# PROBLEM STATEMENT

The aim of this project is to make a **Database for City Waste Collection & Recycling Management** that tracks waste bins, collection trucks, staff, and recycling plants. The database is normalized to the maximum extent to ensure data consistency, minimize redundancy, and provide useful analytics for efficient city waste management.

# ASSUMPTIONS

## ZONE

The city is divided into multiple **zones** (e.g., North, South, East, West). Each zone has a defined population and area. Waste bins, trucks, and staff are assigned to zones for proper division of work.

## BINS

Each zone contains multiple bins categorized by waste type (Plastic, Paper, Organic, Hazardous, General). Every bin has a fixed capacity and current fill level. When bins are full, they must be scheduled for collection by trucks.

## WASTE TYPES

Different waste types exist such as Plastic, Paper, Organic, Hazardous, and General. Some of these are recyclable while others are not. Each waste type has an associated disposal/processing method such as **Recycling, Composting, Landfill, or Incineration**.

## TRUCKS

Trucks are assigned to specific zones. Each truck has a unique number plate, capacity, and a shift schedule for collection. Trucks are responsible for collecting waste from bins and transporting it to the assigned processing plant.

## STAFF

Staff members are assigned to trucks to monitor and handle waste collection. Each staff has a role (Driver, Worker, Supervisor) and works in shifts.

## COLLECTION SCHEDULE

The city maintains a schedule for when bins will be collected. A schedule links bins, trucks, and staff for a given collection time. The status of each collection (Pending, Completed, Missed) is recorded.

## PROCESSING PLANTS

Different plants are responsible for handling collected waste. Types of plants include Recycling Plants, Composting Facilities, Incineration Units, and Landfills. Each plant has a processing capacity and location.

### RECYCLING REPORTS

Processing plants generate daily reports of waste received, amount recycled, and efficiency of recycling. These reports are stored for analysis.

### COMPLAINTS

Citizens can raise complaints regarding overflowing bins, delayed collection, or other waste-related issues. Each complaint is linked to a specific bin and zone.

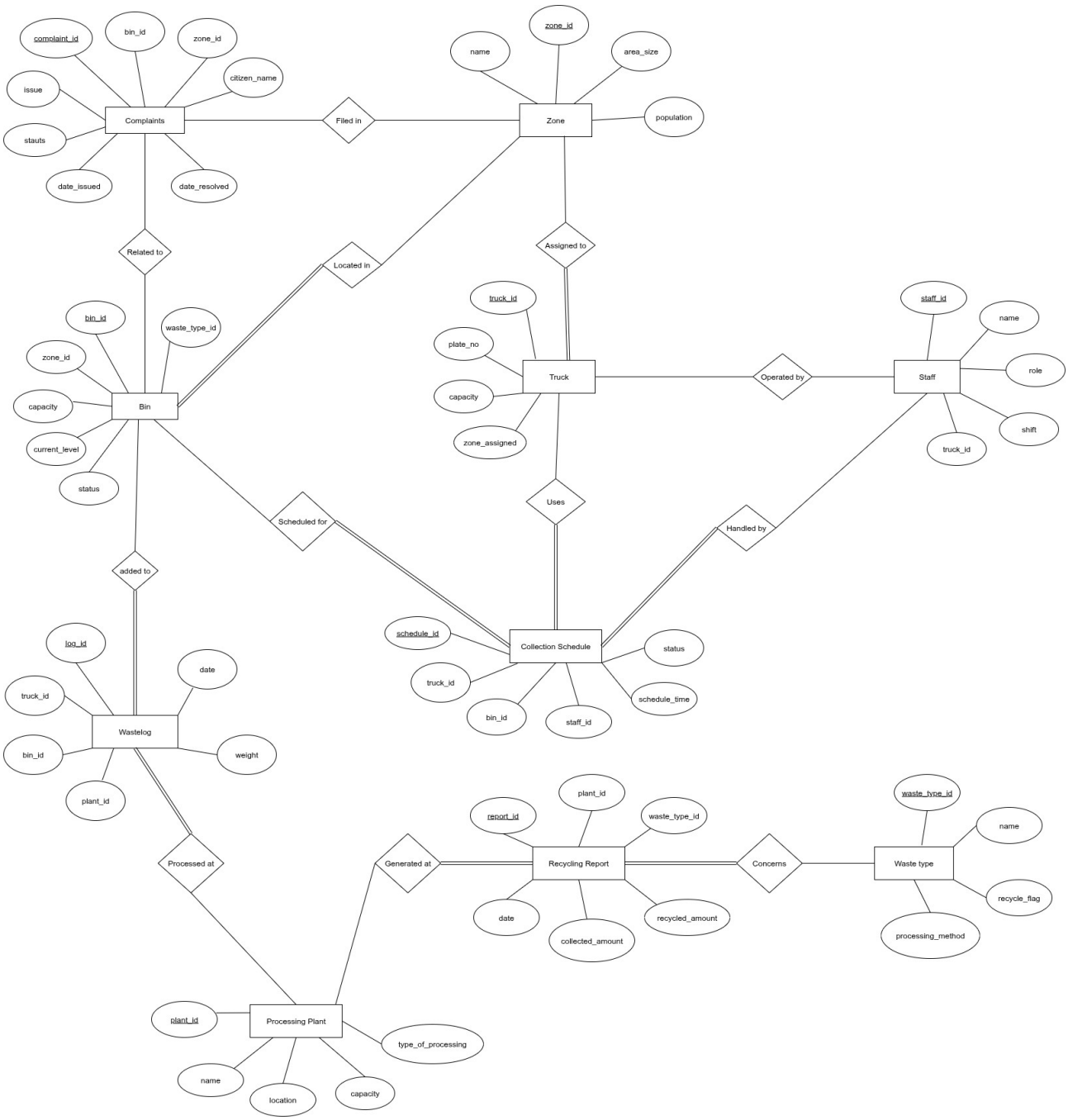
### WASTE LOGS

Every time waste is collected, a record is stored in the WasteLog table. It includes which truck collected from which bin, the weight of waste, the plant it was delivered to, and the collection date.

# FLOW OF PROCESS

1. The city is divided into multiple **zones**, each with its own bins for different waste types.
2. Waste bins are filled by citizens. Once bins near capacity, they are scheduled for collection.
3. A **truck with assigned staff** collects the waste from bins according to the schedule.
4. The collected waste is transported to a **processing plant** (Recycling, Composting, Incineration, or Landfill).
5. **Recycling reports** are generated by plants showing how much waste was collected and how much was successfully recycled.
6. Citizens can raise **complaints** if bins are not collected on time or are overflowing.
7. A **waste log** is maintained for every collection trip, recording bin, truck, weight, and plant details.

ER DIAGRAM:


complaint_id
bin_id
zone_id
citizen_name
issue
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date_issued
date_resolved
Complaints
Filed in
zone_id
name
area_size
population
Zone
Related to
Located in
Assigned to
bin_id
waste_type_id
zone_id
capacity
current_level
status
Bin
truck_id
plate_no
capacity
zone_assigned
Truck
Operated by
staff_id
name
role
shift
truck_id
Staff
Scheduled for
Uses
Handled by
added to
schedule_id
truck_id
bin_id
staff_id
Collection Schedule
status
schedule_time
log_id
truck_id
bin_id
plant_id
date
weight
Wastelog
Processed at
Generated at
report_id
plant_id
waste_type_id
date
collected_amount
recycled_amount
Recycling Report
Concerns
waste_type_id
name
recycle_flag
processing_method
Waste type
plant_id
name
location
capacity
type_of_processing
Processing Plant

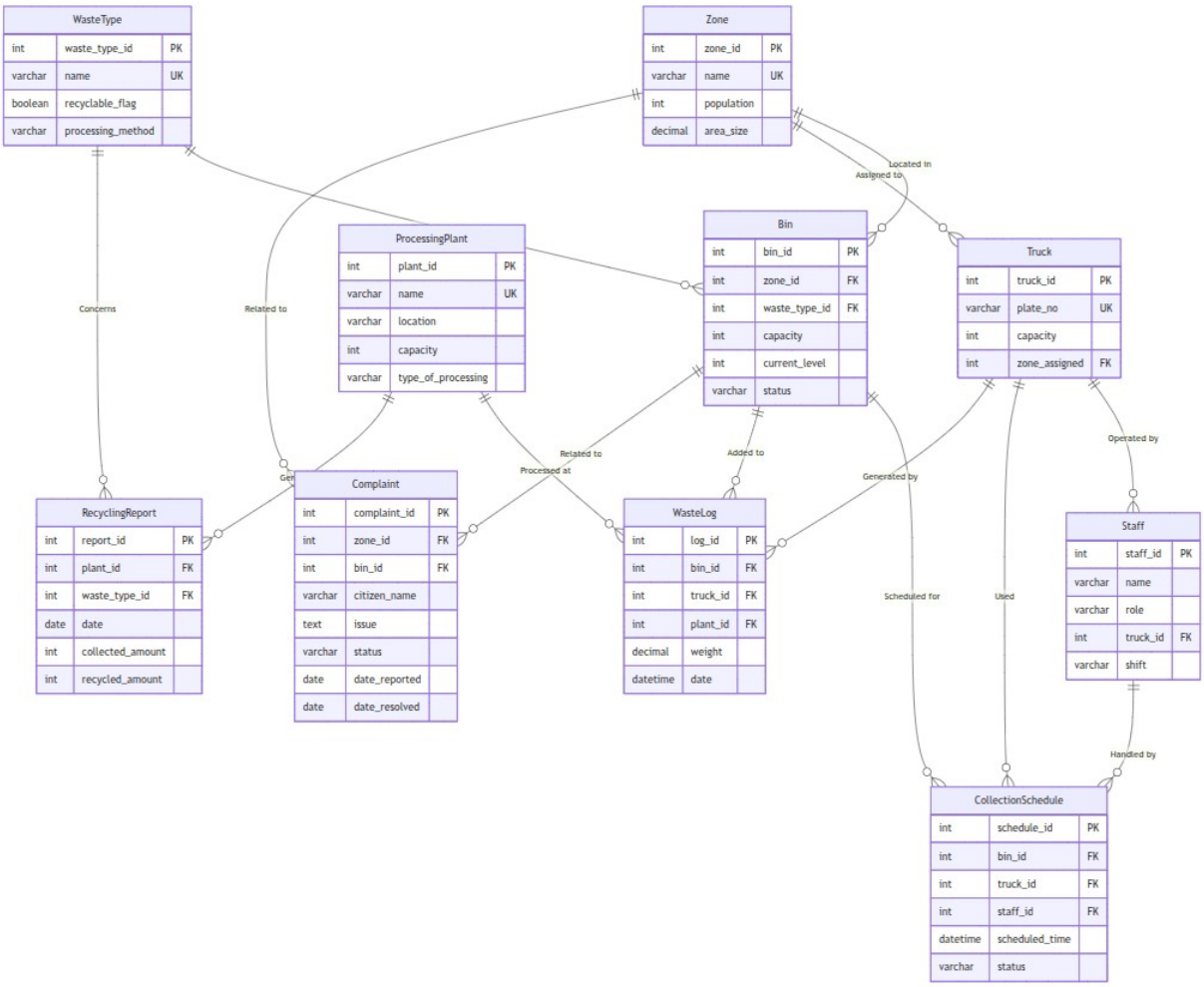
# ENTITIES

- Zone
- Bin
- WasteType
- Truck
- Staff
- CollectionSchedule
- ProcessingPlant
- RecyclingReport
- Complaint
- WasteLog

# Relations

- Filed in
- Related to
- Located in
- Assigned to
- Operated by
- Uses
- Handled by
- Scheduled for
- Added to
- Processed at
- Generated by
- Concerns

# Relational schema:




## FUNCTIONAL DEPENDENCIES AND TABLES BEFORE NORMALIZATION

1. **ZONE**
   `(zone_id, name, population, area_size)`
   FDs: `zone_id → name, population, area_size`
   **Normal Form: BCNF**

2. **WASTE TYPE**
   `(waste_type_id, name, recyclable_flag, processing_method)`
   FDs: `waste_type_id → name, recyclable_flag, processing_method`
   **Normal Form: BCNF**

3. **BIN**
   `(bin_id, zone_id, waste_type_id, capacity, current_level, status)`

FDs: `bin_id → zone_id, waste_type_id, capacity, current_level, status`

**Normal Form: BCNF**

4. **TRUCK**
   `(truck_id, plate_no, capacity, zone_id)`
   FDs: `truck_id → plate_no, capacity, zone_id`
   **Normal Form: BCNF**
5. **STAFF**
   `(staff_id, name, role, truck_id, shift)`
   FDs: `staff_id → name, role, truck_id, shift`
   **Normal Form: BCNF**
6. **COLLECTION SCHEDULE**
   `(schedule_id, bin_id, truck_id, staff_id, scheduled_time, status)`
   FDs: `schedule_id → bin_id, truck_id, staff_id, scheduled_time, status`
   **Normal Form: BCNF**
7. **PROCESSING PLANT**
   `(plant_id, name, location, capacity, type_of_processing)`
   FDs: `plant_id → name, location, capacity, type_of_processing`
   **Normal Form: BCNF**
8. **RECYCLING REPORT**
   `(report_id, plant_id, waste_type_id, date, collected_amount, recycled_amount)`
   FDs: `report_id → plant_id, waste_type_id, date, collected_amount, recycled_amount`
   **Normal Form: BCNF**
9. **COMPLAINT**
   `(complaint_id, zone_id, bin_id, citizen_name, issue, status, date_reported, date_resolved)`
   FDs: `complaint_id → zone_id, bin_id, citizen_name, issue, status, date_reported, date_resolved`
   **Normal Form: BCNF**
10. **WASTE LOG**
    `(log_id, bin_id, truck_id, plant_id, weight, date)`
    FDs: `log_id → bin_id, truck_id, plant_id, weight, date`
    **Normal Form: BCNF**

The tables in schema are already in BCNF so no further normalization is done.

# IMPLEMENTATION IN SQL

```
-- Zone Table
CREATE TABLE Zone (
    zone_id INT PRIMARY KEY,
    name VARCHAR(255) NOT NULL UNIQUE,
    population INT,
    area_size DECIMAL(10, 2)
);

-- WasteType Table
CREATE TABLE WasteType (
    waste_type_id INT PRIMARY KEY,
    name VARCHAR(255) NOT NULL UNIQUE,
    recyclable_flag BOOLEAN,
    processing_method VARCHAR(255)
);

-- Bin Table
CREATE TABLE Bin (
    bin_id INT PRIMARY KEY,
    zone_id INT NOT NULL,
    waste_type_id INT NOT NULL,
    capacity INT,
    current_level INT,
    status VARCHAR(50), -- e.g., 'Empty', 'Half-Full', 'Full', 'Overfilled', 'Maintenance'
    FOREIGN KEY (zone_id) REFERENCES Zone(zone_id),
    FOREIGN KEY (waste_type_id) REFERENCES WasteType(waste_type_id),
    CHECK (current_level >= 0 AND current_level <= capacity)
);
```

```
-- Truck Table
CREATE TABLE Truck (
    truck_id INT PRIMARY KEY,
    plate_no VARCHAR(20) NOT NULL UNIQUE,
    capacity INT,
    zone_assigned INT, -- FK to Zone
    FOREIGN KEY (zone_assigned) REFERENCES Zone(zone_id)
);

-- Staff Table
CREATE TABLE Staff (
    staff_id INT PRIMARY KEY,
    name VARCHAR(255) NOT NULL,
    role VARCHAR(100),
    truck_id INT, -- FK to Truck
    shift VARCHAR(50), -- e.g., 'Morning', 'Evening', 'Night'
    FOREIGN KEY (truck_id) REFERENCES Truck(truck_id)
);

-- CollectionSchedule Table
CREATE TABLE CollectionSchedule (
    schedule_id INT PRIMARY KEY,
    bin_id INT NOT NULL,
    truck_id INT NOT NULL,
    staff_id INT NOT NULL,
    scheduled_time DATETIME NOT NULL,
    status VARCHAR(50), -- e.g., 'Scheduled', 'In Progress', 'Completed', 'Cancelled'
    FOREIGN KEY (bin_id) REFERENCES Bin(bin_id),
    FOREIGN KEY (truck_id) REFERENCES Truck(truck_id),
    FOREIGN KEY (staff_id) REFERENCES Staff(staff_id)
);
```

```
-- ProcessingPlant Table
CREATE TABLE ProcessingPlant (
    plant_id INT PRIMARY KEY,
    name VARCHAR(255) NOT NULL UNIQUE,
    location VARCHAR(255),
    capacity INT,
    type_of_processing VARCHAR(255) -- e.g., 'Recycling', 'Composting', 'Incineration'
);

-- RecyclingReport Table
CREATE TABLE RecyclingReport (
    report_id INT PRIMARY KEY,
    plant_id INT NOT NULL,
    waste_type_id INT NOT NULL,
    date DATE NOT NULL,
    collected_amount INT,
    recycled_amount INT,
    FOREIGN KEY (plant_id) REFERENCES ProcessingPlant(plant_id),
    FOREIGN KEY (waste_type_id) REFERENCES WasteType(waste_type_id),
    CHECK (recycled_amount >= 0 AND recycled_amount <= collected_amount)
);

-- Complaint Table
CREATE TABLE Complaint (
    complaint_id INT PRIMARY KEY,
    zone_id INT, -- FK to Zone, can be null if complaint is not zone-specific
    bin_id INT, -- FK to Bin, can be null if complaint is not bin-specific
    citizen_name VARCHAR(255),
    issue TEXT NOT NULL,
    status VARCHAR(50), -- e.g., 'Open', 'In Progress', 'Resolved', 'Closed'
    date_reported DATE NOT NULL,
```

```
    date_resolved DATE,
    FOREIGN KEY (zone_id) REFERENCES Zone(zone_id),
    FOREIGN KEY (bin_id) REFERENCES Bin(bin_id)
);

-- WasteLog Table
CREATE TABLE WasteLog (
    log_id INT PRIMARY KEY,
    bin_id INT NOT NULL,
    truck_id INT NOT NULL,
    plant_id INT NOT NULL,
    weight DECIMAL(10, 2) NOT NULL,
    date DATETIME NOT NULL,
    FOREIGN KEY (bin_id) REFERENCES Bin(bin_id),
    FOREIGN KEY (truck_id) REFERENCES Truck(truck_id),
    FOREIGN KEY (plant_id) REFERENCES ProcessingPlant(plant_id),
    CHECK (weight > 0)
);
```

# INSERTION OF VALUES INTO DATABASE

```
-- Zone Data
INSERT INTO Zone (zone_id, name, population, area_size) VALUES
(1, 'North District', 50000, 10.5),
(2, 'South District', 75000, 15.2),
(3, 'East District', 60000, 12.0),
(4, 'West District', 45000, 8.7);

-- WasteType Data
INSERT INTO WasteType (waste_type_id, name, recyclable_flag, processing_method) VALUES
(101, 'General Waste', FALSE, 'Landfill'),
(102, 'Recyclable Plastic', TRUE, 'Recycling'),
(103, 'Recyclable Paper', TRUE, 'Recycling'),
(104, 'Organic Waste', TRUE, 'Composting'),
(105, 'Hazardous Waste', FALSE, 'Special Disposal');

-- Bin Data
INSERT INTO Bin (bin_id, zone_id, waste_type_id, capacity, current_level, status) VALUES
(1001, 1, 101, 1000, 850, 'Full'),
(1002, 1, 102, 500, 200, 'Half-Full'),
(1003, 1, 103, 500, 450, 'Full'),
(1004, 2, 101, 1200, 1100, 'Full'),
(1005, 2, 104, 600, 300, 'Half-Full'),
(1006, 2, 102, 500, 100, 'Empty'),
(1007, 3, 101, 1000, 700, 'Half-Full'),
(1008, 3, 103, 500, 400, 'Half-Full'),
(1009, 3, 105, 300, 250, 'Full'),
(1010, 4, 101, 1000, 900, 'Full'),
(1011, 4, 102, 500, 350, 'Half-Full'),
(1012, 4, 104, 600, 550, 'Full');
```

```
-- Truck Data
INSERT INTO Truck (truck_id, plate_no, capacity, zone_assigned) VALUES
(501, 'ABC-123', 5000, 1),
(502, 'DEF-456', 6000, 2),
(503, 'GHI-789', 5500, 1),
(504, 'JKL-012', 7000, 3),
(505, 'MNO-345', 6500, 2);

-- Staff Data
INSERT INTO Staff (staff_id, name, role, truck_id, shift) VALUES
(201, 'Alice Smith', 'Driver', 501, 'Morning'),
(202, 'Bob Johnson', 'Collector', 501, 'Morning'),
(203, 'Charlie Brown', 'Driver', 502, 'Evening'),
(204, 'Diana Prince', 'Collector', 502, 'Evening'),
(205, 'Ethan Hunt', 'Driver', 503, 'Morning'),
(206, 'Fiona Glenanne', 'Collector', 503, 'Morning'),
(207, 'George Jetson', 'Driver', 504, 'Night'),
(208, 'Hannah Montana', 'Collector', 504, 'Night'),
(209, 'Ian Malcolm', 'Driver', 505, 'Evening'),
(210, 'Jane Doe', 'Collector', 505, 'Evening');

-- CollectionSchedule Data
INSERT INTO CollectionSchedule (schedule_id, bin_id, truck_id, staff_id, scheduled_time, status)
VALUES
(3001, 1001, 501, 201, '2025-08-28 08:00:00', 'Completed'),
(3002, 1002, 503, 205, '2025-08-28 09:00:00', 'Completed'),
(3003, 1003, 501, 202, '2025-08-28 10:00:00', 'Completed'),
(3004, 1004, 502, 203, '2025-08-28 11:00:00', 'Completed'),
(3005, 1005, 505, 209, '2025-08-28 12:00:00', 'Completed'),
(3006, 1006, 502, 204, '2025-08-28 13:00:00', 'Completed'),
(3007, 1007, 504, 207, '2025-08-28 14:00:00', 'Completed'),
(3008, 1008, 504, 208, '2025-08-28 15:00:00', 'Completed'),
```

(3009, 1009, 504, 207, '2025-08-28 16:00:00', 'Completed'),

(3010, 1010, 505, 210, '2025-08-28 17:00:00', 'Completed'),

(3011, 1011, 505, 209, '2025-08-28 18:00:00', 'Completed'),

(3012, 1012, 502, 204, '2025-08-28 19:00:00', 'Completed');

-- ProcessingPlant Data

INSERT INTO ProcessingPlant (plant_id, name, location, capacity, type_of_processing) VALUES

(701, 'Central Recycling Facility', '123 Recycle Way', 10000, 'Recycling'),

(702, 'North Compost Center', '456 Compost Lane', 5000, 'Composting'),

(703, 'West Hazardous Waste Site', '789 Hazard Road', 2000, 'Special Disposal');

-- RecyclingReport Data

INSERT INTO RecyclingReport (report_id, plant_id, waste_type_id, date, collected_amount, recycled_amount) VALUES

(4001, 701, 102, '2025-08-27', 1500, 1200),

(4002, 701, 103, '2025-08-27', 2000, 1800),

(4003, 702, 104, '2025-08-27', 3000, 2800),

(4004, 701, 102, '2025-08-26', 1400, 1150);

-- Complaint Data

INSERT INTO Complaint (complaint_id, zone_id, bin_id, citizen_name, issue, status, date_reported, date_resolved) VALUES

(6001, 1, 1001, 'John Doe', 'Bin is overflowing and smells bad.', 'Open', '2025-08-27', NULL),

(6002, 2, 1004, 'Jane Smith', 'Recycling bin not collected on schedule.', 'Open', '2025-08-28', NULL),

(6003, 1, NULL, 'Peter Jones', 'Street cleaning needed in North District.', 'Resolved', '2025-08-26', '2025-08-27'),

(6004, 3, 1009, 'Mary Brown', 'Hazardous waste bin is damaged.', 'Open', '2025-08-28', NULL),

(6005, 4, 1010, 'David Lee', 'General waste bin is full.', 'Resolved', '2025-08-27', '2025-08-28');

-- WasteLog Data

INSERT INTO WasteLog (log_id, bin_id, truck_id, plant_id, weight, date) VALUES

(5001, 1001, 501, 703, 850.50, '2025-08-28 08:15:00'),

(5002, 1002, 503, 701, 200.75, '2025-08-28 09:30:00'),

(5003, 1003, 501, 703, 450.00, '2025-08-28 10:15:00'),

(5004, 1004, 502, 702, 1100.20, '2025-08-28 11:30:00'),

(5005, 1005, 505, 702, 300.00, '2025-08-28 12:45:00'),

(5006, 1006, 502, 701, 100.50, '2025-08-28 13:15:00'),

(5007, 1007, 504, 703, 700.00, '2025-08-28 14:30:00'),

(5008, 1008, 504, 701, 400.00, '2025-08-28 15:30:00'),

(5009, 1009, 504, 703, 250.00, '2025-08-28 16:15:00'),

(5010, 1010, 505, 701, 900.00, '2025-08-28 17:30:00'),

(5011, 1011, 505, 701, 350.00, '2025-08-28 18:30:00'),

(5012, 1012, 502, 702, 550.00, '2025-08-28 19:30:00');