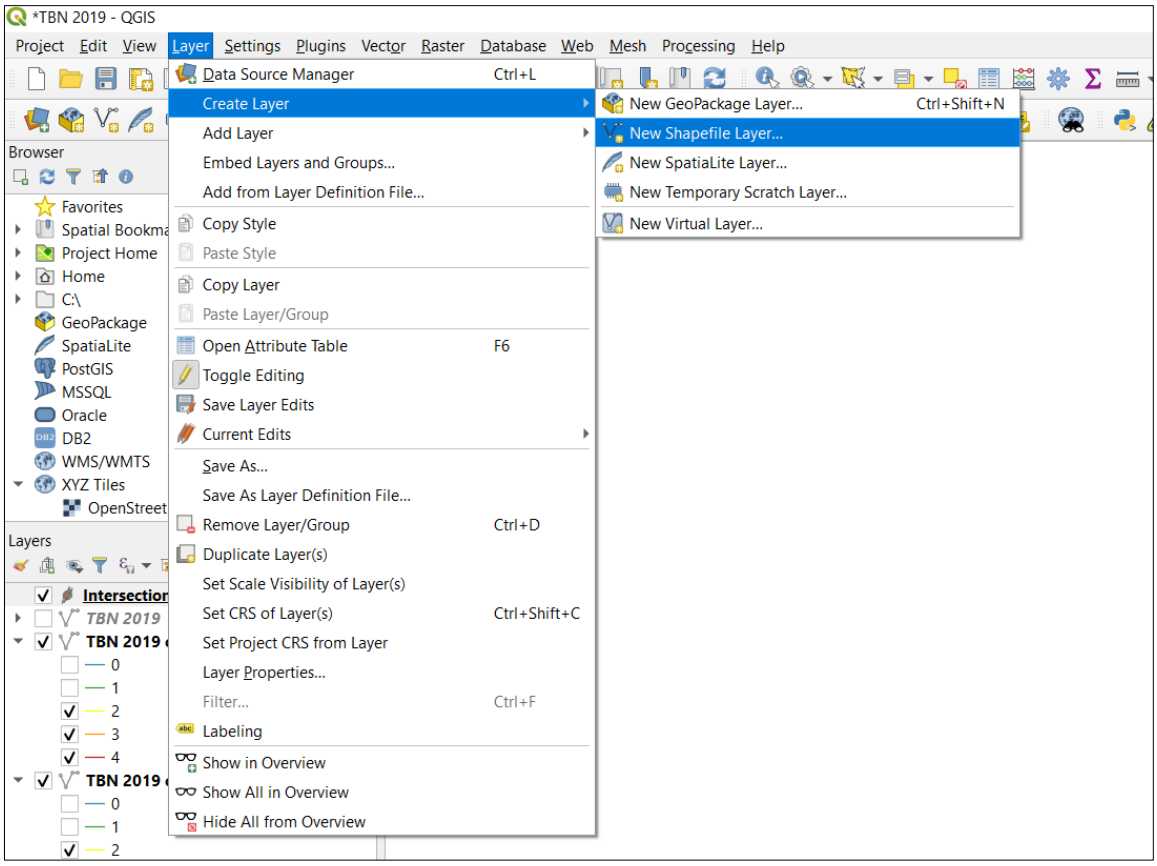
Figure 5.37: Class A and B Road Network Under LOC 2 to 4

5.4 Identification of Traffic Bottlenecks

(1) Intersection

The intersections with at least one inflow link categorized as LOC 3 to 4 are considered as "Traffic Bottlenecks (TBN)." Moreover, the 17 LGUs and MMDA determined intersection traffic bottlenecks by considering road classification and traffic conditions during peak hours. The following steps describes how to add an intersection based on the criteria mentioned above and how to add for other fields for the database.

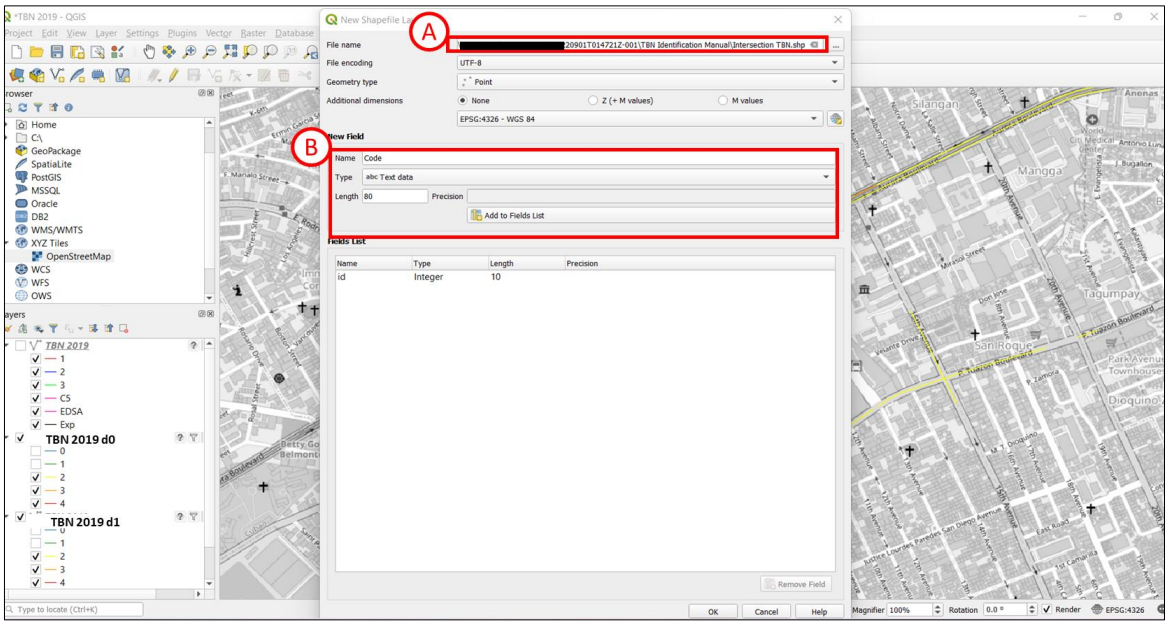
(a) Click "Layer" -> "Create Layer" -> "New Shape Layer."



Source: JPT

Figure 5.38: Creating an Intersection TBN Layer

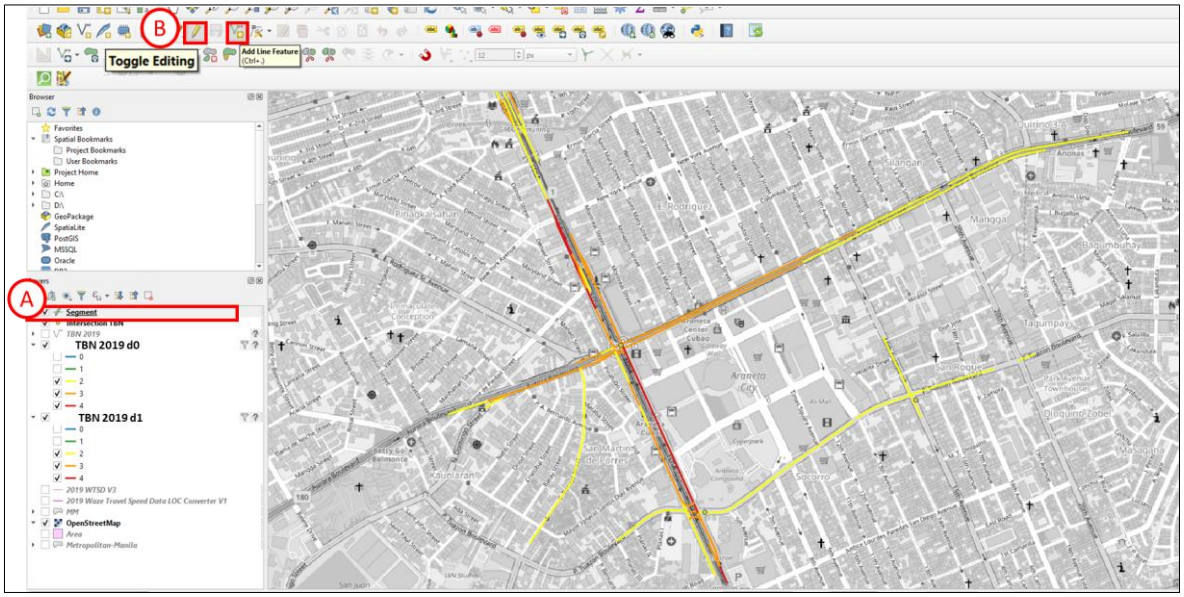
(b) A: Locate where you want to save the new shape layer by filling-out the file name. Save file name as "Intersection TBN" B: Add an filed or column by typing "Code" below "New Field", select data type, and click "Add to Field List". Repeat Step B and add "LGU" and "IntType".



Source: JPT

Figure 5.39: Saving Point Shape File

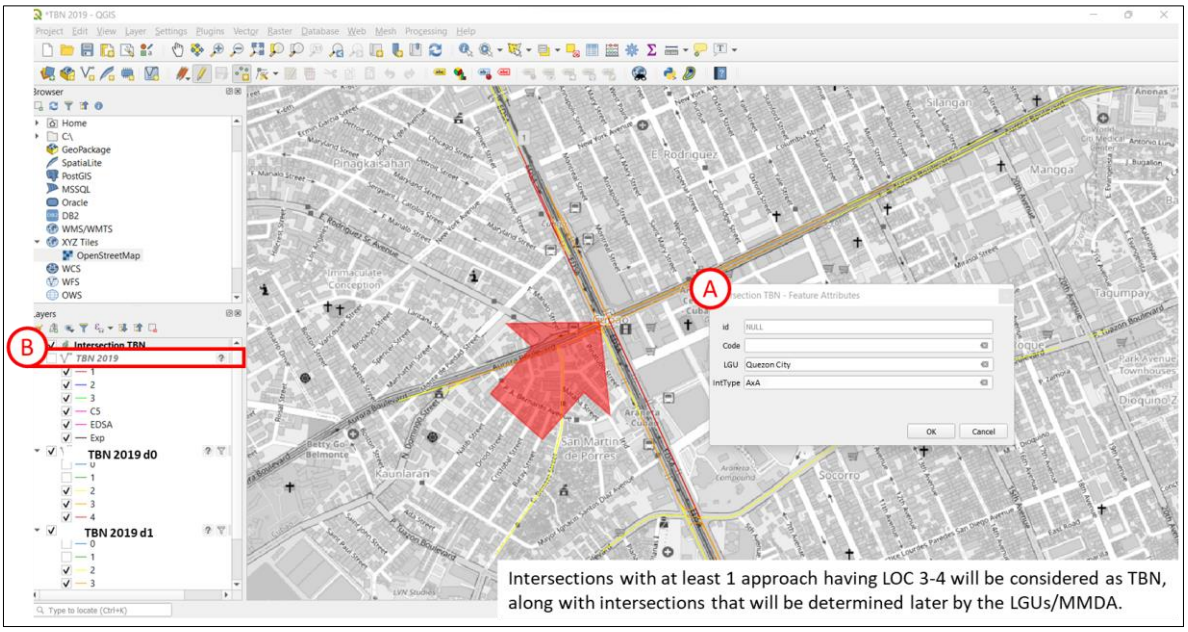
(c) A: Select “Intersection TBN”. B: Click “Toggle Editing” and then “Add Point Feature”.



Source: JPT

Figure 5.40: Toggle Editing

(d) A: Select intersection TBN on the map based on LOC criteria and LGU-MMDA recommendations. Then, input the LGU on the pop-up tab that will appear. B: Select “TBN 2019” and unselect “TBN 2019 d0 and TBN 2019 d1” to determine the “IntType”.

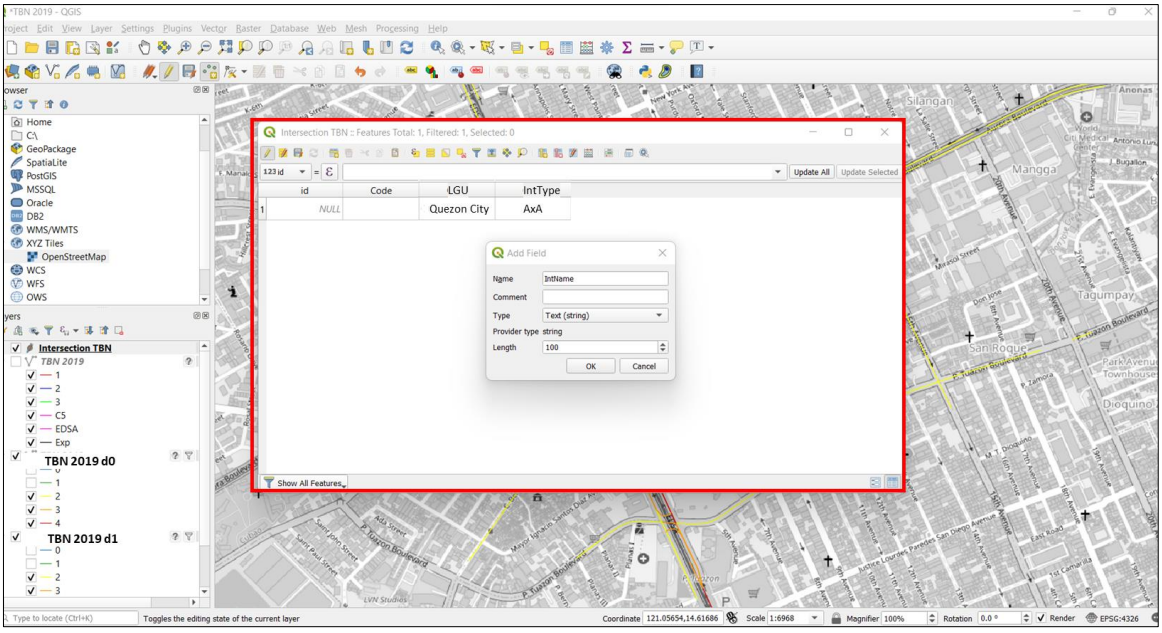


Source: JPT

Figure 5.41: Creating a Point

(e) After creating all the points/intersections, name the codes by Intersection LGU (A-Z), then Intersection Type (AxA – BxB). Example: QC22.

(f) Add other fields by right-clicking “Intersection TBN”, selecting “Attribute table”, clicking “New field”, typing the Name of the field or column and selecting the field Type. Save and click “Toggle editing mode” to lock the changes.



Source: JPT

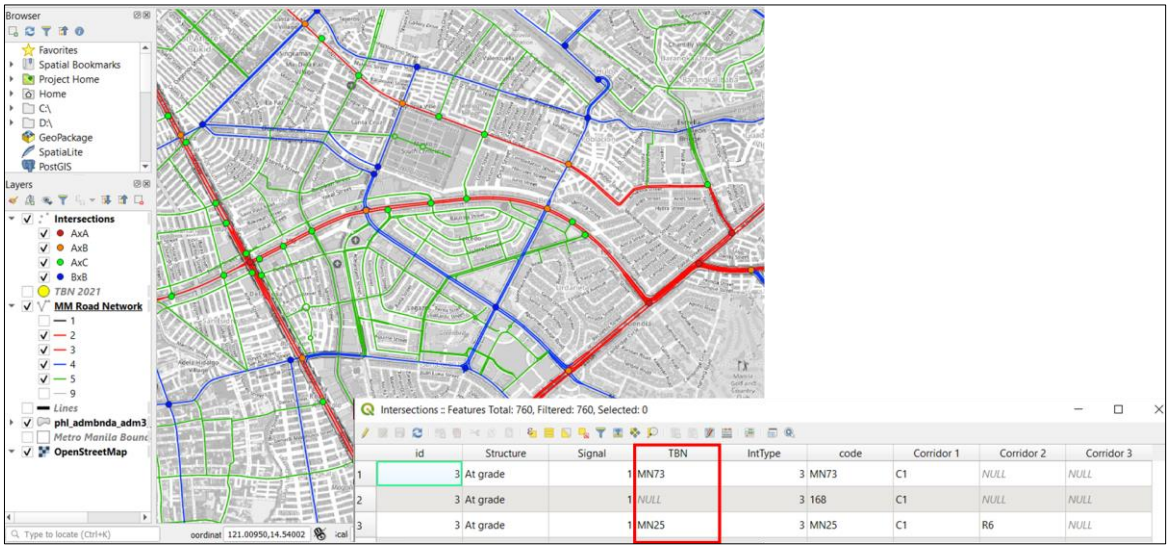
Figure 5.42: Intersection TBN Attribute Table

The following are other fields to add after data collection:

- Intersection Name (IntName), Text
- LGU, Text
- Intersection Type (IntType), Text (i.e. AxA, AxB, AxC, BxB)

- Structure, Text (i.e. At-grade/Segregated)
- Number of Legs (Legs), Whole Number
- X Coordinate (X), Decimal
- Y Coordinate (Y), Decimal
- Segment TBN, Whole Number
- Area TBN, Text
- PUV Stop, Whole Number (i.e. 1-Yes, 0-No)
- Corridor, Text (e.g. C4, C5, R10)
- Signal, Whole Number (i.e. 1-Yes, 0-No)
- Signal Type, Whole Number
  - 1 – At-grade, Unsignalized
  - 2 – Segregated, Unsignalized
  - 3 – At-grade, Signalized
  - 4 – Segregated, Signalized
- Crossing Conflict (Crossing), Whole Number
- Merging (Crossing), Whole Number
- Diverging (Crossing), Whole Number
- AutoCAD, Whole Number (i.e. 1-Yes, 0-No)
- Volume Count, Whole Number (i.e. 1-Yes, 0-No)

The JPT has predetermined intersections (target intersections) under AxA, AxB, AxC, and BxB class. These points may be used as a base data for TBN maps. The “TBN” field requires the code of the intersection. Both points and fields may be added to this shape file.



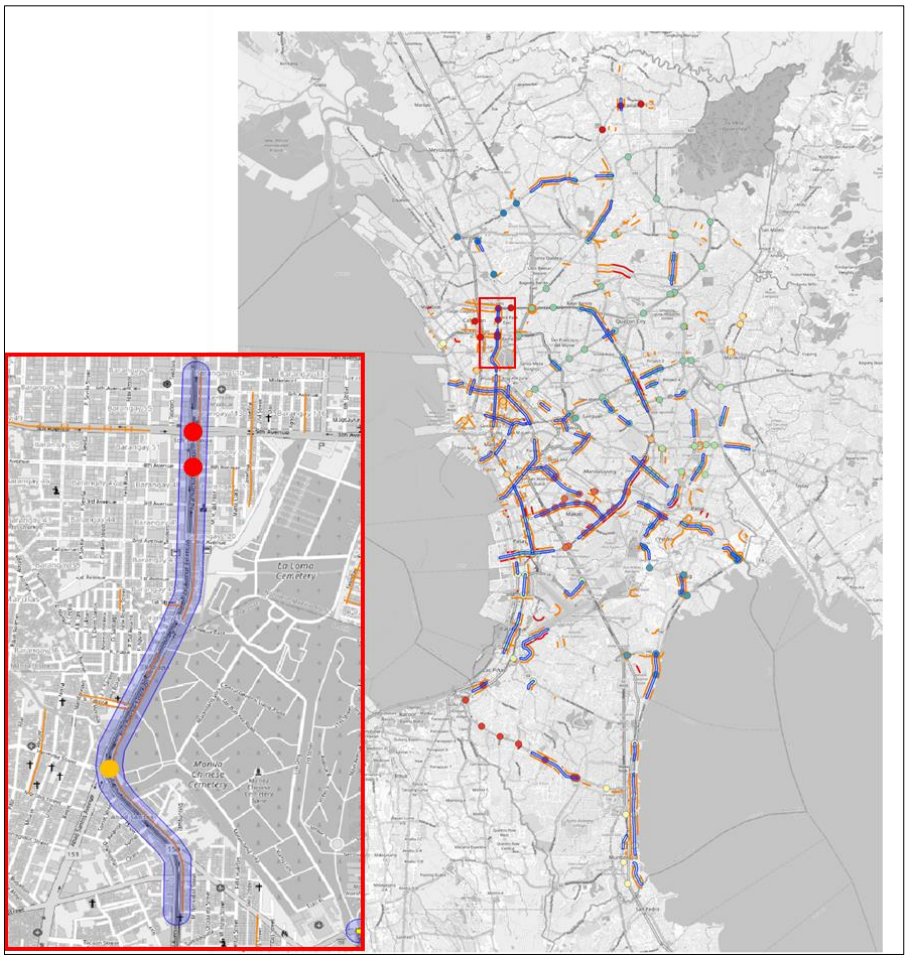
Source: JPT

Figure 5.43: Target Intersections

(2) Segment

A segment TBN is a road segment with at least one (1) intersection TBN that overlaps with links having LOC 3 to 4. The length of the segment is identified by the continues links with

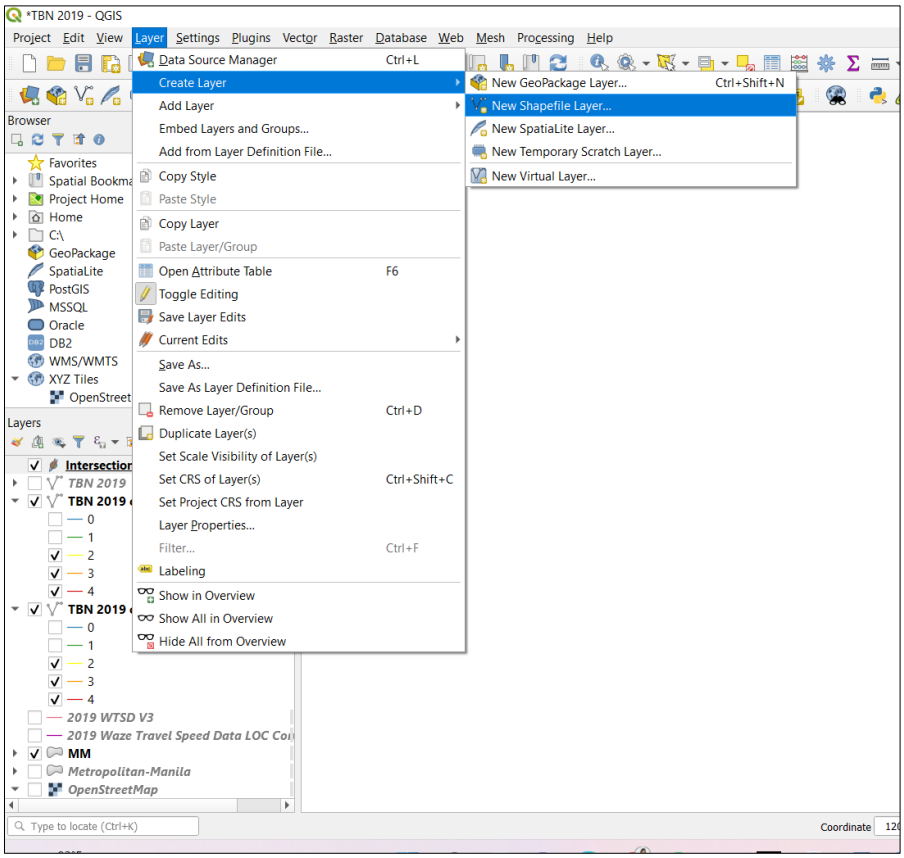
LOC 3 to 4 on either side of the road. LOC 3 to 4 links disconnected by less than 100-meter distance shall still be considered as part of the segment. And, segment TBN should have a length equal to or more than 500 meters.



Source: JPT

Figure 5.44: Segment TBN Criteria

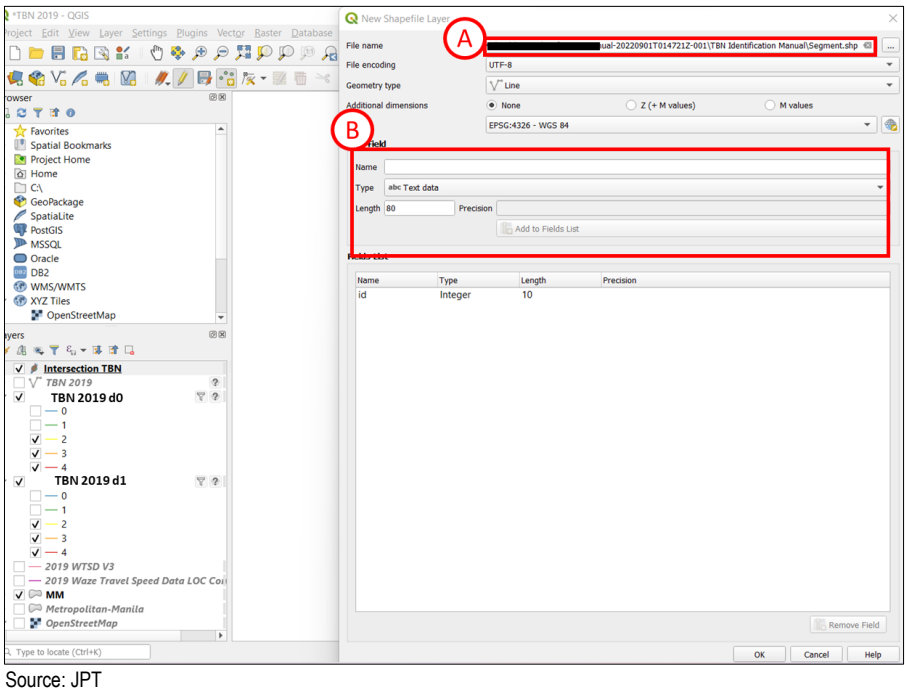
(a) Click “Layer” -> “Create Layer” -> “New Shape Layer.”



Source: JPT

Figure 5.45: Creating a Segment TBN Layer

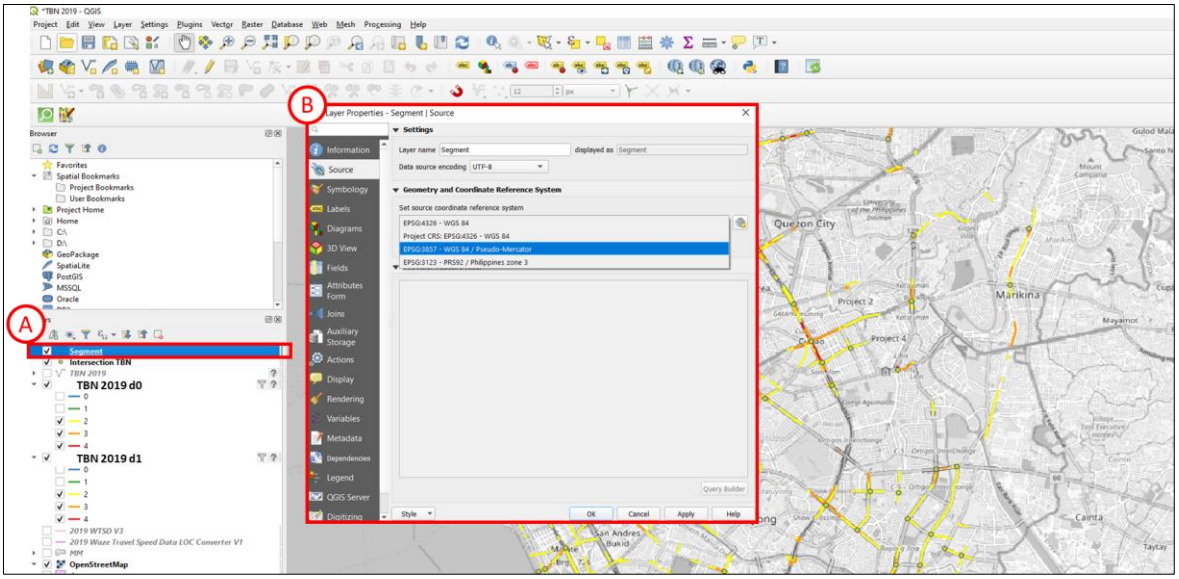
(b) A: Locate where you want to save the new shape layer by filling-out the “File Name”. B: Add an attribute or column by typing desired name, select data type, and click “Add to Field List”.



Source: JPT

Figure 5.46: Saving Line Shape File

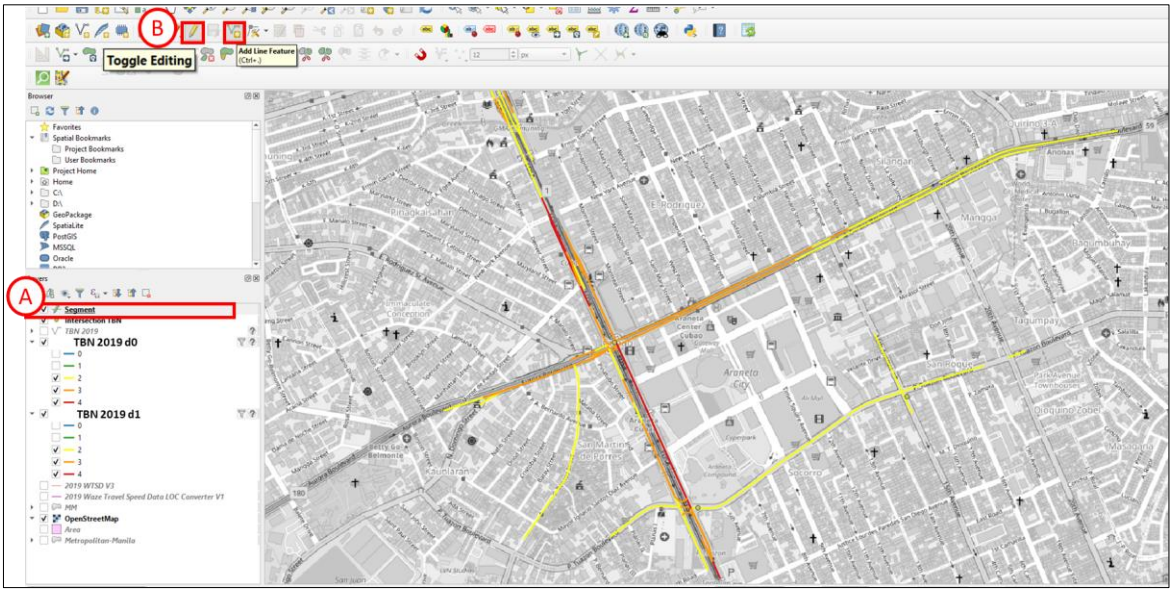
(c) A: Right click the Segment layer. B: Change the source of the layer to EPSG:3857



Source: JPT

Figure 5.47: Setting Coordinate System of Segment TBN

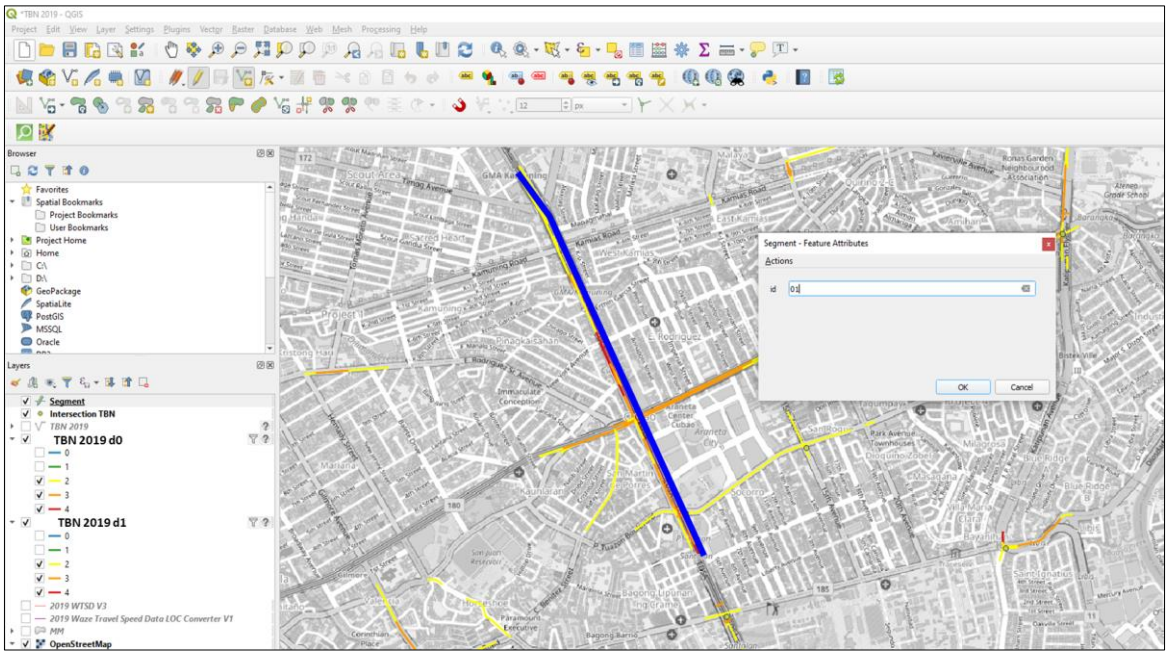
(d) A: Select “Segment TBN”. B: Click “Toggle Editing” and then “Add Line Feature”.



Source: JPT

Figure 5.48: Toggle Editing

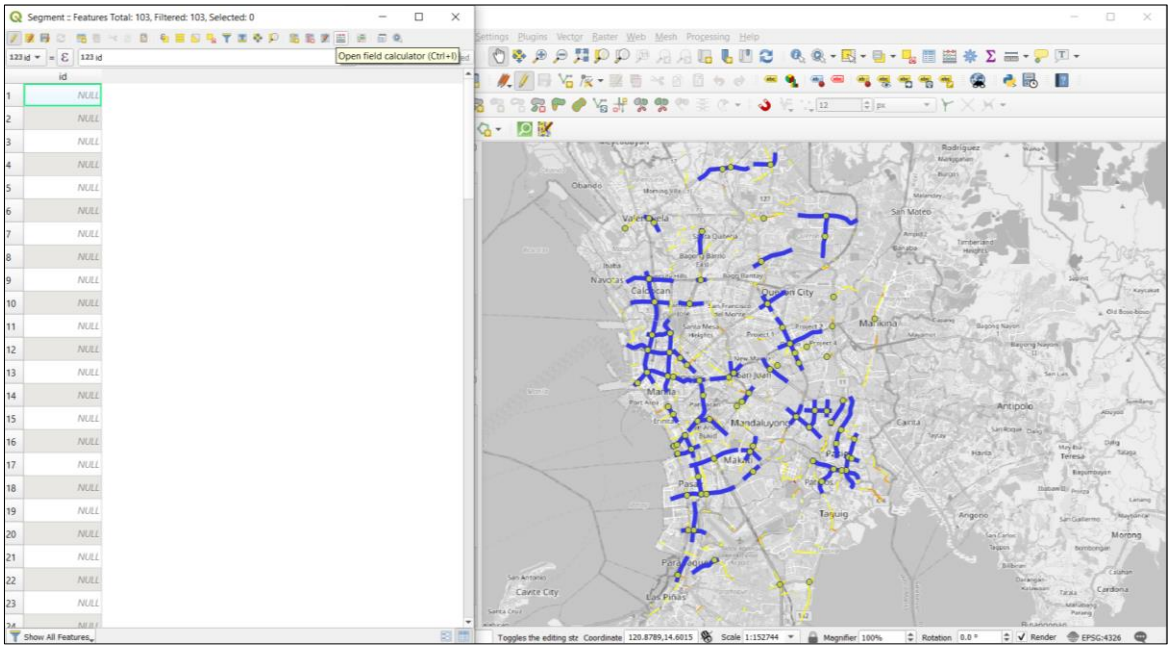
(e) Trace the segment based on the given criteria and right-click. Fill-out necessary information. Add other fields by right-clicking “Segment”, selecting “Attribute table”, clicking “New field”, typing the Name of the field or column and selecting the field Type.



Source: JPT

Figure 5.49: Creating Line for Segment TBN

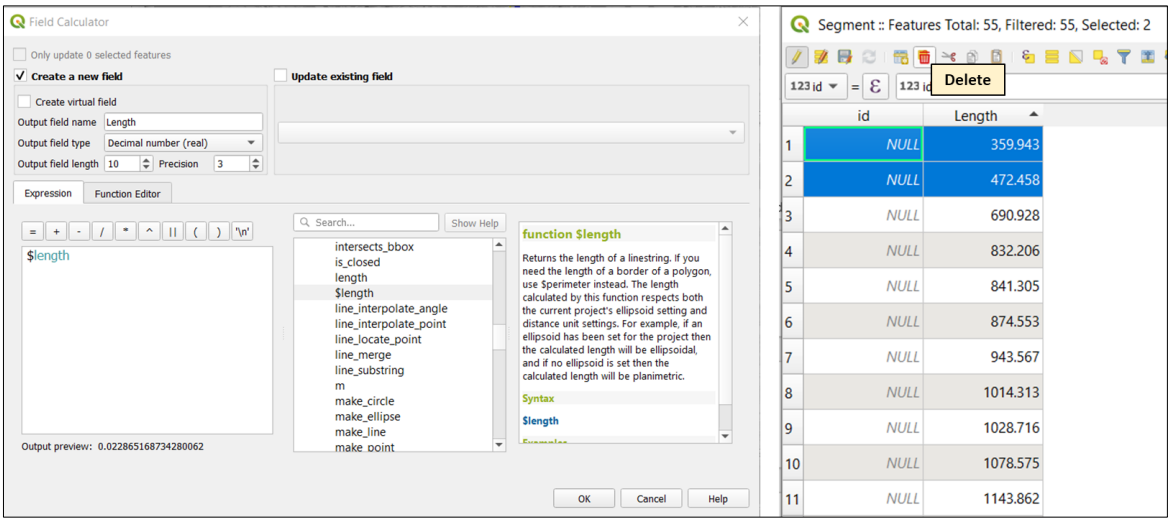
(f) Open attribute table -> Click “Toggle editing mode” -> “Open filed calculator”.



Source: JPT

Figure 5.50: Attribute Table of Segment TBN

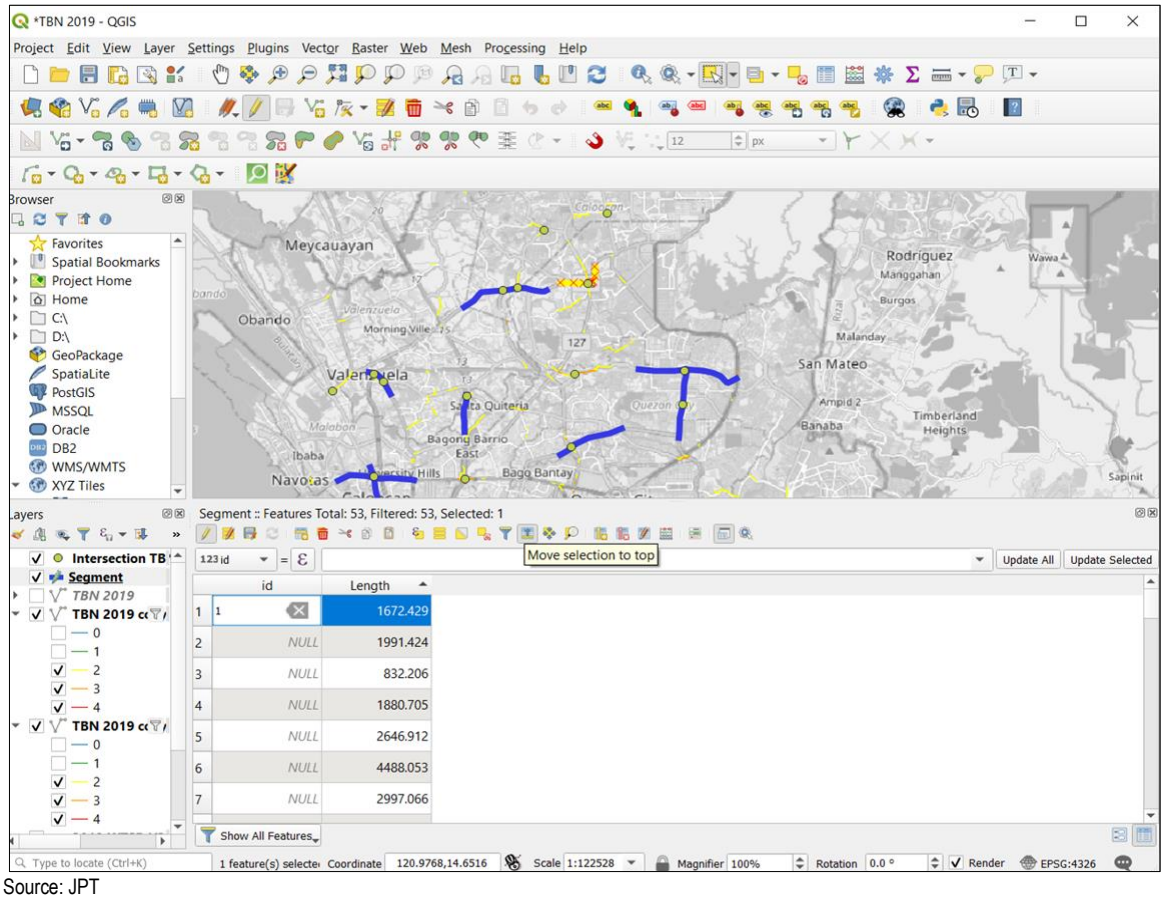
(g) A: Type “Length” beside Output field name -> Select “Decimal” from Output field type -> Double click or type “$length” under “Geometry”. B: Open attribute table -> Click “Toggle editing mode” -> Double click on the “Length” field to sort from smallest to biggest -> Highlight the lengths less than 500 m -> Click “Delete” and save.



Source: JPT

Figure 5.51: Computing for Segment TBN Length

(h) Name segments from North to South. Click “Dock Attribute Table” -> Click “Move selection to top” -> Select the Segment from North to South and type Segment number on “id” field.



Source: JPT

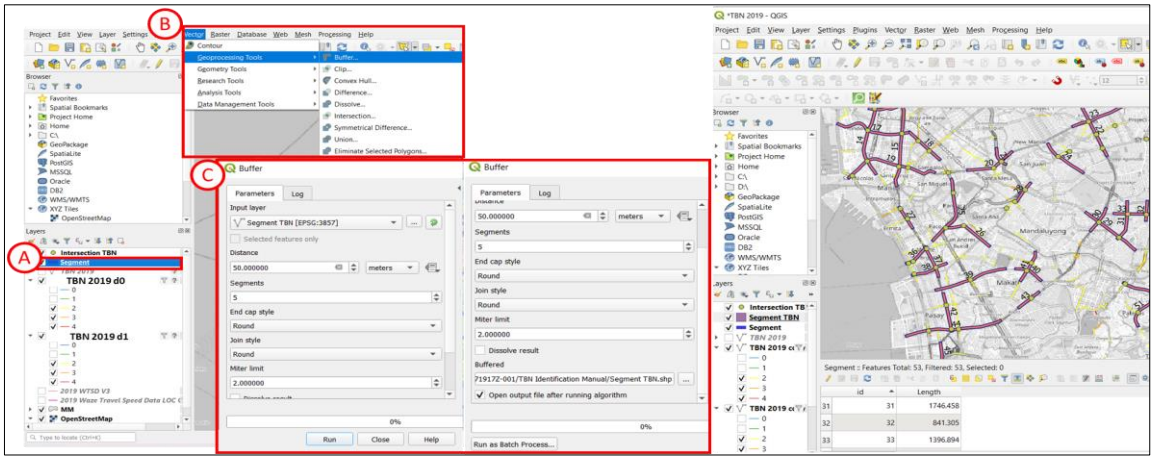
Figure 5.52: Naming Segment TBNs

Add other fields by right-clicking “Segment”, selecting “Attribute table”, clicking “New field”, typing the Name of the field or column and selecting the field Type. Save and click “Toggle editing mode” to lock the changes.

Other fields to be added include:

- Road Name (RdName), Text
- Road Class (RdClass), Text (i.e. A, B, C, Others)

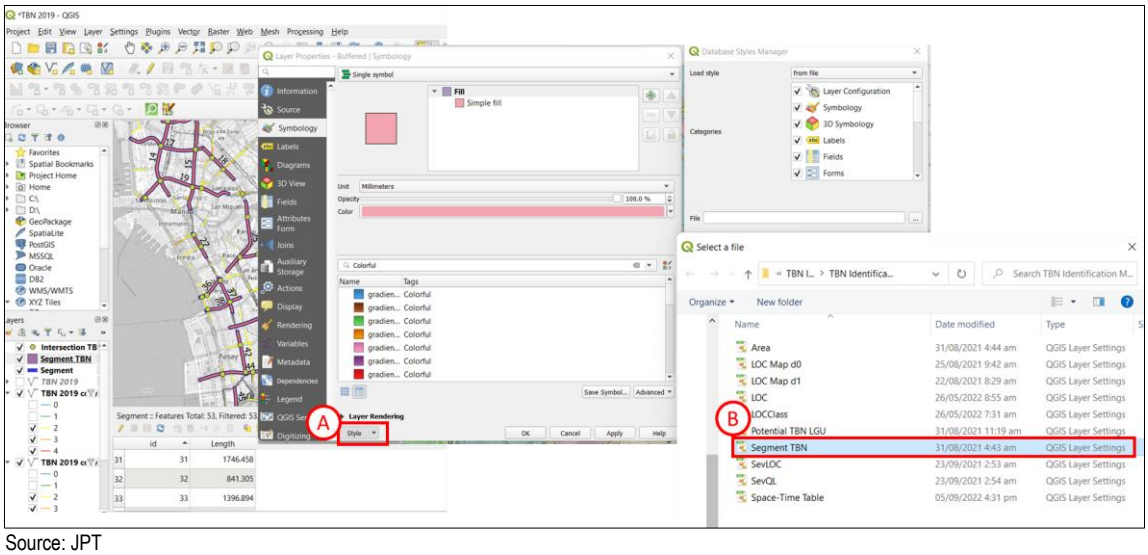
(i) To create a buffer, A: select “Segment”, B: click “Vector” -> “Geoprocessing Tools” -> “Buffer”. C: Select the layer “Segment TBN” and change “Distance = 50 meters” -> Go to “Buffered” -> Select “Save to File” -> Name it as Segment TBN -> Click “Run”.



Source: JPT

Figure 5.53: Creating a Buffer for Segment TBN

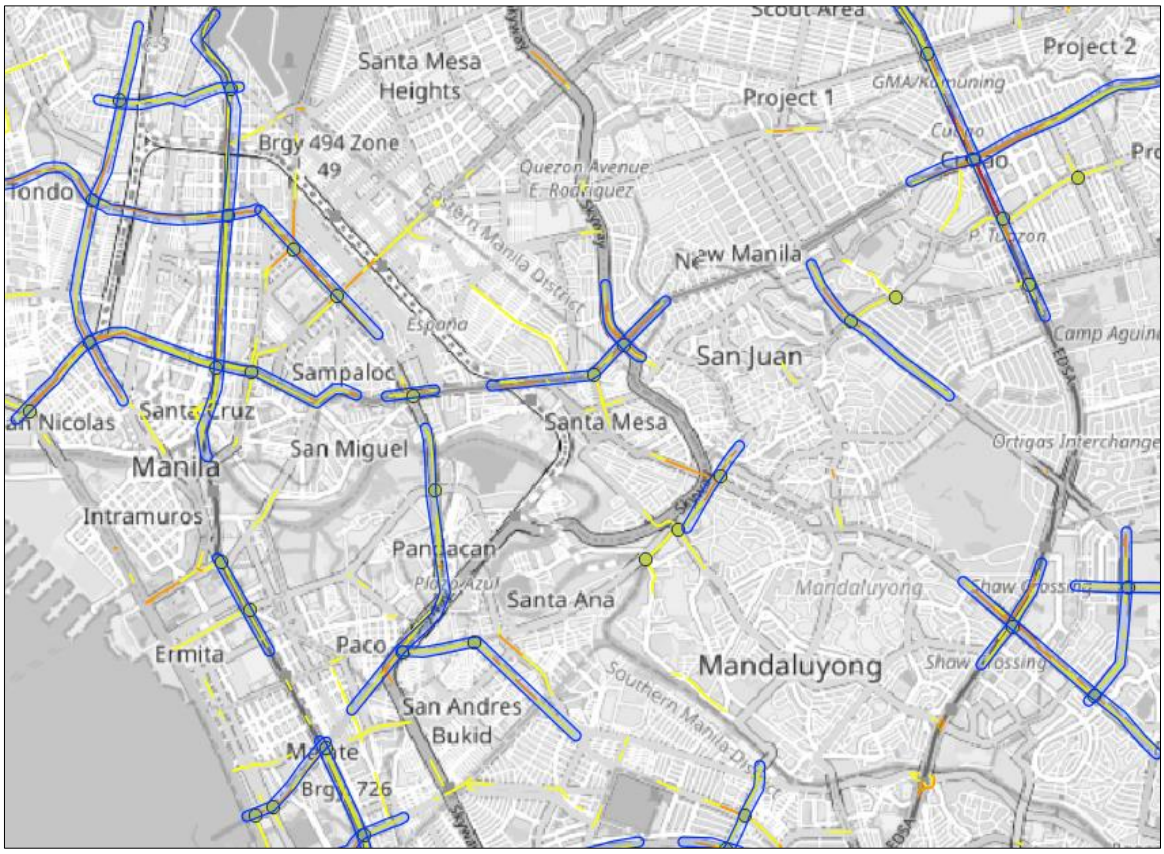
(j) hange the symbology of the buffer by opening the “Properties” and A: clicking “Style”. B: Select “Segment TBN”.



Source: JPT

Figure 5.54: Load Segment TBN Style

The map below shows the buffered segment TBNs (blue lines) that groups the intersection TBNs (yellow points).



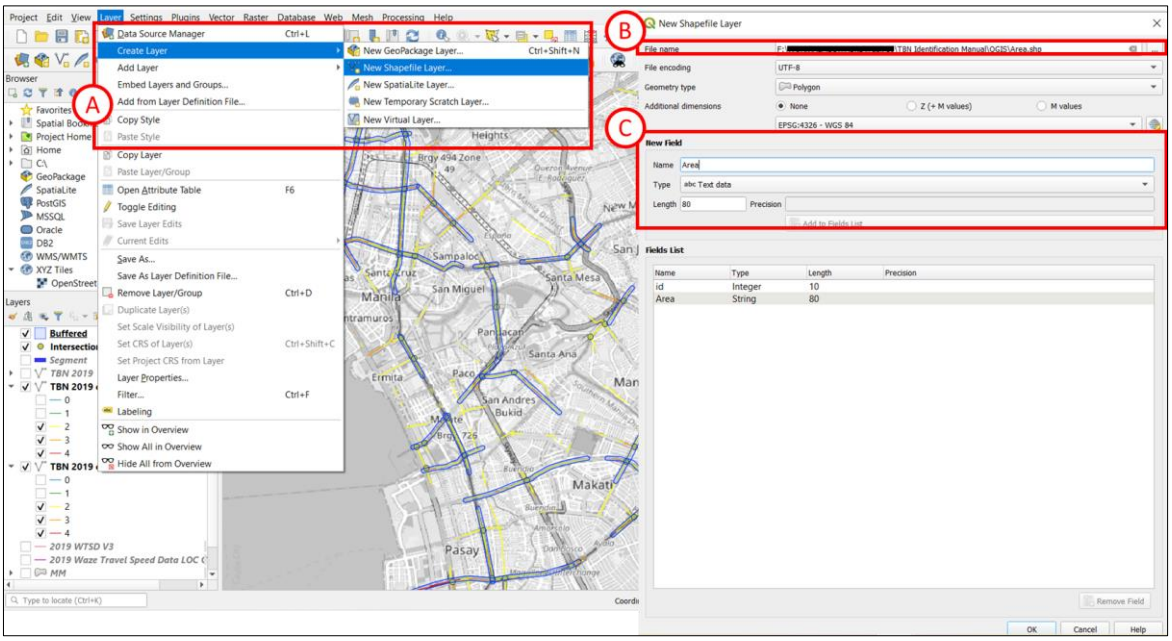
Source: JPT

Figure 5.55: Intersection and Segment TBNs with LOC Map

(3) Area

Area TBN further groups the segment and intersection TBNs for future project implementation. Saturated regions of the map with LOC 3 to 4 links, and intersection and segment TBNs comprise this TBN. It should be noted that relationship, distance, and local ordinances between intersection and segment TBNs should be considered in grouping them. The steps below show how to create a polygon for area TBNs.

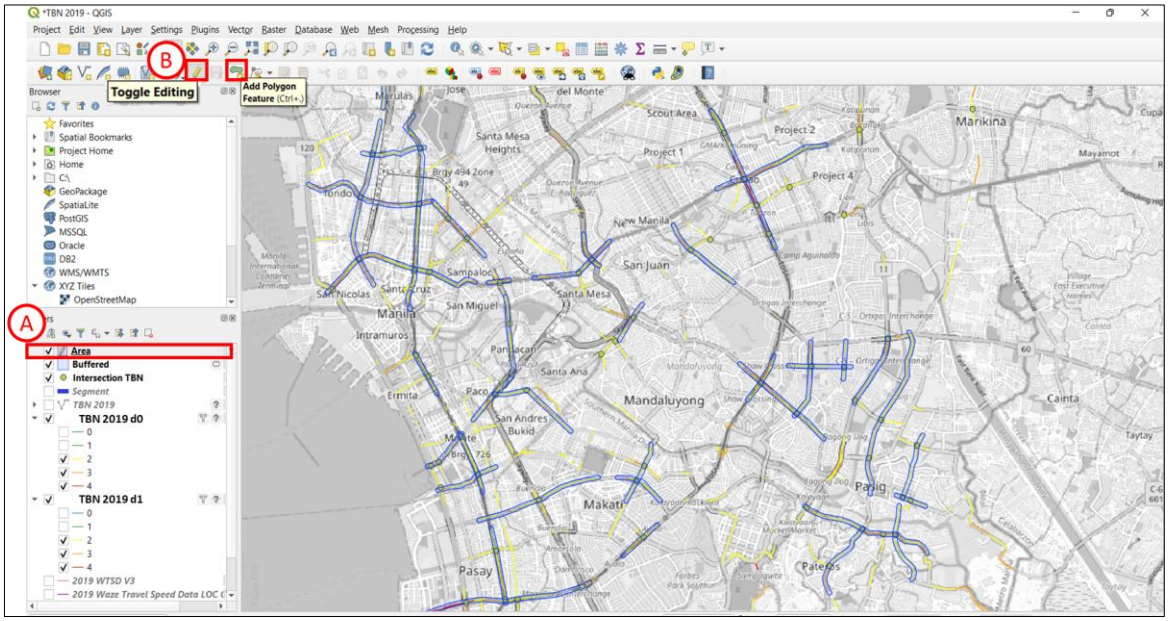
(a) A: Click “Layer” -> “Create Layer” -> “New Shape Layer.” B: Locate where you want to save the new shape layer by filling-out the “File Name”. C: Add an attribute or column by typing desired name, select data type, and click “Add to Field List”.



Source: JPT

Figure 5.56: Creating an Area Shape File

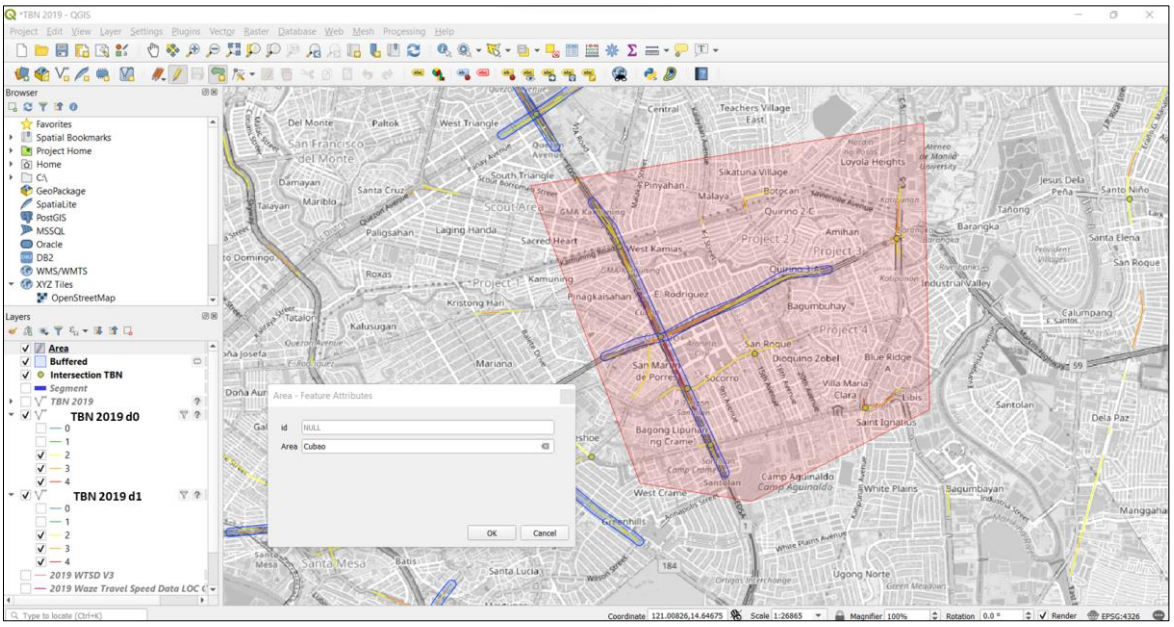
(b) A: Select “Area”. B: Click “Toggle Editing” and then “Add Polygon Feature”.



Source: JPT

Figure 5.57: Toggle Editing

(c) Draw a polygon following the criteria for area and fill-out information in the pop-up box that will appear. Add other fields by right-clicking “Area”, selecting “Attribute table”, clicking “New field”, typing the Name of the field or column and selecting the field Type.



Source: JPT

Figure 5.58: Adding Area TBN Data

APPENDIX

Method of Data Collection and Longlist

The Project for Comprehensive Traffic Management Plan for Metro Manila

Data Collection

CTMP Database Training

September 2022

JICA Project Team

V.A Data Collection

- I. Road Classification
- II. Metro Manila Waze Data Dashboard
- III. Application of Waze Travel Speed Data
- IV. Identification of TBNs (Intersection, Segment, Area)
- V.A Data Collection → V.B MS Access
- VI. Prioritizing Major Intersection TBNs
- VII.A Factor of Congestion and Countermeasures → VII.B Application of Space-Time Table
- VIII. Road Inventory → LOC Criteria Development
- IX. Corridor Database
- X. Corridor Profile

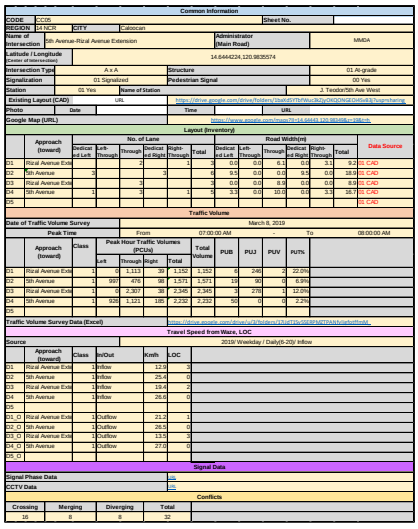
VI.A. DATA COLLECTION

OUTLINE

1. Datasheet Information
2. Datasheet 1
   a. Contents
   b. Common Information
   c. Layout Inventory
   d. Traffic Volume
3. Datasheet 2
   a. Contents
   b. Site Survey
      i. Objectives
      ii. Ideal Workflow
      iii. Methodology
      iv. Summary
4. Longlist

1. DATASHEET INFORMATION

Datasheet 1



Common Information					
CODE	CC05			Sheet No.	
REGION	14 NCR	CITY	Caloocan		
Name of Intersection	5th Avenue-Rizal Avenue Extension		Administrator (Main Road)	MMDA	
Latitude / Longitude (Center of Intersection)	14.644234,120.983574				
Intersection Type	A x A		Structure	01 At-grade	
Signalization	01 Signalized		Pedestrian Signal	00 Yes	
Station	01 Yes	Name of Station		J. Teodoro/5th Ave West	
Existing Layout (CAD)	URL				
Photo	Date		Time	URL	
Google Map (URL)					

Layout Inventory

	Approach (toward)	No. of Lane: Dedicated Left	Left Through	Through	Right Through	Dedicated Right	Total	Road Width(m): Dedicated Left	Left Through	Through	Right Through	Dedicated Right	Total	Data Source
01	Rizal Avenue Exte			3		1	3	0.0	0.0	6.1	0.0	3.1	9.2	01 CAD
02	5th Avenue		1		3		4	0.0	6.5	0.0	0.0	5.5	12.0	01 CAD
03	Rizal Avenue Exte			3			3	0.0	0.0	8.9	0.0	0.0	8.9	01 CAD
04	5th Avenue	1		3		1	5	3.3	0.0	10.0	0.0	3.3	16.7	01 CAD
05														01 CAD

Traffic Volume

Date of Traffic Volume Survey	March 8, 2019										
Peak Time	From	07:00:00 AM	To	08:00:00 AM							

	Approach (toward)	Class	Peak Hour Traffic Volumes (PCUs): Left	Through	Right	Total	Total Volume	PUB	PUJ	PUV	PUTs
01	Rizal Avenue Exte	1	0	1,113	39	1,152	1,152	9	246	2	22.0%
02	5th Avenue	1	997	476	98	1,571	1,571	19	90	0	6.9%
03	Rizal Avenue Exte	1	0	2,307	38	2,345	2,345	5	278	1	12.0%
04	5th Avenue	1	926	1,121	185	2,232	2,232	50	0	0	2.2%
05											

Traffic Volume Survey Data (Excel)

Travel Speed from Waze, LOC

Source: 2019/ Weekday / Daily(5-20)/ Inflow

	Approach (toward)	Class	In/Out	Km/h	LOC
01	Rizal Avenue Exte	1	Inflow	12.9	3
02	5th Avenue	1	Inflow	25.4	0
03	Rizal Avenue Exte	1	Inflow	19.4	2
04	5th Avenue	1	Inflow	26.6	0
05					
01_O	Rizal Avenue Exte	1	Outflow	21.2	1
02_O	5th Avenue	1	Outflow	28.5	0
03_O	Rizal Avenue Exte	1	Outflow	13.5	3
04_O	5th Avenue	1	Outflow	27.6	0
05_O					

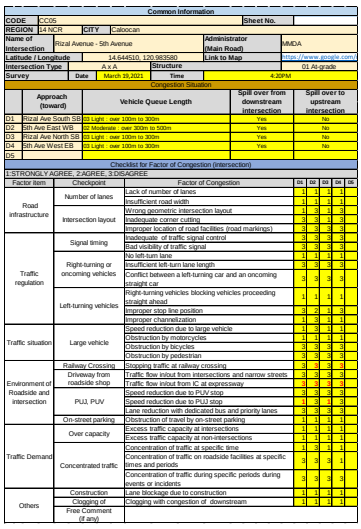
Signal Data

Signal Phase Data	no
CCTV Data	no

Conflicts

Crossing	Merging	Diverging	Total
16	8	8	32

Datasheet 2



Common Information					
CODE	CC05			Sheet No.	
REGION	14 NCR	CITY	Caloocan		
Name of Intersection	Rizal Avenue - 5th Avenue		Administrator (Main Road)	MMDA	
Latitude / Longitude	14.644510, 120.983580		Link to Map	https://www.google.com/	
Intersection Type	A x A		Structure	01 At-grade	
Survey	Date	March 19,2021	Time	4:30PM	

Congestion Situation

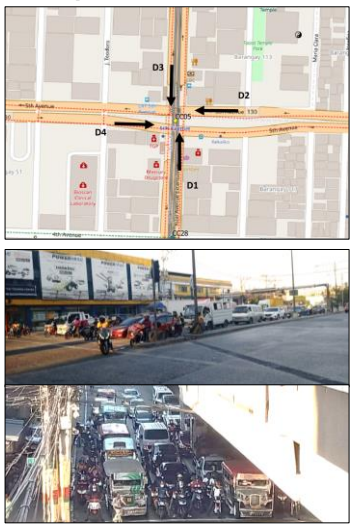
	Approach (toward)	Vehicle Queue Length	Spill over from downstream intersection	Spill over to upstream intersection
D1	Rizal Ave South SB	03 Light : over 100m to 300m	Yes	No
D2	5th Ave East WB	02 Moderate : over 300m to 500m	Yes	No
D3	Rizal Ave North SB	03 Light : over 100m to 300m	Yes	No
D4	5th Ave West EB	03 Light : over 100m to 300m	Yes	No
D5				

Checklist for Factor of Congestion (Intersection)

1:STRONGLY AGREE, 2:AGREE, 3:DISAGREE

Factor Item	Checkpoint	Factor of Congestion	D1	D2	D3	D4	D5
Road infrastructure	Number of lanes	Lack of number of lanes	1	1	1	1	
		Insufficient road width	1	1	1	1	
	Intersection layout	Wrong geometric intersection layout	1	2	1	2	
		Inadequate corner cutting	3	3	1	3	
Traffic regulation	Signal timing	Improper location of road facilities (road markings)	3	3	3	3	
		Inadequate of traffic signal control	3	3	3	3	
		Bad visibility of traffic signal	3	3	3	3	
	Right-turning or oncoming vehicles	No left-turn lane	1	1	1	1	
		Insufficient left-turn lane length	3	3	3	3	
		Conflict between a left-turning car and an oncoming straight car	3	3	3	3	
	Left-turning vehicles	Right-turning vehicles blocking vehicles proceeding straight ahead	1	1	1	1	
		Improper stop line position	3	2	1	3	
		Improper channelization	1	3	1	1	
Traffic situation	Large vehicle	Speed reduction due to large vehicle	1	3	1	1	
		Obstruction by motorcycles	1	1	1	1	
		Obstruction by bicycles	3	3	3	3	
		Obstruction by pedestrian	3	3	3	3	
Environment of Roadside and intersection	Railway Crossing	Stopping traffic at railway crossing	3	3	3	3	
	Driveway from roadside shop	Traffic flow in/out from intersections and narrow streets	3	3	3	3	
		Traffic flow in/out from IC at expressway	3	3	3	3	
	PUJ, PUV	Speed reduction due to PUV stop	3	3	3	3	
		Speed reduction due to PUJ stop	3	3	3	3	
		Lane reduction with dedicated bus and priority lanes	3	3	3	3	
	On-street parking	Obstruction of travel by on-street parking	1	1	1	1	
Traffic Demand	Over capacity	Excess traffic capacity at intersections	1	1	1	1	
		Excess traffic capacity at non-intersections	1	1	1	1	
	Concentrated traffic	Concentration of traffic at specific time	1	2	1	1	
		Concentration of traffic on roadside facilities at specific times and periods	3	3	3	1	
		Concentration of traffic during specific periods during events or incidents	3	3	3	3	
Others	Construction	Lane blockage due to construction	1	1	1	1	
	Clogging of	Clogging with congestion of downstream	1	1	1	1	
	Free Comments (if any)						

Map and Actual Photos



2.a. DATASHEET 1: Contents

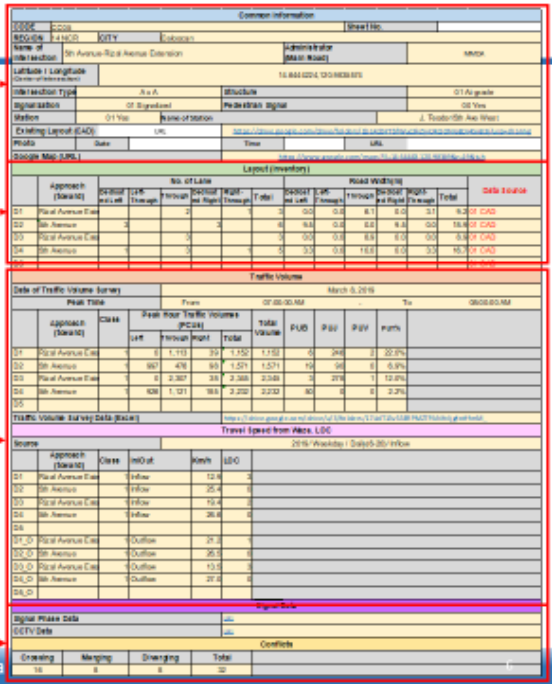
- Contains information to support the site surveys.
- Can be accomplished by desk work.

Basic Information

Layout/Inventory Information
- No. of Lanes
- Road Width

Traffic Data
- Traffic count per approach
- Traffic counter per PUV type
- Waze Speed data and LOC

Additional Information
- Traffic Signal and CCTV data (drive links)
- No. of conflicts



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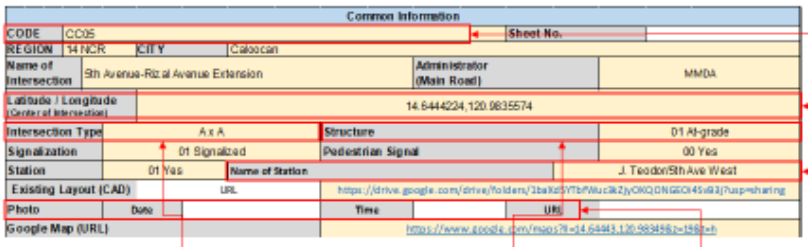
2.b. DATASHEET 1: Common Information



CODE
- Unique ID for each TBN

- **Latitude/Longitude**
- XY coordinates

Name of Station
- Name of railway station if present

Date of Survey
- **Time** of Survey
- Google drive **URL** of survey photos

Intersection Type
- Based on road class:
  - A: Primary
  - B: Secondary
  - C: Tertiary

Structure
- A: Primary
- B: Secondary
- C: Tertiary
- Based on road class

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2.c. DATASHEET 1: Layout (Inventory)

Layout (Inventory)

	Approach (toward)	No. of Lane						Road Width(m)						Data Source
		Dedicated Left	Left-Through	Through	Dedicated Right	Right-Through	Total	Dedicated Left	Left-Through	Through	Dedicated Right	Right-Through	Total	
D1	Rizal Avenue Exte			2		1	3	0.0	0.0	6.1	0.0	3.1	9.2	01 CAD
D2	5th Avenue	3			3		6	9.5	0.0	0.0	9.5	0.0	18.9	01 CAD
D3	Rizal Avenue Exte			3			3	0.0	0.0	8.9	0.0	0.0	8.9	01 CAD
D4	5th Avenue	1		3		1	5	3.3	0.0	10.0	0.0	3.3	16.7	01 CAD
D5														01 CAD

Approach
- Road name per approach

No. of Lanes
- No. per movement
- If there is no dedicated movement direction, count as "through"

Road Width
- Carriageway width per approach

Data Source
- Source of inventory data
  - 01 CAD
  - 02 Assumption from street view
  - 03 DPWH Atlas
  - 04 Inventory Survey
  - 05 Others

2.d. DATASHEET 1: Traffic Volume

Traffic Volume

Date of Traffic Volume Survey	March 8, 2019
Peak Time	From 07:00:00 AM - To 08:00:00 AM

	Approach (toward)	Class	Peak Hour Traffic Volumes (PCUs)				Total Volume	PUB	PUJ	PUV	PUTN	
			Left	Through	Right	Total						
D1	Rizal Avenue Exte	1	0	1,113	39	1,152	1,152	6	246	2	22.0%	
D2	5th Avenue	1	997	476	98	1,571	1,571	19	90	0	6.9%	
D3	Rizal Avenue Exte	1	0	2,307	38	2,345	2,345	3	278	1	12.0%	
D4	5th Avenue	1	926	1,121	185	2,232	2,232	50	0	0	2.2%	
D5												

Traffic Volume Survey Data (Excel) https://drive.google.com/drive/u/3/folders/17tJdT15v55ERPMZTPANNdjgfotffmM_

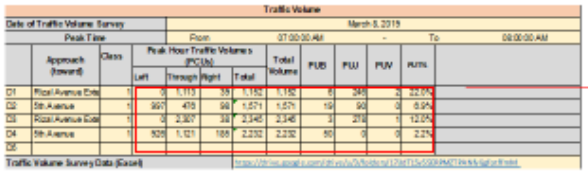
Date of Traffic Count Survey

Peak Time
- Get the higher total between the AM Peak and PM Peak

LOCATION: C-3 ROAD - RIZAL AVE. - 5th AVENUE
DATE OF SURVEY: FRIDAY, MARCH 08, 2019

FROM	4TH AVE.		6TH AVE.		A. MABINI AVE.			A. BONIFACIO AVE.			A. MABINI	A. BONIFACIO	Total
TO	6TH AVE.	A. BONIFACIO AVE.	4TH AVE.	A. MABINI AVE.	6TH AVE.	A. BONIFACIO AVE.	4TH AVE.	4TH AVE.	A. MABINI AVE.	5TH AVE.	U-TURN	U-TURN	
Time of Day	2	3	5	6	7	8	9	10	11	12	7a	10a	
0600 - 0700	1153	46	1802	60	152	908	122	553	449	53	521	125	6021
0700 - 0800	1113	39	2307	38	185	1121	185	829	476	98	741	168	7300
0800 - 0900	1105	24	1861	29	143	1398	153	889	425	62	426	142	6657
0900 - 1000	1422	52	1846	33	234	1018	131	925	447	115	449	125	6588
1000 - 1100	1243	60	1813	35	129	1111	139	964	405	50	151	138	6238
1100 - 1200	1307	44	1629	51	179	887	154	856	520	114	109	84	5725
1200 - 1300	1334	40	1653	40	155	859	169	703	521	90	81	71	5716
1300 - 1400	1271	55	1140	32	94	651	146	568	424	99	78	100	4658
1400 - 1500	1409	60	1612	58	167	716	143	734	428	138	127	65	5657
1500 - 1600	1425	55	1534	58	124	603	118	863	406	75	102	64	5427
1600 - 1700	1644	56	1672	82	138	734	162	751	426	87	136	89	5977
1700 - 1800	1617	50	1801	93	141	695	169	751	415	69	149	100	6070
1800 - 1900	1660	65	1702	98	134	743	196	707	470	128	195	90	6188
1900 - 2000	1558	54	1601	85	109	653	149	636	519	114	183	81	5742
TOTAL	19281	700	23773	792	2084	12097	2186	10629	6331	1289	3430	1442	84034

2.d. DATASHEET 1: Traffic Volume



Volume per approach and per PUV type

Traffic Count Data from MMDA

- Raw volume counts
- PCU values applied

Car	1.0
PUJ	1.5
UV	1.0
Taxi	1.0
PUB	2.2
Med. Truck	2.0
Lrg. Truck	2.5
Motorcycle	0.8
Tricycle	0.5
Bicycle	0.3

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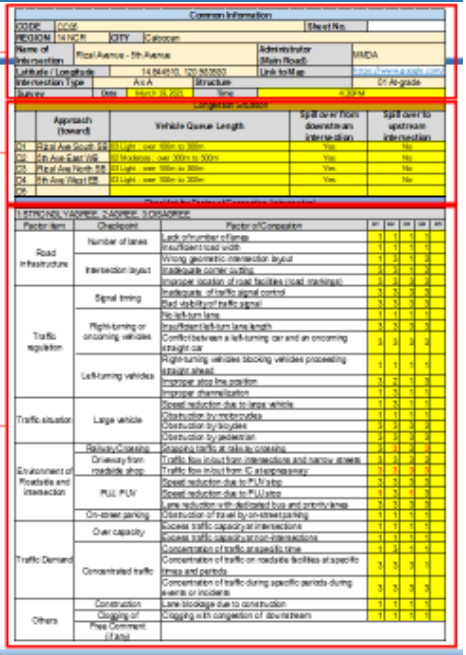
3.a. DATASHEET 2: Contents

Basic Information
- Code/ID
- Location
- Structure and Intersection Type

Congestion Situation
- Road name and direction per approach
- Queue Length
- Spillover upstream or downstream

Factors of Congestion (FOC)
- Traffic count per approach
- Traffic counter per PUV type
- Waze Speed data and LOC



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3.b. DATASHEET 2: Site Survey (Objectives)

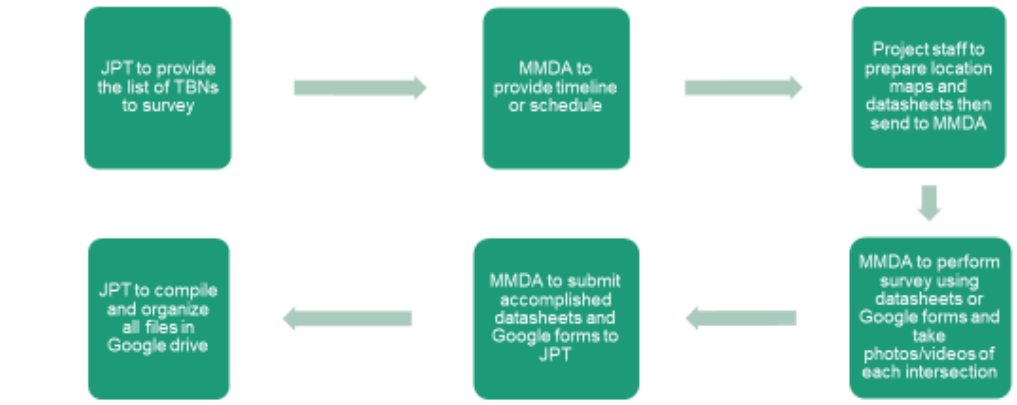
Objectives :

- To grasp the traffic situation for each potential Traffic Bottlenecks (TBNs)
- To find the factor/cause of traffic congestion at each TBNs

- Based on the site observation and data, countermeasures against traffic congestion will be initially considered and incorporated into CTMP
- MMDA can do the series of activities by themselves sustainably

3.b. DATASHEET 2: Site Survey (Ideal Workflow)

Ideal Workflow



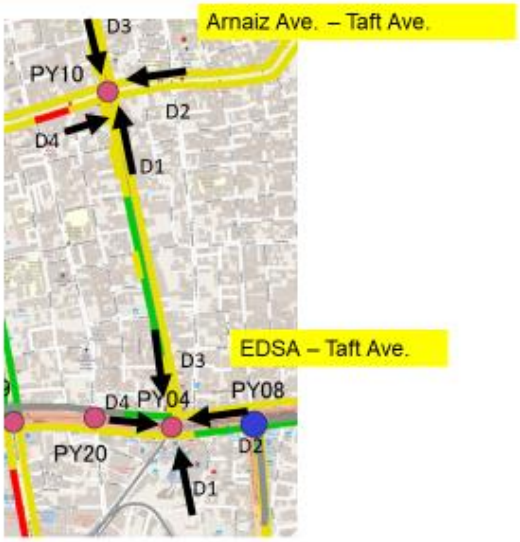
3.b. DATASHEET 2: Site Survey (Methodology)

Trial Sites

Two trial sites were considered before the actual survey.

This will help identify possible problems and concerns to address them accordingly.

There are many complicated intersections in Metro Manila that JPT would like to investigate. The project team will provide each map with corresponding direction labels.



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3.b. DATASHEET 2: Site Survey (Methodology)

Sample Intersections

MK50: EDSA - Magallanes

Location:
- Makati City

Remarks:
- Elevated intersection

Since it is difficult to consider the solution at elevated intersections such as flyover and underpass, focus on the merging points, especially at-grade.

For D1 and D2, surveyors need to observe from MRT Magallanes footbridge.

The Project for Comprehensive Traffic Management Plan for Metro Manila 15

3.b. DATASHEET 2: Site Survey (Methodology)

Sample Intersections

MN02: Mel Lopez Blvd. - C.M. Recto - Delpan St.

Location:
- City of Manila

Remarks:
- 6-legged intersection
- Consider only the specified directions for the survey (higher class roads)

The Project for Comprehensive Traffic Management Plan for Metro Manila 16

3.b. DATASHEET 2: Site Survey (Methodology)

Sample Intersections

SJ02: Ortigas Avenue – Wilson

Location:
- San Juan City

Remarks:
- Presence of service road
- Maybe service road may be considered for D3 only

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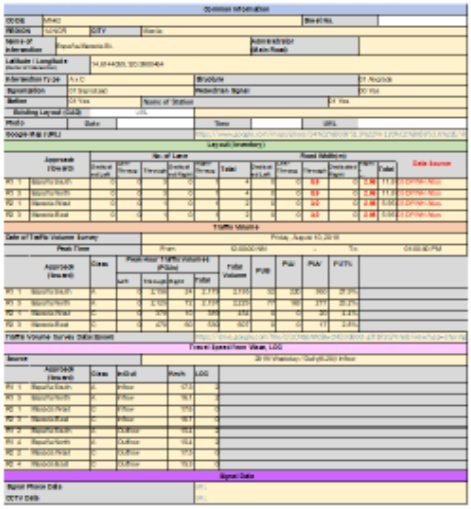
3.b. DATASHEET 2: Site Survey (Methodology)

Datasheet 1: Desk Work

- Prepared by project staff → Bring on the site to support survey

Data sheet for intersection



3.b. DATASHEET 2: Site Survey (Methodology)

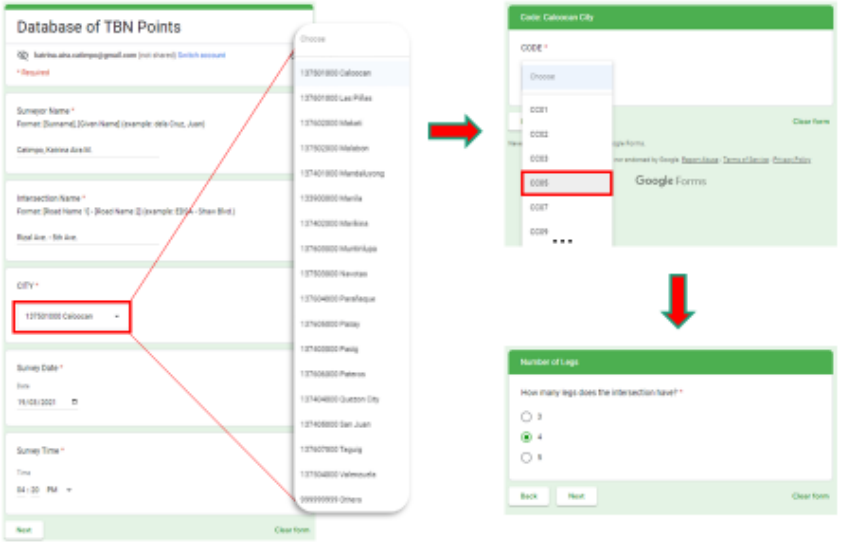
A Google form was developed to be used by the traffic enforcers for the site survey.

Part I: Basic Information

- Name of Surveyor
- Intersection Name
- City/LGU
- Survey Date
- Survey Time
- Code (TBN ID)
- No. of Legs

Links:

- For editor
- For surveyor
- Responses



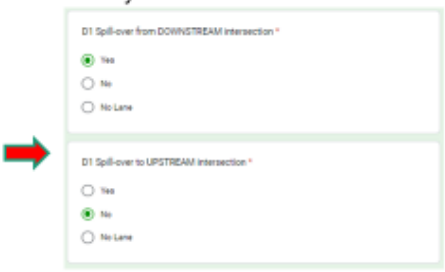
3.b. DATASHEET 2: Site Survey (Methodology)

A Google form was developed to be used by the traffic enforcers for the site survey.

Part II: Congestion Situation

- Queue Length
- Spill-over from downstream intersection
- Spill-over to upstream intersection

Links:
- For editor
- For surveyor
- Responses



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3.b. DATASHEET 2: Site Survey (Methodology)

A Google form was developed to be used by the traffic enforcers for the site survey.

Part III: Factor of Congestion

Links:
- For editor
- For surveyor
- Responses

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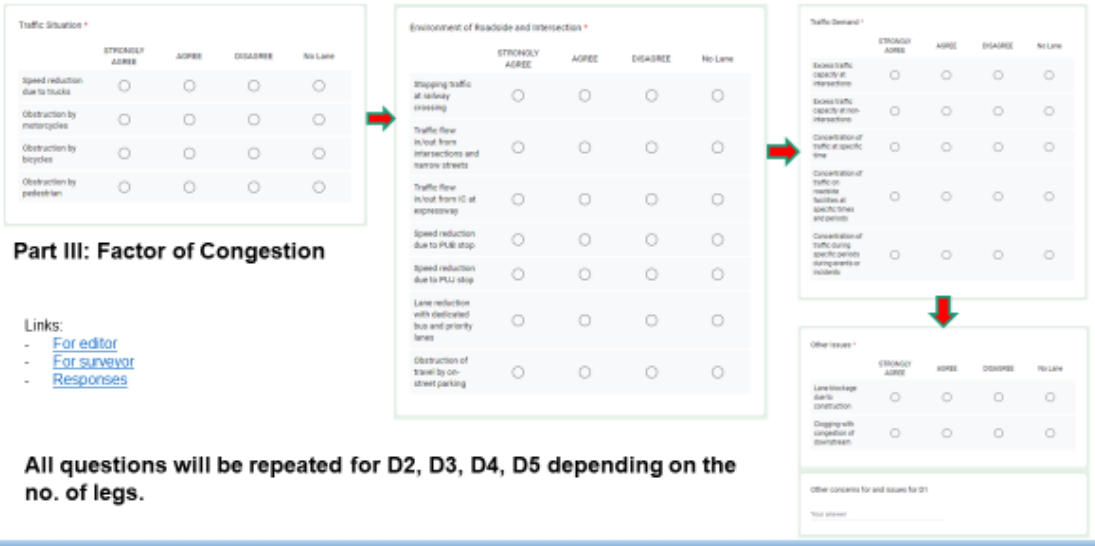
3.b. DATASHEET 2: Site Survey (Methodology)

A Google form was developed to be used by the traffic enforcers for the site survey.



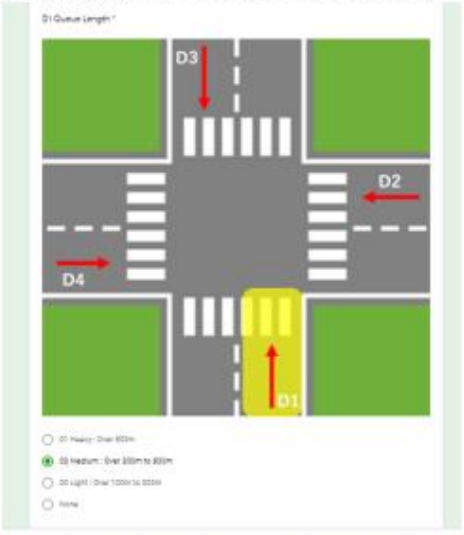
Part III: Factor of Congestion

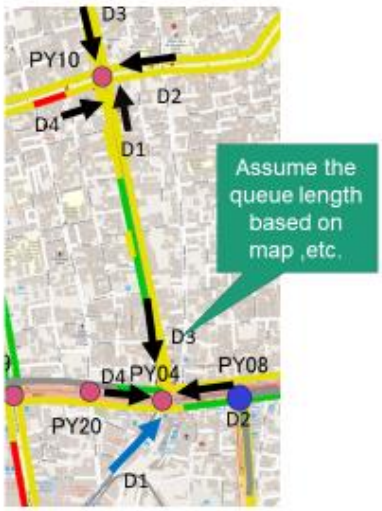
Links:
- For editor
- For surveyor
- Responses

All questions will be repeated for D2, D3, D4, D5 depending on the no. of legs.

3.b. DATASHEET 2: Site Survey (Methodology)

Example: EDSA-Taft (Based on MMDA's survey)





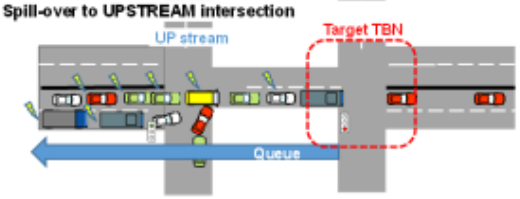
3.b. DATASHEET 2: Site Survey (Methodology)

D1 Direction

From where is the start of congestion? Upstream or downstream of the target TBN?

Spill-over from DOWNSTREAM intersection

Spill-over to UPSTREAM intersection



Even when the traffic signal towards the direction of travel becomes green, vehicle cannot move due to "spill- over" situation.

3.b. DATASHEET 2: Site Survey (Methodology)

As much as possible, "strongly agree" or " disagree" should be selected. "Agree" is only for the factors with less effect on congestion.

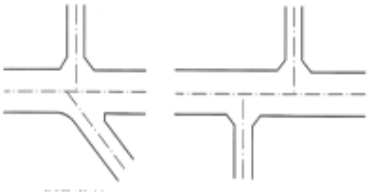
View: Facing D1 from intersection

Factor of congestion
-> Can it be improved by infrastructure or not?

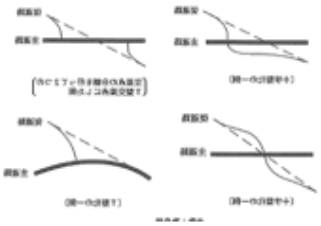
3.b. DATASHEET 2: Site Survey (Methodology)

Wrong geometric layout → Many conflicts occur which lead to traffic jams

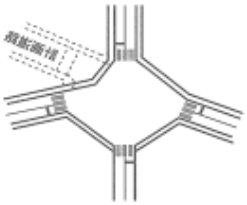
Offset intersection



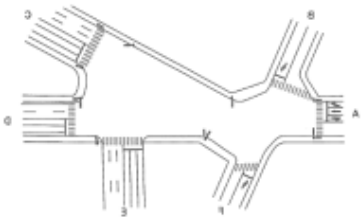
Diagonal intersection



5 or more inflow



Complicated



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3.b. DATASHEET 2: Site Survey (Methodology)

Improper road facilities

- No road marking (No transit guideline, No stop line ,etc)
- No sign

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3.b. DATASHEET 2: Site Survey (Methodology)

As much as possible, "strongly agree" or " disagree" should be selected. "Agree" is only for the factors with less effect on congestion.

View: Facing D1 from intersection

Is the signal phase adequate for the traffic flow?

Can drivers see signal clearly? Location, light condition

Prohibited left turn from southbound?

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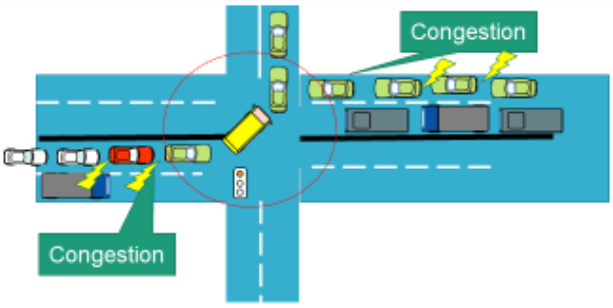
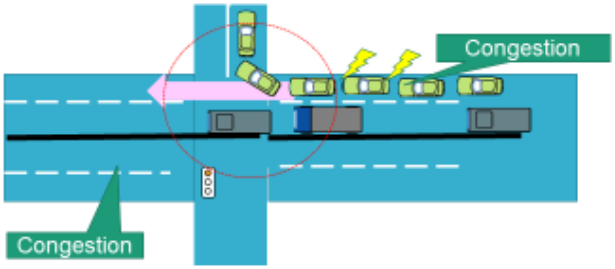
3.b. DATASHEET 2: Site Survey (Methodology)

Conflict between a left-turning car and an oncoming straight car



Right-turning vehicles blocking vehicles proceeding straight ahead



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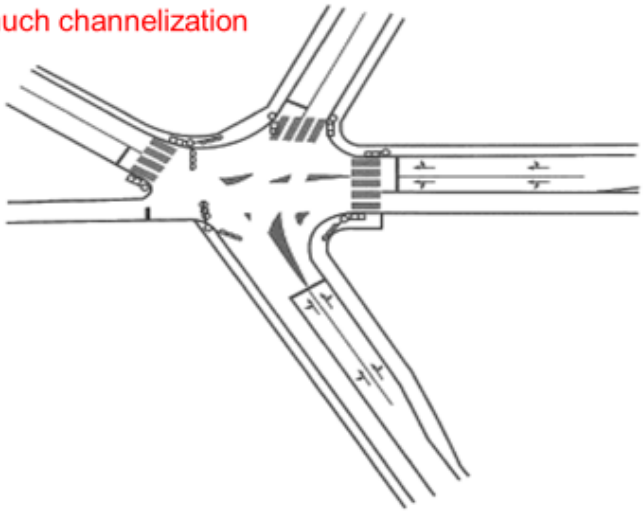
3.b. DATASHEET 2: Site Survey (Methodology)

Improper channelization

- Insufficient or too much channelization



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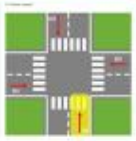
3.b. DATASHEET 2: Site Survey (Methodology)

As much as possible, answer "strongly agree" or " disagree".

View: Facing D1 from intersection



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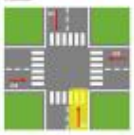
3.b. DATASHEET 2: Site Survey (Methodology)

View: Facing D1 from intersection



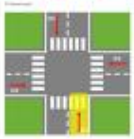
PUVs tend to slow down or stop in this area.

Environment of Roadside and Intersection *

	STRONGLY AGREE	AGREE	DISAGREE	No Line
Stopping traffic at railway crossing	○	○	◉	○
Traffic flow in/out from intersections and narrow streets	○	◉	○	○
Traffic flow in/out from IC at expressway	○	○	◉	○
Speed reduction due to PUV stop	○	◉	○	○
Speed reduction due to PUJ stop	○	◉	○	○
Lane reduction with dedicated bus and priority lanes	○	◉	○	○
Obstruction of travel by on-street parking	○	◉	○	○

3.b. DATASHEET 2: Site Survey (Methodology)

View: Facing D1 from intersection



Traffic Demand *

	STRONGLY AGREE	AGREE	DISAGREE	No Line
Excess traffic capacity at intersections	○	◉	○	○
Excess traffic capacity at non-intersections	○	◉	○	○
Concentration of traffic at specific time	○	◉	○	○
Concentration of traffic on roadside facilities at specific times and periods		◉	○	○
Concentration of traffic during specific periods during events or incidents	○	◉	○	○

Shopping mall, station, etc.

Black spots? Accident

3.b.iii. DATASHEET 2: Site Survey (Methodology)

View: Facing D1 from intersection

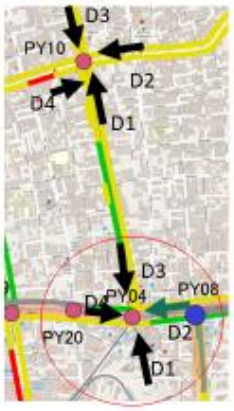
3.b. DATASHEET 2: Site Survey (Methodology)

View: Facing D1 from intersection

3.b. DATASHEET 2: Site Survey (Methodology)

Observation order :D1 → D2 → D3 →D4

Then, move to the next direction.



3.b. DATASHEET 2: Site Survey (Methodology)

Output : Based on the answer from google form, project staff convert it to the datasheet

Common Information					
CODE	MN43			Sheet No.	
REGION	14 NCR	CITY	Manila		
Name of Intersection	España-Maceda St.			Administrator (Main Road)	
Latitude / Longitude (Center of Intersection)	14.6144055,120.9883464			Link to Map	https://www.google.c
Intersection Type	A x C		Structure		01 At-grade
Survey	Date		Time		

Congestion Situation				
	Approach (forward)	Vehicle Queue Length	Spill over from downstream intersection	Spill over to upstream intersection
R1_1	A. Bonifacio South			
R1_2	A. Bonifacio North			
R2_1	11th Ave. West			
R2_2				

Checklist for Factor of Congestion (Intersection)						
1:STRONGLY AGREE, 2:AGREE, 3:DISAGREE						
Factor item	Checkpoint	Factor of Congestion	R1_1	R1_2	R2_1	R2_2
Road infrastructure	Number of lanes	Lack of number of lanes				
		Insufficient road width				
	Intersection layout	Wrong geometric intersection				
		Inadequate corner cutting				
		Improper location of road facilities				
Traffic regulation/	Signal timing	Inadequate of traffic signal control				
		Bad visibility of traffic signal				
	Right-turning or oncoming vehicles	No left-turn lane				
		Insufficient left-turn lane length				
		Conflict between a left-turning car				
	Left-turning vehicles	Right-turning vehicles blocking				
		Improper stop line position				
		Improper channelization				
Traffic situation	Large vehicle	Speed reduction due to large				
		Obstruction by motorcycles				
		Obstruction by bicycles				
		Obstruction by pedestrian				
Environment of Roadside and Intersection	Railway Crossing	Stopping traffic at railway crossing				
	Driveway from roads side shop	Traffic flow in/out from				
		Traffic flow in/out from IC at				
	PUJ, PUV	Speed reduction due to PUV stop				
		Speed reduction due to PUJ stop				
		Lane reduction with dedicated bus				
	On-street parking	Obstruction of travel by on-street				
Traffic Demand	Over capacity	Excess traffic capacity at intersections				
		Excess traffic capacity at non-intersections				
	Concentrated traffic	Concentration of traffic at specific time				
		facilities at specific times and periods				
		specific periods during events or incidents				
Others	Construction	Lane blockage due to construction				
	Clogging of downstream	Clogging with congestion of downstream				
	Free Comment (if any)					

LOCATION MAP AND ACTUAL SITE PHOTOS

Screenshot from QGIS with TBN and Road Class info

D1: towards Monumento | D2: towards C3

D3: towards Manila | D4: towards A. Bonifacio

Actual site photos taken by traffic enforcers

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3.b. DATASHEET 2: Site Survey (Methodology)

Strengths
- Real-time and actual situation is considered.

Weaknesses
- The data collected is qualitative, which means it can vary depending on the surveyor.

Opportunities
- The traffic enforcers know the traffic situation well.

Threats
- COVID-19 travel restrictions affect the traffic situation, especially PUV operations.
- Special events during the time of survey may cause variations from the actual situation.

The subjectivity of the information will be supplemented by road inventory data.

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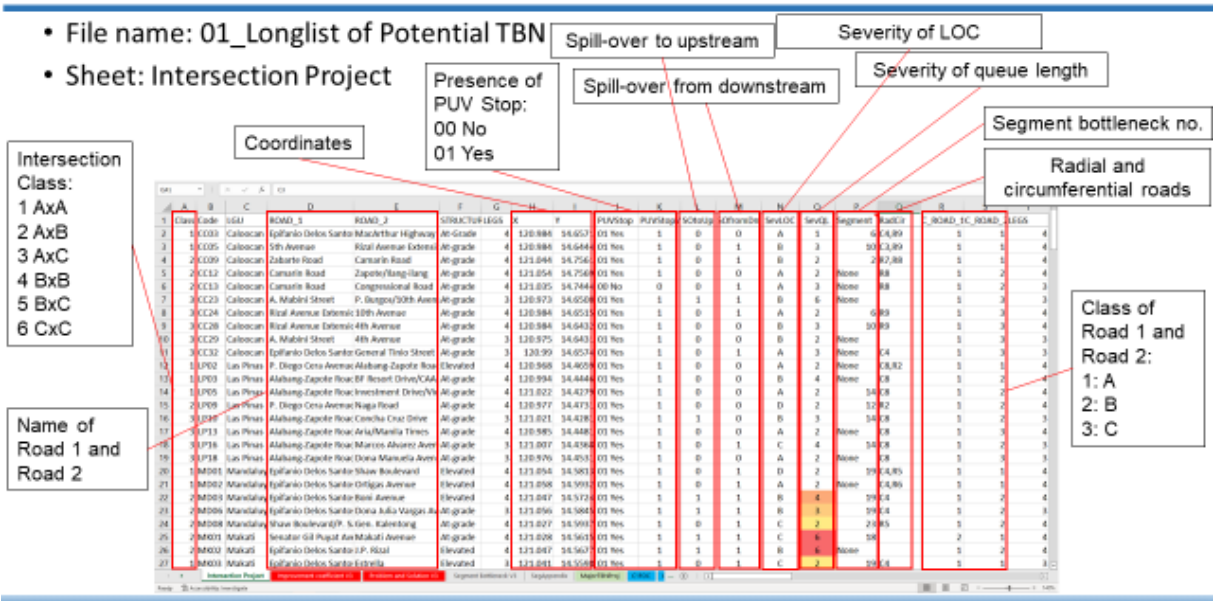
4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Intersection Project



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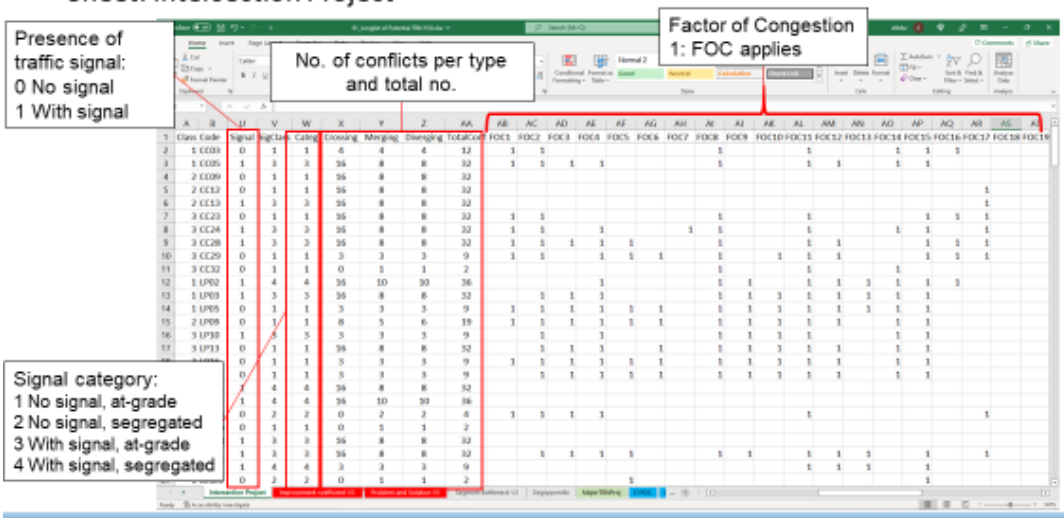
4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Intersection Project



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4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Intersection Project

Factor of Congestion
1: FOC applies

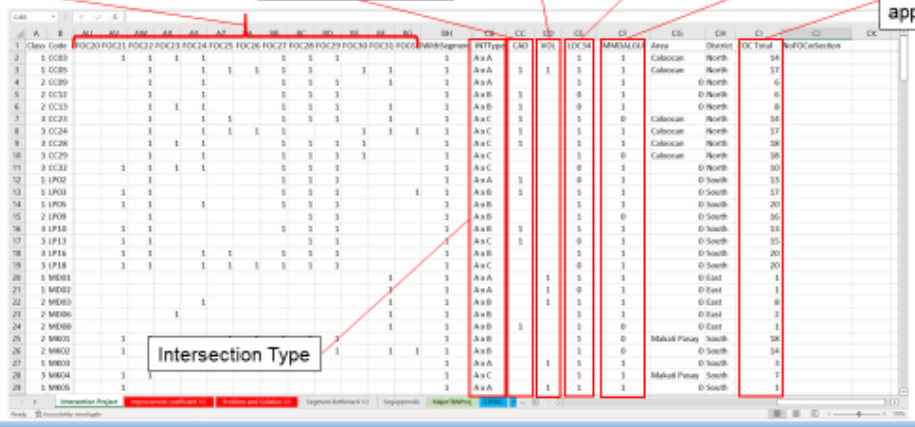
CAD file available?
0 or blank: No
1: Yes

Volume count available?
0 or blank: No
1: Yes

LOC = 3 or 4
0: No
1: Yes

TBN identified by MMDA or LGU?
0: No
1: Yes

Total no. of applicable LOCs



Intersection Type

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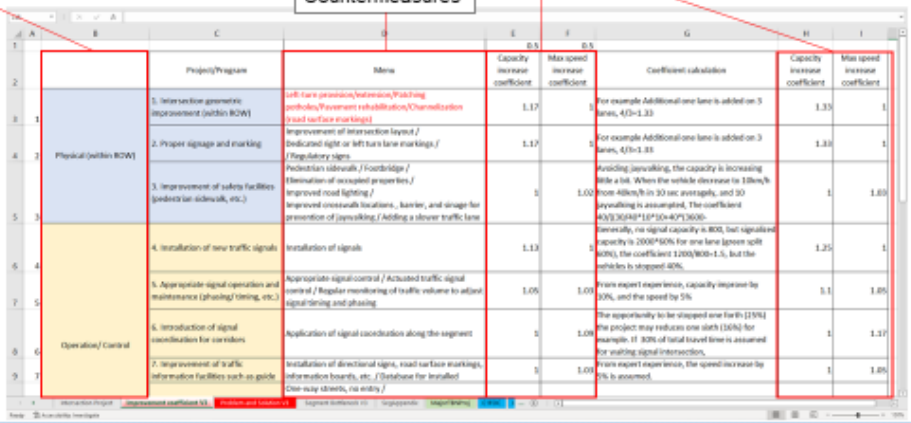
4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Improvement Coefficient

Type of Project/Program

Countermeasures

Est. capacity and speed increase coefficient



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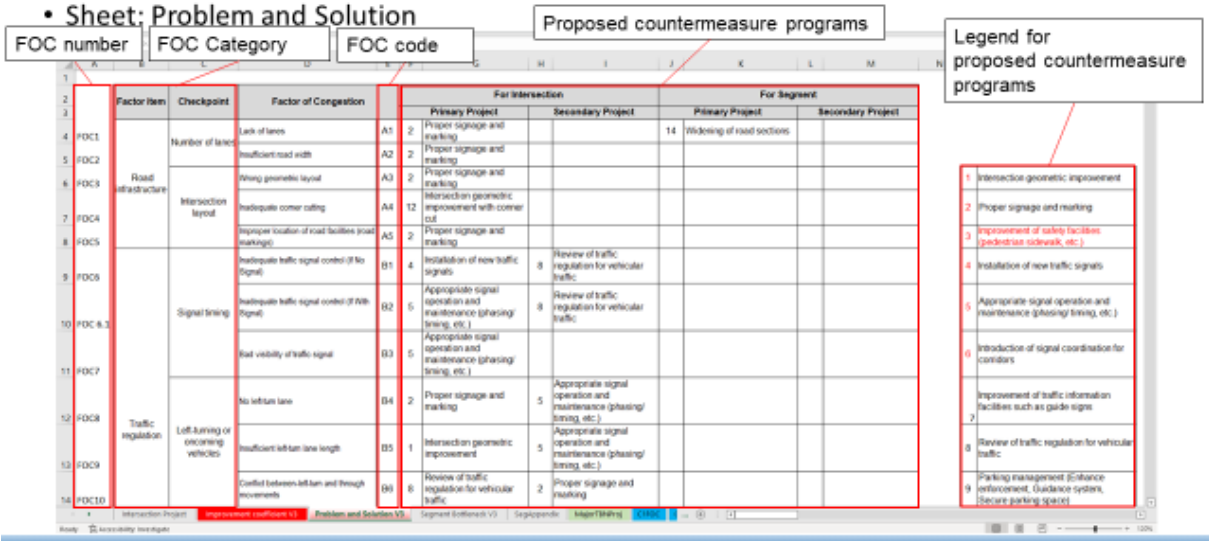
4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Problem and Solution



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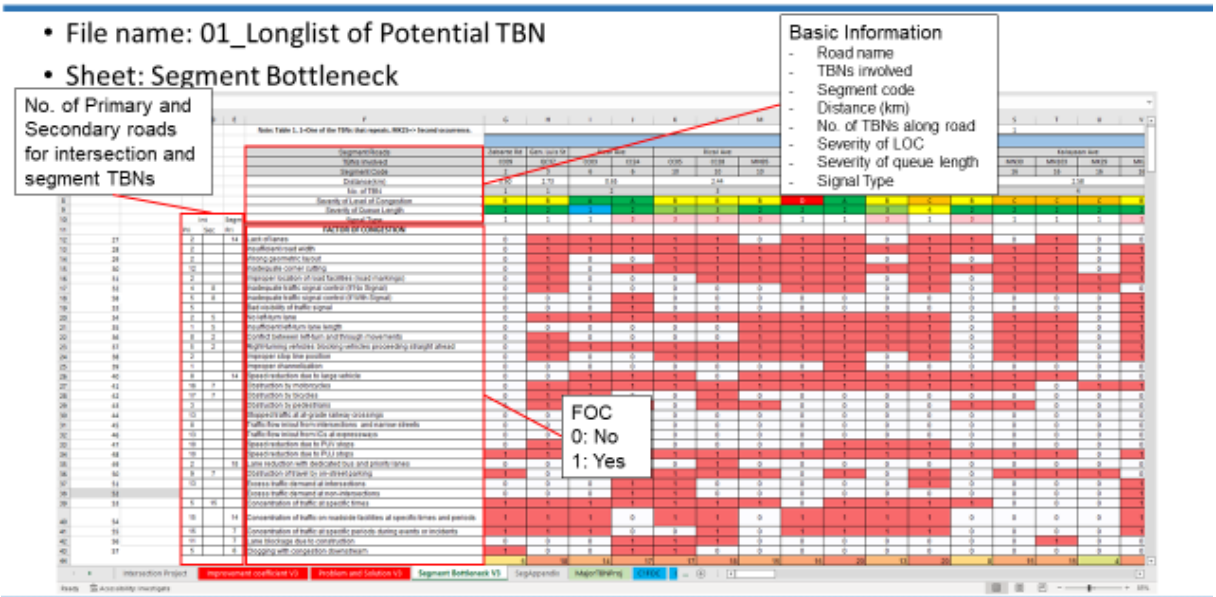
4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Segment Bottleneck



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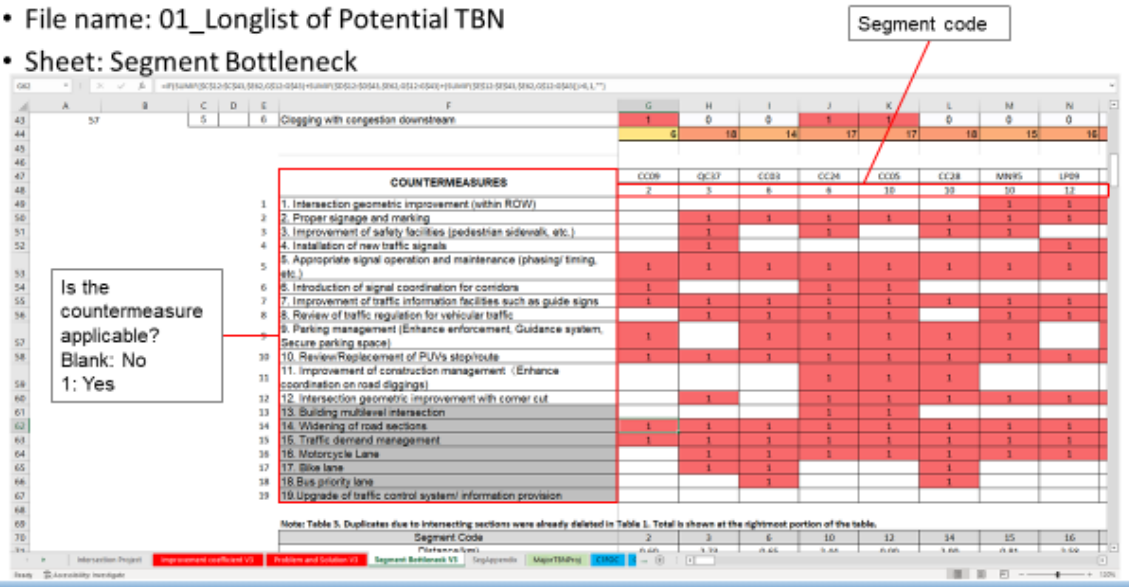
4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Segment Bottleneck



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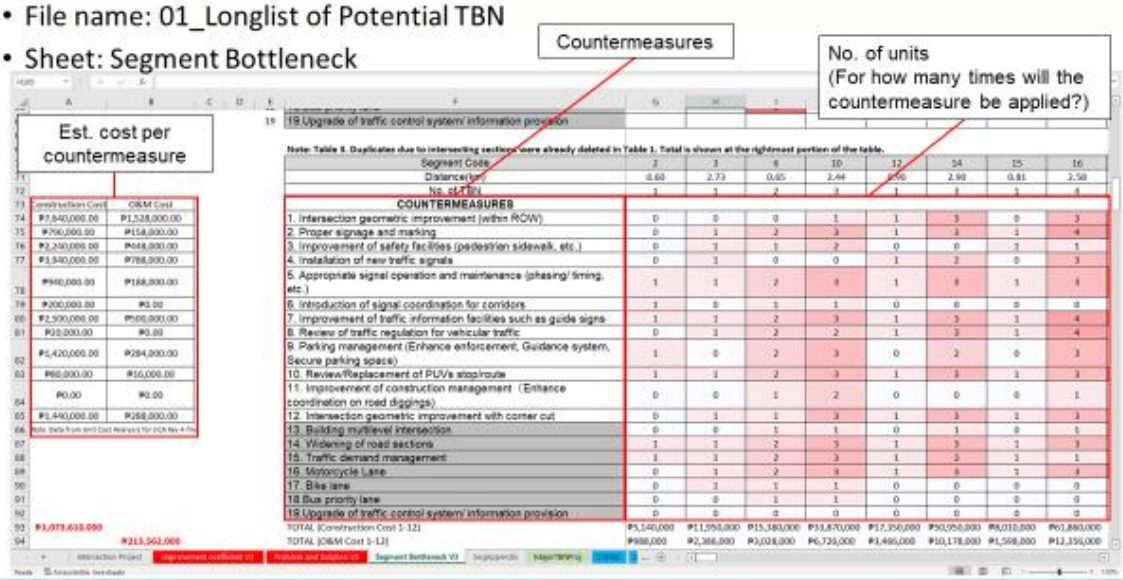
4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Segment Bottleneck



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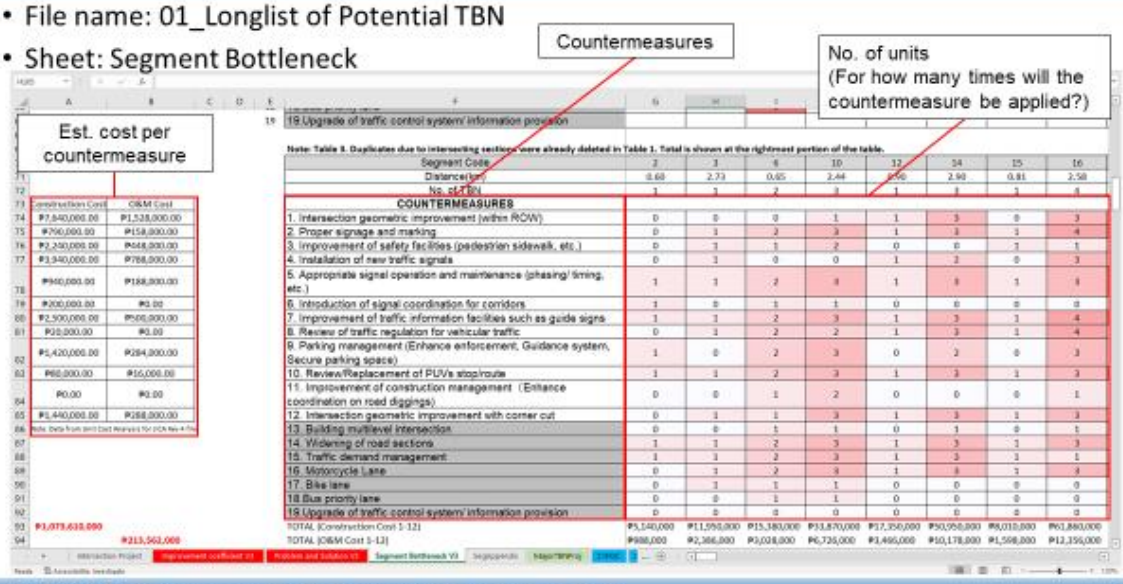
4. LONGLIST

- File name: 01_Longlist of Potential TBN
- Sheet: Segment Bottleneck



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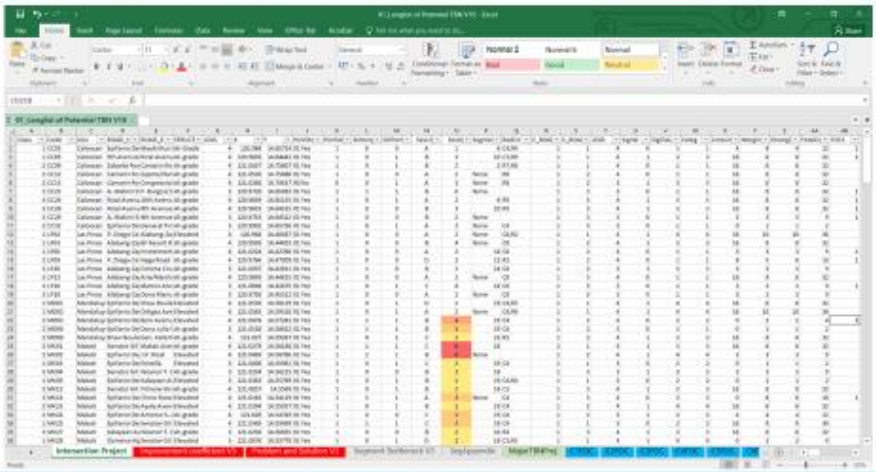
Compilation of Survey Data

- The list of bottlenecks, including the survey data, will be compiled into the longlist for further analysis.



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Relevant links

- Google form for surveyor: https://forms.gle/tScWTX3qVjMNsbT99
- Form responses: https://docs.google.com/spreadsheets/d/1GFASy_doBBX46gDqH7elKWNrXHiu_jp189xlANc6QPU/edit?usp=sharing
- Google form for editor: https://docs.google.com/forms/d/1kYLftyUJSaf1T3P6pQIBMNssMEII6x--cI2S4UMRjCs/edit

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE PROJECT FOR COMPREHENSIVE TRAFFIC MANAGEMENT PLAN FOR METRO MANILA

TECHNICAL REPORT NO. 5

INTERSECTION CAPACITY ANALYSIS

November 2022

ALMEC CORPORATION
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TRANSPORTATION RESEARCH INSTITUTE CO., LTD.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

CTMP	Comprehensive Traffic Management Plan
G/C	green/cycle
JICA	Japan International Cooperation Agency
JPT	JICA Project Team
MMDA	Metropolitan Manila Development Authority
RTOR	right-turn on red
TCU	through car unit
V/S	volume/saturation

1 USER'S GUIDE FOR SPREADSHEET CAPACITY ANALYSIS TEMPLATES

1.1 Introduction

Three (3) spreadsheet templates have been developed to facilitate capacity analyses of signalized and non-signalized intersections.

This user's guide describes the basic operations of the templates concerning the initialization and data entry, and critical assumptions and analytical procedures from which the templates are constructed. The users are assumed to have an adequate working knowledge of personal computers and the Microsoft Excel spreadsheet program. It is also assumed that the users are sufficiently familiar with traffic engineering terminology and understand the theoretical bases of intersection capacity analysis to properly interpret the results.

Because traffic, roadway, and control factors can sometimes produce a very complicated situation as far as capacity analysis is concerned, it is imperative that the user understands the basic assumptions and equations which have been used in constructing the templates. In particular, when an analysis involves shared left/through lanes and/or overlap phasing, an assessment should be made to determine if the methodology remains applicable. Sometimes, it may be necessary to alter the input data to "trick the system" into producing a better result. This cannot be done without a thorough understanding of the methodology.

1.2 The Templates

The first template, named "Intersection Turning Movement Survey – Conversion to TCUs," is for converting intersection turning movement counts into Through Car Unit (TCU) which can then be input into the capacity analysis templates.

The second template, named "Intersection Capacity Analysis - Planning Method," is for evaluating future intersections, geometric improvements, and signal warrants, and in various planning and preliminary engineering studies which do not warrant a detailed analysis of signal operations.

The third template, named "Intersection Capacity Analysis - Operations Method," is for the detailed evaluation of intersection operations, particularly in evaluating the effectiveness of existing signal control, developing timing plans, comparing alternative phasing plans, and final intersection design.

Both planning and operations methods require traffic volumes and intersection lane configuration as basic input. The main difference is that the user must specify signal phasing and timing in the operations method while such input data is not required for the planning method.

1.3 A Few Words of Caution

The templates are not perfect in the sense that there are unusual circumstances that would render the assumptions and the various parameters embedded in the templates inaccurate or invalid. The user should always review the input data and the results carefully before drawing conclusions. There is no substitute for sound engineering judgment, and one must take care not to fall into the "GIGO" trap[1].

A macro command to initialize the input data cells is incorporated into the templates. When the template is opened, a warning message regarding the use of macros may be displayed. Select "Enable Macros" to continue. Alternatively, macros can be disabled, and the template can be initialized manually when used for other intersections.

The templates have been designed to avoid accidental alteration of the internal logic, and all cells are protected except the cells where data input is done by the user. If you try to input data into a protected cell, a warning message is displayed. Press the "Cancel" button in the dialogue box to terminate the operation. Do not remove the protection unless you know exactly what you are doing.

Where input of a value data (including zero) is required, entering a label (including blank spaces) may result in errors in related cells. Therefore, one must not use the space bar to blank out a numerical entry; enter a zero (0) instead.

[1] "GIGO" is an acronym used at IBM, back in the Stone Age of computers, and it stands for "Garbage In – Garbage Out" – in other words, the quality of the finished product will not be better than the quality of the input.

1.4 From Start to Finish

The file names of the three templates are “TM_CONV_MMDA.xlsm,” “Capa_PL_MMDA.xlsm,” and “Capa_OP_MMDA.xlsm.” The “xlsm” file format indicates that macro is embedded in the template and its use is explained below. These and any filled-in templates can be retrieved for editing or to start a new analysis.

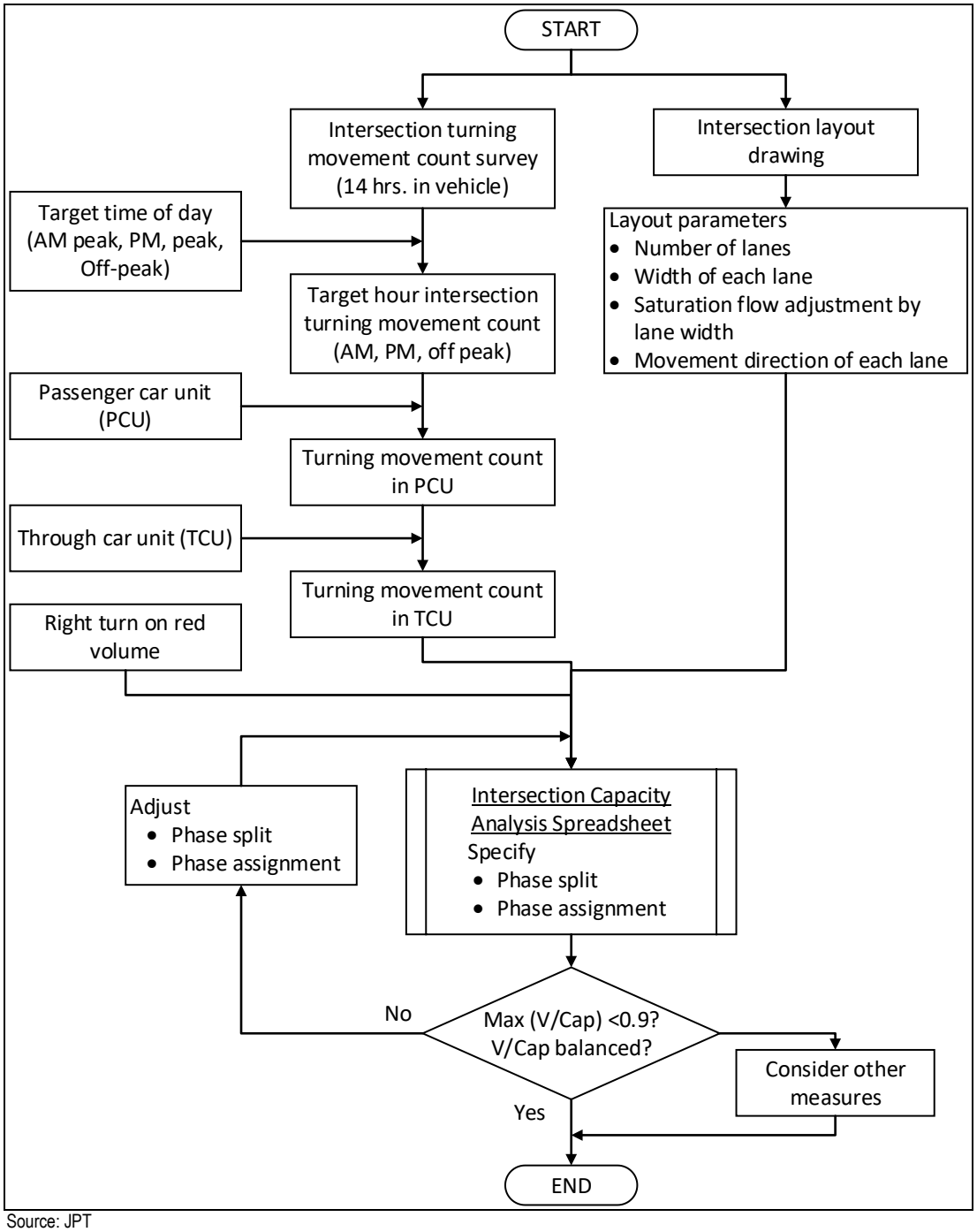
To start a new analysis from a previously filled-in template, press the “Shift,” “Ctrl” and “I” keys simultaneously. This will initialize all input data cells except for a few locations where default values are supplied but can still be changed by the user as they are not protected.

The initialized template shows zero blanks in numerical cells and “XXXXX” in label cells. In addition, the initial texts in cells intended for inputs are colored blue to help distinguish which cells are intended for data entry. Note that time should be entered as a label and unnecessary zeroes may be erased as desired. For example, when left-turn movement is prohibited, a blank entry in the left-turn volume cell may be less ambiguous than a zero entry.

Follow standard Excel procedures to print and store data sheets. Default print ranges and margins have been pre-defined but, again, they can be changed if necessary.

Since data entry requires little effort, saving a datasheet to a file is not critical if a hard copy is retained, especially if one is kept in the traffic count folder. This would avoid the trouble of keeping track of the files. Otherwise, a file-naming scheme should be devised and followed to avoid confusion and make file identification and retrieval easier. As a suggestion, one might use “T” for the first digit to indicate that it is a turning movement survey file, “P” for the planning method, and “O” for the operations method. The next three digits could be the intersection number and the last four digits could be “_01A” to indicate the first count or analysis of 2022. The file name should appear on each spreadsheet at the upper right-hand corner following the title “FN:.”

The workflow of intersection capacity analysis is shown in Figure 1.1.



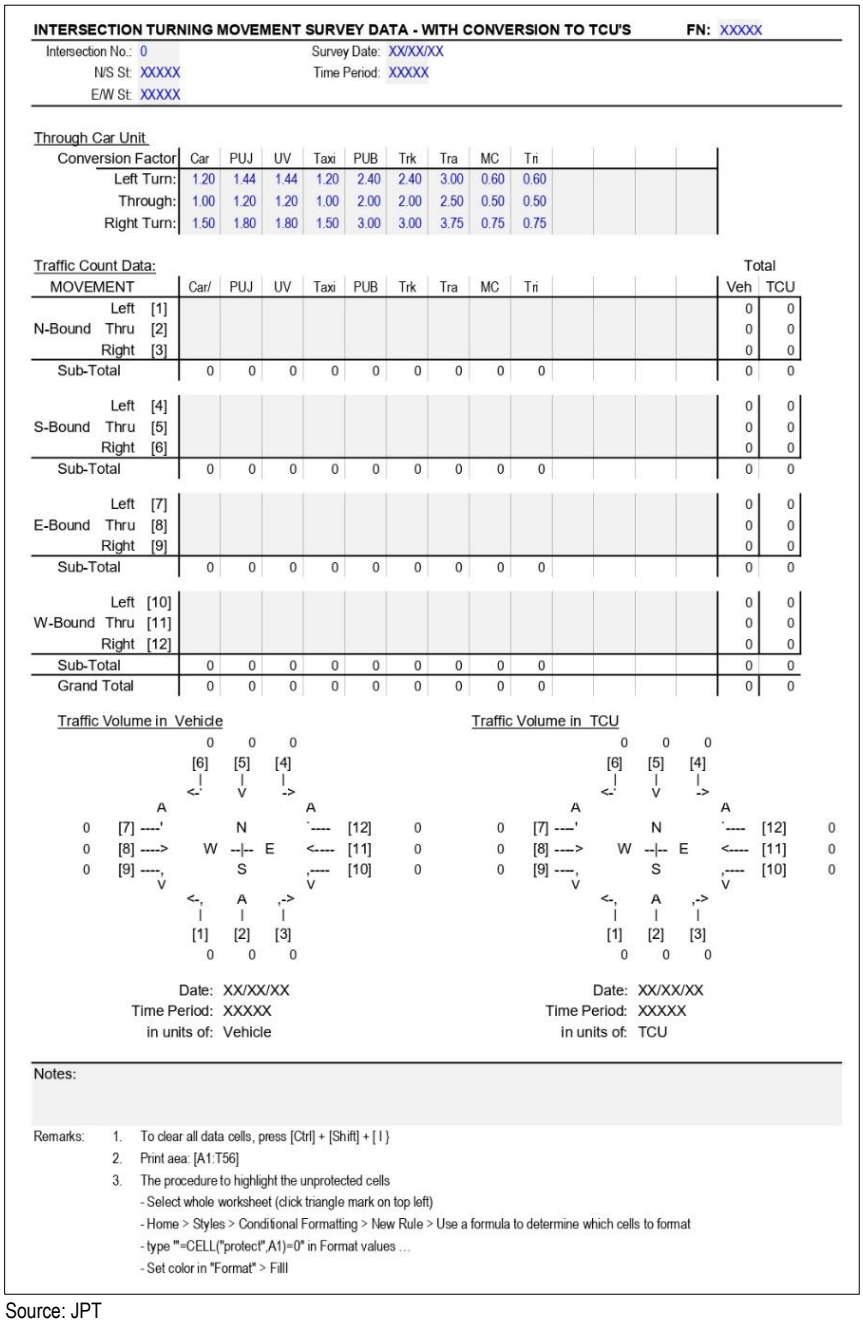
Source: JPT

Figure 1.1: Intersection Capacity Analysis Process Flow

2 TURNING MOVEMENT SURVEY TEMPLATE

This template is set up to process turning movement counts for a period on a separate worksheet. The upper part of the template identifies the location and the time period. The next section shows the through car units (TCU) used by the Template. The TCU converts the traffic count of different types of vehicles in different movement directions into equivalent car units. Below the TCU units are spaces for entering volume counts by classification and movement. Total vehicles and the equivalent TCUs for each movement are computed automatically.

The turning movement diagrams at the bottom are plotted automatically using the total vehicle and TCU figures in the date entry table.



INTERSECTION TURNING MOVEMENT SURVEY DATA - WITH CONVERSION TO TCU'S FN: XXXXX

Intersection No.: 0 Survey Date: XX/XX/XX
N/S St: XXXXX Time Period: XXXXX
E/W St: XXXXX

Through Car Unit

Conversion Factor	Car	PUJ	UV	Taxi	PUB	Trk	Tra	MC	Tri
Left Turn:	1.20	1.44	1.44	1.20	2.40	2.40	3.00	0.60	0.60
Through:	1.00	1.20	1.20	1.00	2.00	2.00	2.50	0.50	0.50
Right Turn:	1.50	1.80	1.80	1.50	3.00	3.00	3.75	0.75	0.75

Traffic Count Data:

MOVEMENT		Car/	PUJ	UV	Taxi	PUB	Trk	Tra	MC	Tri	Total Veh	Total TCU
N-Bound	Left [1]										0	0
	Thru [2]										0	0
	Right [3]										0	0
Sub-Total		0	0	0	0	0	0	0	0	0	0	0
S-Bound	Left [4]										0	0
	Thru [5]										0	0
	Right [6]										0	0
Sub-Total		0	0	0	0	0	0	0	0	0	0	0
E-Bound	Left [7]										0	0
	Thru [8]										0	0
	Right [9]										0	0
Sub-Total		0	0	0	0	0	0	0	0	0	0	0
W-Bound	Left [10]										0	0
	Thru [11]										0	0
	Right [12]										0	0
Sub-Total		0	0	0	0	0	0	0	0	0	0	0
Grand Total		0	0	0	0	0	0	0	0	0	0	0

Traffic Volume in Vehicle

Date: XX/XX/XX
Time Period: XXXXX
in units of: Vehicle

Traffic Volume in TCU

Date: XX/XX/XX
Time Period: XXXXX
in units of: TCU

Notes:

Remarks:
1. To clear all data cells, press [Ctrl] + [Shift] + [I]
2. Print aea: [A1:T56]
3. The procedure to highlight the unprotected cells
- Select whole worksheet (click triangle mark on top left)
- Home > Styles > Conditional Formatting > New Rule > Use a formula to determine which cells to format
- type '"=CELL("protect",A1)=0" in Format values ...
- Set color in "Format" > Fill

Source: JPT

Figure 2.1: Intersection Turning Movement Survey – Conversion to TCUs

2.1 Street Orientation

To avoid confusion, it is necessary to designate one of the two intersecting streets as north-south street and the other one as an east-west street. The two street names should be entered separately in the designated cells. Also, each of the movements is numbered 1 to 12 for uniformity. The movement numbers are shown in the table and the plots (Figure 2.1). After all the data are entered, the plots should be visually checked to spot any abnormalities.

2.2 Conversion Factors

Conversion factor converts the traffic count of different vehicle types and movement direction into the equivalent traffic volume of passenger cars through movement. There are 9 vehicle types used by MMDA for classified traffic count surveys and three (3) factors for three (3) movements (left turn, through, and right turn). Thus, a total of 27 factors are defined.

Large vehicles are less maneuverable than small vehicles and less efficient in terms of intersection operation. Passenger car equivalent converts the volume count of different vehicle types into that of a passenger car. The unit for the converted count is called the passenger car unit or PCU.

Likewise, turning vehicles (left and right turns) normally take more time than through movement to pass through an intersection as they have to reduce the speed. Effective traffic count is thus higher than the actual count, or conversely, intersection capacity is reduced by turning vehicles. Through car equivalent adjusts the effective traffic volume into through car unit.

The classification, applicable vehicle type, and default conversion factor are set in Table 2.1. These factors are not protected and not initialized, and one can alter the factors, if necessary. It is recommended however to set the standard factors and apply these factors consistently.

Table 2.1: Vehicle Type Conversion Factor

	Left turn	Through	Right turn
1. Car	1.20	1.00	1.50
2. Public utility jeepney (PUJ)	1.44	1.20	1.80
3. UV Express (UV)	1.44	1.20	1.80
4. Taxi	1.20	1.00	1.50
5. Public Bus (PUB)	2.40	2.00	3.00
6. Truck (Trk)	2.40	2.00	3.00
7. Trailer (Tra)	3.00	2.50	3.75
8. Motorcycle (MC)	0.60	0.50	0.75
9. Tricycle	0.60	0.50	0.75

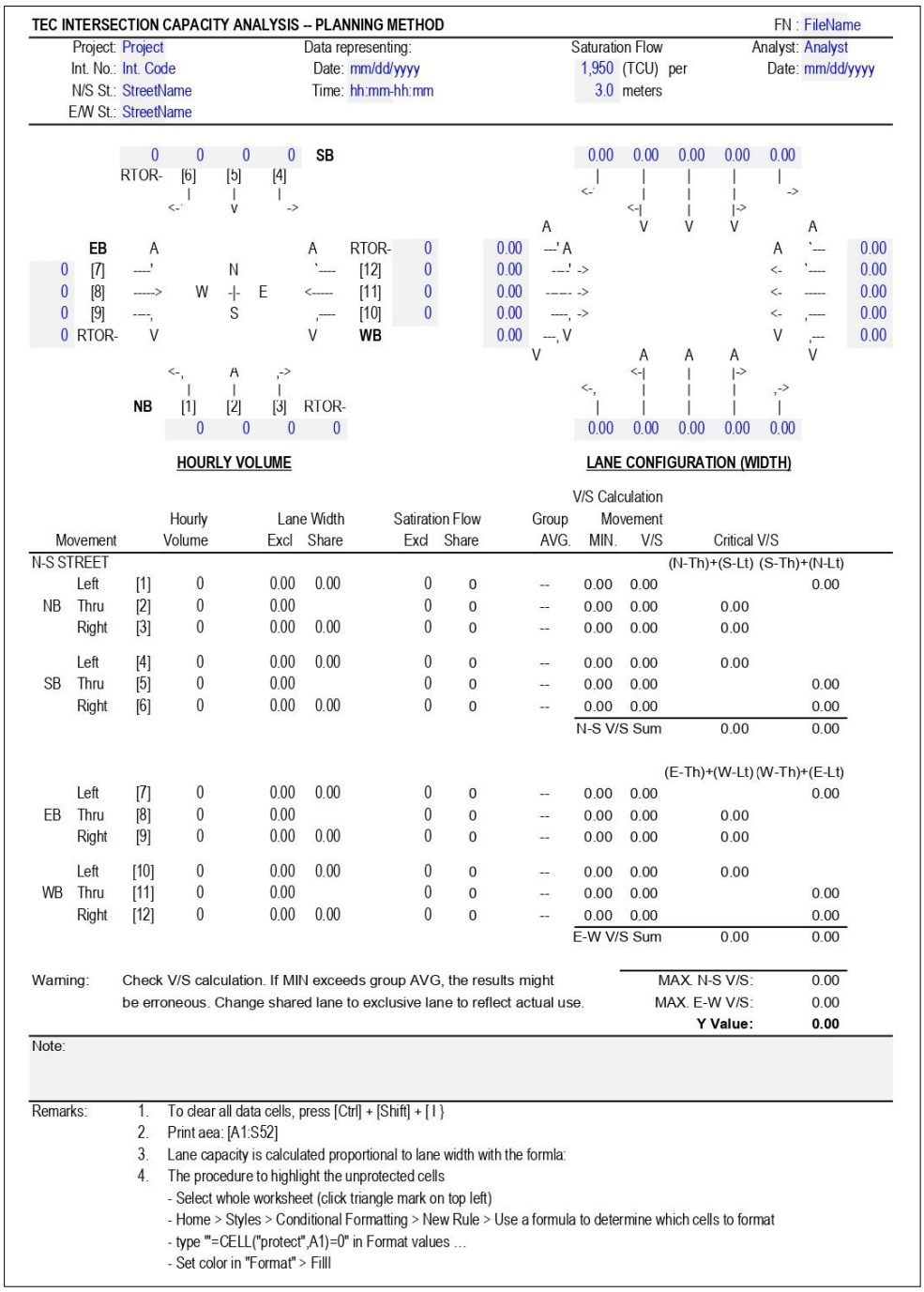
Source: JPT

2.3 Notes

Three rows of the template following the heading “Notes:” are unprotected. They may be used to document any observations or comments which apply to the data.

3 CAPACITY ANALYSIS TEMPLATE – PLANNING METHOD

This template is organized into four sections. The upper portion identifies the location, period of study, and assumed saturation flow rate. This is followed by a turning movement diagram and a lane configuration diagram. These are the main data entry sections. The next section is the analysis section which computes saturation flows and volume/saturation flow ratios (V/S), selects critical movements, and sums up the critical V/S values. All of these are done automatically. The last section, under the heading of "Notes:" allows the user to enter any remarks or comments which are appropriate or necessary to clarify either the input data or the results.



TEC INTERSECTION CAPACITY ANALYSIS -- PLANNING METHOD FN : FileName

Project: Project | Data representing: | Saturation Flow | Analyst: Analyst
Int. No.: Int. Code | Date: mm/dd/yyyy | 1,950 (TCU) per | Date: mm/dd/yyyy
N/S St.: StreetName | Time: hh:mm-hh:mm | 3.0 meters
E/W St.: StreetName

SB RTOR- [6] [5] [4] — 0 0 0 0 — 0.00 0.00 0.00 0.00 0.00
EB [7] [8] [9] RTOR- — 0 0 0 0 — 0.00 0.00 0.00 0.00
WB [10] [11] [12] RTOR- — 0 0 0 0 — 0.00 0.00 0.00 0.00
NB [1] [2] [3] RTOR- — 0 0 0 0 — 0.00 0.00 0.00 0.00

HOURLY VOLUME **LANE CONFIGURATION (WIDTH)**

Movement		Hourly Volume	Lane Width Excl	Lane Width Share	Satiration Flow Excl	Satiration Flow Share	Group AVG.	V/S Calculation Movement MIN.	V/S	Critical V/S	
N-S STREET										(N-Th)+(S-Lt)	(S-Th)+(N-Lt)
	Left	[1] 0	0.00	0.00	0	0	--	0.00	0.00		0.00
NB	Thru	[2] 0	0.00		0	0	--	0.00	0.00	0.00	
	Right	[3] 0	0.00	0.00	0	0	--	0.00	0.00	0.00	
	Left	[4] 0	0.00	0.00	0	0	--	0.00	0.00	0.00	
SB	Thru	[5] 0	0.00		0	0	--	0.00	0.00		0.00
	Right	[6] 0	0.00	0.00	0	0	--	0.00	0.00		0.00
								N-S V/S Sum		0.00	0.00
										(E-Th)+(W-Lt)	(W-Th)+(E-Lt)
	Left	[7] 0	0.00	0.00	0	0	--	0.00	0.00		0.00
EB	Thru	[8] 0	0.00		0	0	--	0.00	0.00	0.00	
	Right	[9] 0	0.00	0.00	0	0	--	0.00	0.00	0.00	
	Left	[10] 0	0.00	0.00	0	0	--	0.00	0.00	0.00	
WB	Thru	[11] 0	0.00		0	0	--	0.00	0.00		0.00
	Right	[12] 0	0.00	0.00	0	0	--	0.00	0.00		0.00
								E-W V/S Sum		0.00	0.00

Warning: Check V/S calculation. If MIN exceeds group AVG, the results might be erroneous. Change shared lane to exclusive lane to reflect actual use.

MAX. N-S V/S: 0.00
MAX. E-W V/S: 0.00
Y Value: 0.00

Note:

Remarks:
1. To clear all data cells, press [Ctrl] + [Shift] + [I]
2. Print aea: [A1:S52]
3. Lane capacity is calculated proportional to lane width with the formla:
4. The procedure to highlight the unprotected cells
   - Select whole worksheet (click triangle mark on top left)
   - Home > Styles > Conditional Formatting > New Rule > Use a formula to determine which cells to format
   - type '"=CELL("protect",A1)=0" in Format values ...
   - Set color in "Format" > Filll

Source: JPT

Figure 3.1: Intersection Capacity Analysis - Planning Method

3.1 Units

Both the saturation flow rate and the volumes should normally be entered in units of TCU (through car unit) per hour. However, this is entirely up to the user as long as they are consistent.

Lane widths must be in units of meters, with a maximum of two digits following the decimal point.

3.2 Right-Turn on Red (RTOR)

Where a right-turn on a red signal is permitted, a reduction in the right-turn volume should be considered. The user must estimate and enter these RTOR volumes in spaces provided in the volume diagram. In general, if there is a separate right-turn lane with adequate length, all of the right-turn vehicles may be treated as RTOR vehicles. On the other extreme where the right-turn volume is very small and there is no right-turn lane or right-turn island, no RTOR should be assumed.

Another consideration to be made is the interference with the through traffic from the crossing road. If right-turning traffic has to merge with the through traffic of the crossing road, the former must give way to the through traffic resulting in the reduction of the volume that can make a right turn on red. On the other hand, if there is an exclusive lane for right-turning traffic on the exit, there would be no interference with the through traffic on the crossing road.

Usually, 10 to 20 percent of right-turn vehicles can be assumed to be RTOR.

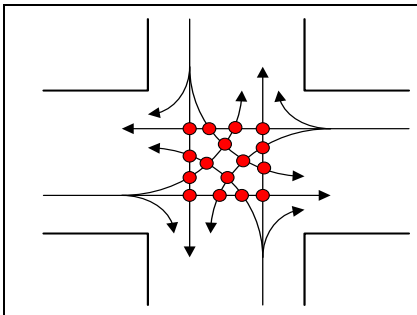
3.3 Saturation Flow Rate (S)

A default value of 1950 TCU per 3.0 meters of pavement width is provided in the template based on TEC's current practice. This can be modified to any value by the user. The program calculates the saturation ratio of lanes proportionally using this value.

3.4 Conflicting and Critical Movements

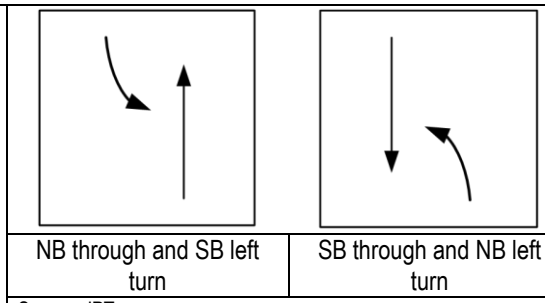
The planning method of capacity analysis is formulated mainly based on “Conflicting Movements” and “Critical Movements.” The concept is explained below:

For a typical 4-legged intersection, there are twelve (12) movements (northbound left, northbound through, northbound right, etc.). Some of the movements can move concurrently (e.g. through movements on the same street) while some are conflicting (e.g. northbound through and southbound left-turn) and must move during different times of the signal cycle. Thus, signal timing is controlled by conflicting movements.



Source: JPT

Figure 3.2: Movements and Conflicting Points



Source: JPT

Figure 3.3: Conflicting Movements

For any two-way street, there are mainly two sets of conflicting movements. Take a north-south street, for example, the northbound through and the southbound left-turn form a set of conflicting movements (Figure 3.3) while the southbound through and northbound left-turn form the other set. One of these two sets of conflicting movements is critical that it will require more green time than the other. In some cases, left-turn movement can become critical because left-turns from one direction also conflict with right-turns from the other direction. Nevertheless, the concept is the same.

The amount of time required to process the critical conflicting movements in each cycle must be less than the cycle length if the intersection is to be free of congestion. The lower the G/C ratio of the critical conflicting movements, the better the intersection operation.

Since the amount of green time required is proportional to the number of vehicles and inversely proportional to the saturation flow rate, the required G/C of all critical movements is proportional to the sum of V/S of all critical movements where S is the saturation flow rate. The sum of V/S of the critical conflicting movements is therefore a good indicator of an intersection's level of saturation and is defined as the saturation factor “Y”.

3.5 The "Y" Value

The planning method begins by computing V/S for all movements. The next step is summing up the V/S values for all possible combinations of conflicting movements. Finally, the combination of conflicting movements which yields the highest total V/S value is chosen.

Because the assumed saturation flow rate is achievable only under ideal conditions and because inter-green loss time and specific signal timing are not considered in the planning method, it is extremely important to understand that the computed “Y” value is not equivalent to volume/capacity ratio or even close to it. For a signal to operate without significant congestion, the “Y” value should be less than 0.75. Severe congestion should be expected if the “Y” value reaches 0.85. Typically, the results of planning analysis are interpreted qualitatively as follows:

Table 3.1: “Y” Value and Traffic Condition

Range of Y Value	Interpretation
< 0.75	below capacity
0.75 to 0.85	near capacity
> 0.85	over capacity

Source: JPT

Comparing "Y" values in a quantitative way should be avoided especially for different locations and when the value differential is relatively small. For example, one should not quickly conclude that location “A” is better than location “B” because the “Y” values are 0.65 and 0.70 respectively. Similarly, it may be erroneous to conclude that scheme “A” is better than scheme “B” because the former has a “Y” value of 0.76 while the latter has a “Y” value of 0.78.

3.6 Shared Lane

Saturation flow rates under shared lane conditions are extremely complicated as explained in Section 4 of this user's guide. For the planning method application, minimum V/S values are computed assuming the shared lane is actually used exclusively by the movement. When a movement uses exclusive lanes only, the minimum V/S is its actual V/S. When a shared lane is involved, a movement group (e.g. right/through as a group) V/S is computed. The group V/S is then used in lieu of the V/S for the specific movement. However, this is modified in two respects:

(a) When the minimum V/S is greater than the group average, the minimum dictates the V/S value because the shared lane is, in reality, operating as an exclusive lane. When this is found to be the case, the user must modify the lane configuration, i.e., change the shared lane to the exclusive lane, and redo the analysis.

(b) When right turns are made from a shared lane only, the V/S for the right turn is computed as if the shared lane is an exclusive right-turn lane. This is reasonably accurate as right-turn vehicles will accumulate in the shared lane while through vehicles will shy away from the lane.

3.7 Shared Left-Right Lane and Single-Lane Approach

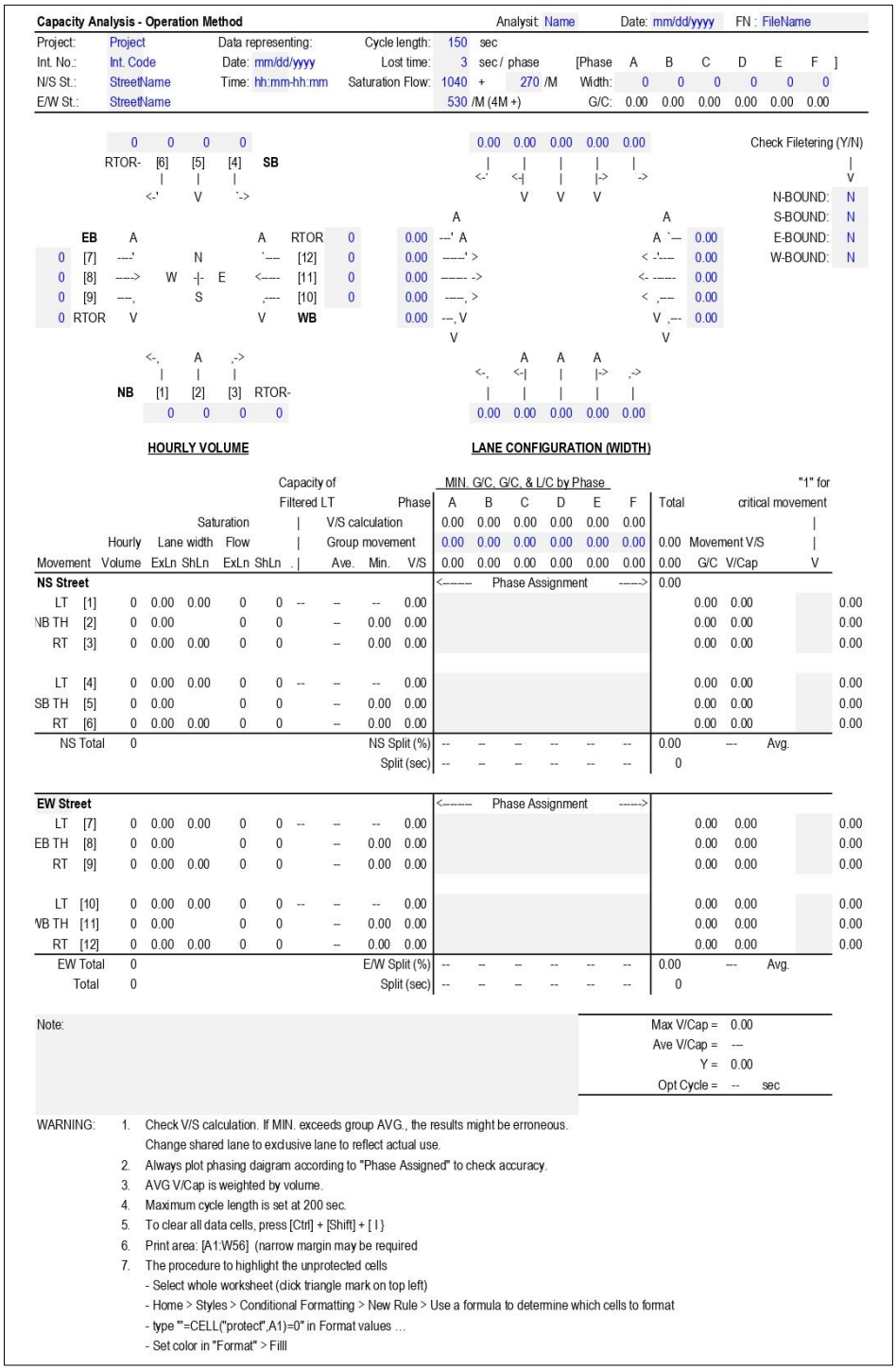
Where left and right-turns share a single-lane, either the left-turns or the right-turns must be treated as through traffic in order to fit into the template layout. If there is no opposing traffic, as at T intersections, either way, will work correctly. If there is opposing through traffic, the left-turns should be treated as through traffic.

For a single-lane approach, the single lane should be treated as a shared right-through lane. The template will automatically adjust the through volume to include the left-turn traffic.

4 CAPACITY ANALYSIS TEMPLATE – OPERATIONS METHOD

The organization of this template is similar to the planning method template, i.e., starting with a location and basic parameter section, followed by volume and lane configuration diagrams and an analysis section, and finally a “Notes” section.

Location, time, volume, and lane configuration data are entered exactly the same as with the planning template, but additional input data are required. Cycle length and lost time are self-explanatory. The others are discussed below.



Capacity Analysis - Operation Method — Analyst: Name — Date: mm/dd/yyyy — FN : FileName

Project:	Project		Data representing:		Cycle length:	150	sec										
Int. No.:	Int. Code		Date: mm/dd/yyyy		Lost time:	3	sec / phase		[Phase	A	B	C	D	E	F	]
N/S St.:	StreetName		Time: hh:mm-hh:mm		Saturation Flow:	1040	+	270 /M	Width:	0	0	0	0	0	0	
E/W St.:	StreetName					530	/M (4M +)		G/C:	0.00	0.00	0.00	0.00	0.00	0.00	

Check Filetering (Y/N)

N-BOUND: N
S-BOUND: N
E-BOUND: N
W-BOUND: N

HOURLY VOLUME — **LANE CONFIGURATION (WIDTH)**

MIN. G/C, G/C, & L/C by Phase

	A	B	C	D	E	F
Phase	0.00	0.00	0.00	0.00	0.00	0.00
V/S calculation	0.00	0.00	0.00	0.00	0.00	0.00
Group movement	0.00	0.00	0.00	0.00	0.00	0.00

"1" for critical movement

Movement	Hourly Volume	Saturation Flow: Lane width ExLn	ShLn	ExLn	ShLn	Capacity of Filtered LT: Ave.	Min.	V/S	Total	Movement V/S: G/C	V/Cap	"1" for critical movement: V
NS Street									<------ Phase Assignment ------>			
LT [1]	0	0.00	0.00	0	0	--	--	-- 0.00		0.00	0.00	0.00
NB TH [2]	0	0.00		0	0		--	0.00 0.00		0.00	0.00	0.00
RT [3]	0	0.00	0.00	0	0		--	0.00 0.00		0.00	0.00	0.00
LT [4]	0	0.00	0.00	0	0	--	--	-- 0.00		0.00	0.00	0.00
SB TH [5]	0	0.00		0	0		--	0.00 0.00		0.00	0.00	0.00
RT [6]	0	0.00	0.00	0	0		--	0.00 0.00		0.00	0.00	0.00
NS Total	0						NS Split (%)	-- -- -- -- -- --	0.00	---	Avg.	
							Split (sec)	-- -- -- -- -- --	0			
EW Street									<------ Phase Assignment ------>			
LT [7]	0	0.00	0.00	0	0	--	--	-- 0.00		0.00	0.00	0.00
EB TH [8]	0	0.00		0	0		--	0.00 0.00		0.00	0.00	0.00
RT [9]	0	0.00	0.00	0	0		--	0.00 0.00		0.00	0.00	0.00
LT [10]	0	0.00	0.00	0	0	--	--	-- 0.00		0.00	0.00	0.00
WB TH [11]	0	0.00		0	0		--	0.00 0.00		0.00	0.00	0.00
RT [12]	0	0.00	0.00	0	0		--	0.00 0.00		0.00	0.00	0.00
EW Total	0						E/W Split (%)	-- -- -- -- -- --	0.00	---	Avg.	
Total	0						Split (sec)	-- -- -- -- -- --	0			

Note:

Max V/Cap = 0.00
Ave V/Cap = ---
Y = 0.00
Opt Cycle = -- sec

WARNING:
1. Check V/S calculation. If MIN. exceeds group AVG., the results might be erroneous. Change shared lane to exclusive lane to reflect actual use.
2. Always plot phasing daigram according to "Phase Assigned" to check accuracy.
3. AVG V/Cap is weighted by volume.
4. Maximum cycle length is set at 200 sec.
5. To clear all data cells, press [Ctrl] + [Shift] + [| }
6. Print area: [A1:W56] (narrow margin may be required
7. The procedure to highlight the unprotected cells
   - Select whole worksheet (click triangle mark on top left)
   - Home > Styles > Conditional Formatting > New Rule > Use a formula to determine which cells to format
   - type '"=CELL("protect",A1)=0" in Format values ...
   - Set color in "Format" > Filll

Source: JPT

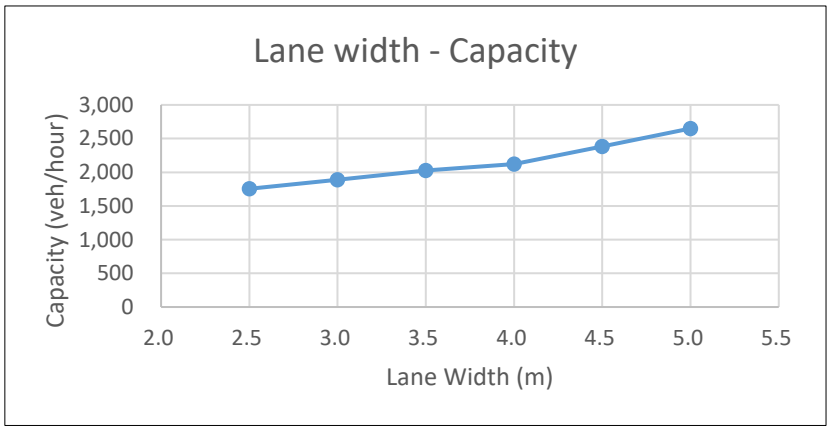
Figure 4.1: Intersection Capacity Analysis - Operations Method

4.1 Saturation Flow Rate

Saturation flow rates of protected movements under the operations method vary depending on the lane width. A base rate of 530 TCUs per meter is used for a lane width of 4 meters or wider. For lane widths between 2.5 and 4 meters, the following equation is used:

S = 1040 + 270 * W where W is the lane width in meters.

Thus, for a single 3-meter and double 3-meter lanes, the saturation flow rates are 1,850 TCUs and 3,180 TCUs respectively. The reduction in per meter rate for wider pavement is necessary to reflect uneven lane distribution of vehicles.



Source: JPT

Figure 4.2: Lane Width vs. Capacity

Saturation flow rate and left-turn capacity under filtered left-turn conditions are described in Sections 4.8 and 4.9.

4.2 Number of Phases

Signal phases are indicated in the template as “A” …”F”. The number of phases is limited to 6 (A to F).

4.3 Minimum G/C for Pedestrian

Where a pedestrian crosswalk is provided, the Green/Cycle (G/C) ratio must be long enough to allow pedestrians to walk across the street safely. This G/C ratio is a function of cycle length and length of pedestrian crossing or width of the carriageway. Enter the pedestrian crossing length for each applicable phase following the heading “Width.” The template computes the minimum G/C and transfers the data into the main analysis section under the heading “Min. G/C, G/C, L/C by Phase” for easy comparison with the actual G/C assigned to each phase.

Minimum G/C for pedestrians is based on a constant “Walk” period of 7 seconds and a flashing “Don't Walk” period which is required to walk from the departing curb face to within 1.5 meters of the curb face on the opposite side (It is normally assumed that pedestrians can finish the last 1.5 meters during the inter-green interval). A walking speed of 1.3 meters per second is assumed.

4.4 Filtering

Where left-turn movement is made through filtering (i.e., without a protected phase), it must be indicated by a "Y" under the heading "Check Filtering (Y/N)." The template is not designed to handle overlapping protective-permissive type phasing. In such cases, a conservative approach would be to ignore the permissive phase, i.e., assume left turns are made in the protected phase only. Based on the experience in the Philippines, the sequence of the protective-permissive left turn is not recommended as left-turning vehicles do not yield to opposing through traffic when the phase changes from protected to permissive.

4.5 G/C and L/C

The second and third rows of data cells under the headings of "Min. G/C, G/C ..." and "Ph.A Ph.B ..." display the actual Green/Cycle ratio assigned to each phase and the Lost Time/Cycle (L/C) ratio computed according to the previously specified lost time and cycle length. The assigned G/C (split) must be entered by the user. The total column is provided to ensure that the assigned G/C and the computed L/C total to one (1.00).

The computed V/S (Volume/Saturation Flow) values under the heading "Movement V/S" provide clues as to what initial G/C values should be tested. To achieve a V/Cap (Volume/Capacity) ratio of less than one, G/C must be greater than V/S for any movement.

By altering the G/C values (split) and the phase assignment, which is described in the next section, the user can find a combination that will produce the smallest V/Cap, a balanced V/Cap among the several movements, or the smallest average V/Cap for all movements. The ability to test different phasing and timing plans quickly is the main advantage of using the template; it does not automatically search for an optimum plan for the user.

4.6 Phase Assigned

The phasing plan is specified by the user under the heading "Phase Assignment" by entering a "1" in the appropriate cell of the movement-phase matrix. For example, a "1" in the upper-left corner cell indicates that a northbound left turn is assigned to Phase A and, conversely, a "0" or blank in this cell indicates that a northbound left-turn is not allowed in Phase A.

4.7 Volume/Capacity Ratio

To provide as much information to the user as possible, V/Cap is computed separately for each movement as well as for each direction and for the entire intersection. A timing plan which produces the lowest maximum V/Cap does not always produce the lowest average V/Cap. It is up to the user to decide which is the best measure to use in selecting the final design. For each movement, V/Cap is computed from:

$$V/Cap = \{V/S\}/\{G/C\}$$

4.8 Capacity of Filtered Left-turn Movement

The capacity of left-turn lanes under permissive left-turn conditions (i.e., filtering) is very difficult to estimate as many factors are involved, including volume level of opposing flow, the proportion of left-turning vehicles, amount of green time allocated to the movement, and lane configuration.

While manual procedures using various charts and tables may produce more accurate results, the benefits are often offset by human errors due to misunderstanding and complexity of the procedures. To overcome the problem in conducting capacity analysis, a somewhat simplified methodology has been developed to allow automatic calculation in the spreadsheet implementation of capacity analysis for signalized intersections.

(a) Capacity of Exclusive Left-turn Lane

Maximum left-turn volumes vary depending on the volume of opposing traffic, G/C ratio, and the number of approach lanes that the left-turning vehicles must travel across. The relationship is depicted in graphic format in Figures 2.1 to 2.3 of "Manual for the Design and Layout of Traffic Signals in the Philippines." Although the relationship is non-linear, a linear approximation is considered satisfactory within typical ranges of volume and G/C ratio. This linear approximation can be expressed as:

$$M(l) = 150 + \{1000-V(o)\}/2 - \{0.5-G/C\}*800 - \{60*\{N(o)-1\}\}$$

where, M(l) = Maximum volume (capacity) of left-turn lane,
V(o) = Volume (Vehicle/Hour) of opposing traffic,
G/C = Green over Cycle ratio (split), and
N(o) = Number of lanes in the opposing direction.

The equation can be simplified as:

$$M(l) = 310 - V(o)/2 + G/C*800 - 60*N(o)$$

Since pavement width is used throughout the spread-sheet application and M(l) has a minimum of 120 Vehicle/Hour, it is computed in the spreadsheet according to the following equation:

MAX(120,310-V(o)/2+G/C*800-(60*W(o)/3)) or,

MAX(120,310-V(o)/2+G/C*800-20*W(o))

where W(o) is the pavement width of the opposing direction and W(o)/3 is used to approximate the number of lanes.

Note that M(l) is not the saturation flow rate; it is the capacity of the left-turn lane for the given G/C. For this special condition, the normal V/S calculation is not carried out for the left-turn movement. The left-turn capacity is obtained as discussed above and V/Cap ratio for the left-turn movement is determined directly instead of from {V/S}/{G/C}.

(b) Capacity of Left-turns from Shared Lane

Where left turns are made from a shared through/left lane, the left-turn capacity would be expected to be less than what is determined from the above equation due to interference of through traffic in the shared lane. However, this reduction should be negligible except when the adjacent exclusive through lanes are heavily congested and the opposing through traffic is light. Under such conditions, a simultaneous left/through phasing would most likely be better which will provide a protected left turn without reducing the capacity. Consequently,

the above formulation for the capacity of an exclusive left-turn lane is also applied to cases where left-turn filtering is made from a shared left-through lane.

4.9 Saturation Flow Rate of Through Movement from Shared Lane

Where left-turns are filtered and are made from a shared left-through lane, the shared lane can be used by through traffic for a portion of the available green time when the lane is not obstructed by left-turning vehicles. This unobstructed green time varies depending on the degree of saturation of the left-turn movement. The maximum volume of through traffic per hour of green time which could make use of the shared lane (Saturation flow rate of through movement) may be estimated from the following:

$$Q(ts)= \{1-V(l)/M(l)\}*Q(t)$$

where, $Q(ts)$ = Saturation flow rate of through traffic in the shared lane,

$V(l)$ = Volume of left-turns in the shared lane,

$Q(t)$ = Saturation flow rate of through traffic in exclusive through lane,

and

$M(l)$ is as determined above.

4.10 Minimum and Group V/S

As explained in the planning method application, it is necessary to compute and compare minimum and group V/S values to ensure that a shared lane is not functioning as an exclusive lane. However, in the cases involving left-turn filtering, computing group V/S values for the left-turn and the through movements is no longer necessary because the saturation flow rates already reflect the filtering condition as described in Sections 4.8 and 4.9.

4.11 Optimum Cycle Length

Optimum cycle length is calculated using Webster's equation. To obtain this value, the user must identify the critical movements by entering a "1" in the spaces provided. Currently, the maximum cycle length is set at 200 seconds. If the template shows 200 seconds as the optimum cycle length, it indicates that the intersection is saturated and cannot process all demands resulting in the queue.

Webster's equation is expressed as follows:

$$Co = \frac{1.5L + 5}{1 - \sum(\frac{V}{S})}$$

Where:

Co = Optimum cycle length (sec)

L = Sum of the lost time for all phases, usually taken as the sum of the inter-green periods (sec)

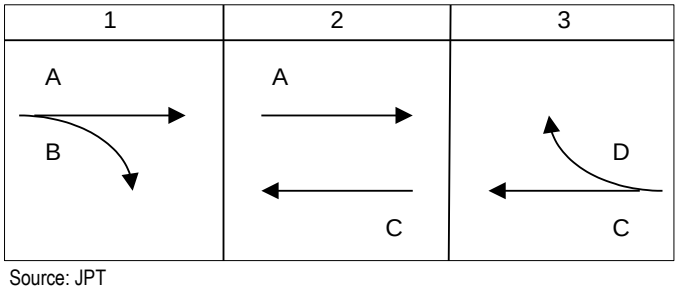
V/S = Ratio of the design flow rate to the saturation flow rate for the critical movement in each phase

If there is no overlap phasing, the critical movement for each phase is the movement that has the largest V/S value of all movements in that phase. If overlap phasing is used, however, the number of critical movements may be less than the number of phases and a movement with a large V/S value may not be critical if it can move in more than one phase. In the example below, movement A is not critical because the sum of the V/S values for movements B and C is greater than the sum for movements A and D. Furthermore, only movements B and C should be identified as critical even though there are three phases.

Table 4.1: Overlapping Phase

Movement	Phase	V/S
A	1+2	.35
B	1	.15
C	2+3	.32
D	3	.10

Source: JPT



Source: JPT

Figure 4.3: Traffic Phases