INFORMATION SYSTEM FOR SOLID WASTE COLLECTION MANAGEMENT: CASE STUDY OF SALAYA MUNICAPALITY, PHUTTAMONTHON, NAKHONPATHOM PROVINCE

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ABSTRACT

The objectives of this study were to develop an information system for solid waste collection management in Salaya municipality, Phuttamonthon, Nakhonpathom province, Thailand, and to study and compile data from the solid waste collection routing system operating in Salaya municipality by using a Geographic Information System (GIS). Visual basic 6.0 was used for information development and information system quality development and work was based on comments and suggestions from academics and government officials from the field of waste management, and randomly selected user's assessment results. The implemented and developed information system was well accepted and could be applicable in solid waste collection management.

The study of solid waste collection route suitability for Salaya municipality found that the new truck collection route reduces the total distance of the solid waste collecting by up to 5796.20 kilometers per year, or 19.73 % of the existing route. This research identified problems based on what happens in garbage collection in Salaya Municipality. If there are any changes in the future that affect the route collection management modifications have to be done to accommodate it. Furthermore, new conditions such as time, seasons, and traffic should be considered in future route planning.

From the study, it was found that an information system to support garbage collection can enable better related garbage data management concerning, for example, garbage bin use, garbage collection points and trucks and related statistical values. Searches can be done and reports can be presented in terms of paper reports and graphics presentations. The author has created a user interface for ease of use and convenience. It can be used to assist in decision making and monitoring and planning better garbage management.

ระบบสารสนเทศเพื่อการจัดการการเก็บขนมูลฝอย กรณีศึกษา: เทศบาลตำบลศาลายา อำเภอพุทธมณฑล จังหวัดนครปฐม (INFORMATION SYSTEM FOR SOLID WASTE COLLECTION MANAGEMENT: CASE STUDY OF SALAYA MUNICAPALITY, PHUTTAMONTHON, NAKHONPATHOM PROVINCE)

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บทคัดย่อ

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อ พัฒนาระบบสารสนเทศเพื่อการจัดการการเก็บขนมูลฝอย สำหรับเทศบาลตำบลศาลายา อำเภอพุทธมณฑล จังหวัดนครปฐม และการจัดเส้นทางการเก็บขนมูลฝอยที่เหมาะสมให้กับเทศบาลตำบลศาลายา โดยใช้ระบบสารสนเทศภูมิศาสตร์เข้ามาช่วยในการจัดหาเส้นทางที่เหมาะสม และใช้โปรแกรม Visual Basic 6.0ในการพัฒนาระบบสารสนเทศ และพัฒนาคุณภาพของระบบด้วยการปรับปรุงแก้ไขตามการประเมินของผู้เชี่ยวชาญและผู้ใช้ จนระบบสารสนเทศที่พัฒนาขึ้นได้รับการยอมรับว่ามีคุณภาพ สามารถนำไปใช้ได้

ผลการศึกษาการจัดเส้นทางการเก็บขนที่เหมาะสมสำหรับเทศบาลตำบลศาลายา พบว่าเส้นทางเดินรถเก็บขนใหม่ที่ได้ ช่วยลดระยะทางรวมในการเดินรถได้ 5796.20 กิโลเมตรต่อปี คิดเป็นร้อยละ 19.73 % ของระยะทางเดิม ซึ่งการศึกษาครั้งนี้ได้มีการกำหนดปัจจัยและเงื่อนไขในการศึกษา ภายใต้สภาพการดำเนินงานในปัจจุบันของเทศบาลตำบลศาลายา ซึ่งในอนาคตหากมีปัจจัยอื่นๆ ที่เกี่ยวข้องและมีผลต่อการจัดเส้นทาง ควรนำปัจจัยเหล่านั้นมาใช้ในการวิเคราะห์ด้วย เช่น การนำปัจจัยด้านเวลา ฤดูกาล และการจราจรมาพิจารณาร่วมด้วย

ผลการพัฒนาระบบสารสนเทศเพื่อการจัดการการเก็บขนพบว่า ระบบสามารถช่วยให้มีการจัดเก็บฐานข้อมูลถังขยะ จุดเก็บขน และรถเก็บขน รวมถึงข้อมูลสถิติที่เกี่ยวข้องไว้ได้อย่างมีระบบ สามารถสืบค้นข้อมูล และนำเสนอรายงานทั้งในรูปแบบรายงาน และกราฟ ทั้งนี้ได้ออกแบบระบบไว้เพื่อให้เกิดความสะดวก รวดเร็ว และง่ายต่อการใช้งานระบบ ซึ่งสามารถนำระบบสารสนเทศที่ได้ไปช่วยสนับสนุนการตัดสินใจ การติดตามตรวจสอบ การวางแผน การจัดการเก็บขนมูลฝอยที่เหมาะสมได้ต่อไป

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CHAPTER 1
INTRODUCTION

1.1 Background

Economy and social statement that have been non-limit developed originate many effect of environmental problems such as water pollution problems, air pollution, solid waste pollution increasing. All of this, If those problems lacking a good manage, it also originate effect on other surrounding. About solid waste management, it has both difficult methods and complicate persuader. It means planning, compilation truck, and transportation and elimination persuader. In case of budget, the most budget were used in transportation persuaders. Expenditures of transportation comprise with labor fees, traveling fees, maintenance fees. So, If that system is defective managed, potentiality of transportation will decrease. In the other hand, If it have good manage, total expenditures will decrease and community also clean, have no germ-spread source. Solid waste collection route management is one of the factors that there are effects on solid waste collection route. That means, If each solid waste truck have a good route management and clearly zone, it will decrease distance and times for operating. Finally, total expenditures will decrease.

Normally, drivers or chift of cleaners often manage route. They often use or think about it by themselves. It always absents academic rule. Therefore, that route is not the best route and that it can overlap each other. Moreover, it has limit of time ; more expenditure and time are lost. To revise this problems, should finding the short distance and times, and less route that overlap. All of these, could consider to correct rule and many factors such as solid waste collection points, quantity of solid waste, period of time that will be spent for this process, form or method of this process ,etc.

In this research close up to find guideline and solve solid waste routing problem by apply with information technology, limit point collecting solid waste for each

trucks and arrange appropriate way for its. Target of all for balance each truck to their responsibility zone, short distance and times for solid waste collection.

In this case study, researcher chooses Salaya municipality, phuttamonthon, and Nakhonpathom to be case study area. Since there are diversity of land use, clearly responsibility zone for solid waste collection and it have no complication of communication network.

Futhermore, there is a problem in solid waste management. Especially, solid wastes collection ; have been no studied, analyzed and planed to appropriate way system for trucks. Completely hardware and software of many office that support this research, support from administer who require develop solid waste collection system to correct and appropriate system that help Salaya municipality development are the important factors which persuade researcher operating this case at this place.

1.2 Objectives

1.2.1 Develop information   system to appropriate solid waste collection management.

1.2.2 To study and compile data from solid waste collection routing system operating of Salaya municipality.

1.2.3 To present appropriate ways and method for solid waste collection management.

1.3 Scope of Study

1.3.1 Case study area

Salaya municipality, Puttamontol, and Nakhonpathom have total areas is 13 k.m.^{2} Since this case study cover it.

1.3.2 Solid waste collection routing system study

Solid waste collection routing system comprised with many procedures. However, this case study was determined only solid waste collection. That mean, study about shortest and appropriate route for each solid waste truck of Salaya municipality. Factors of this study were limited at concerned data as follows:

- Road network system of Salaya municipality.

- Solid waste collection points.

- Quantity of solid waste at solid waste collection points.

- Period of time that will be spent for this process.

- Forms or methods of this process.

- Size of solid waste truck

- The current responsibility zone of each solid waste truck.

- The current route.

1.3.3 Information system development

This case study will be developed information system to appropriate solid waste collection management for users or persons who concern with solid waste collection management planning by network analysis of Geographic information system. All of these , develop this output to information system that support appropriate solid waste collection management.

1.4 Excepted Usefulness

1.4.1 Information systems for appropriate solid waste collection management.

1.4.2 To know about solid waste collection routing operating form of Salaya municipality.

1.4.3 It will be guideline on operating planning for solid waste collection routing of Salaya municipality

CHAPTER 2
LITERATURE REVIEW

2.1 Solid Waste

2.1.1 Meaning of Solid Waste.

From a member of The Royal Institute Dictionary, 1982 defined a solid waste is a remains that are desert, and waste is solid waste. From this text can see the same meaning of them and it can be used replace each other.

Public Health legislation Law since 1992 that refers to waste disposal, waste, and garbage, defines waste as follows:

Waste means scraps of paper, rags, and food particles, fragments of plastic bag, ash, excrement or carcasses, in clouding refuse from roads, market places, farms or other places.

In academic matter always use solid waste in case of anything that is wanted. The most of them are a solid that rotten include remains of animals, animal's rubbish, dust, and remains from household or from some place such as public places, markets and industrial factory except feces and urine of human:

Solid wastes are all the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. This term is inclusive and it encompasses the heterogeneous mass of throwaways from residential and commercial sources as well as the more homogeneous accumulation of a single industrial activity, which described by Peavy, Rowe and Tchobanoglous (1988).

The National Demonstration Water Project (1982) defined the meaning of solid wastes that are garbage, rubbish, animal manure, dead animals and ashes.

2.1.2 Sources and Types of Solid Wastes (Tchobanoglous, Theisen and Vigil,1993)

2.1.2.1 Sources of Solid Wastes

Knowledge of the sources and types of solid wastes, along with data on the composition and rates of generation is basic to the design and operation of the functional elements associated with the management of solid wastes.

Sources of solid wastes in a community are, in general, related to land use and zoning. Although any number of source classifications can be developed, the following categories are useful:

- Residential
- Commercial
- Institutional
- Construction and demolition
- Municipal services
- Treatment plant sites
- Industrial
- Agricultural

Typical waste generation facilities, activities, or locations associated with each of these sources are reported in Table 2-1 , where municipal solid waste (MSW) is normally assumed to include all community wastes with the exception of industrial process wastes and agricultural wastes.

2.1.2.2 Types of Solid Wastes

As a basis for subsequent discussions, it will be helpful to define the various types of solid wastes that are generated (see Table 2-1). (t is important to be aware that the definitions of solid waste terms and the classifications vary greatly in the literature and in the profession. Consequently, the use of published data requires considerable care, judgment, and common sense. The following definitions are intended to serve as a guide and are not meant to be precise in a scientific sense.

Table 2-1 Sources of solid wastes within a community

Source	Typical facilities, activities, or locations where wastes are generated	Types of solid wastes
Residential	Single family and multifamily detached dwellings, low-, medium-, and high-rise apartments, etc.	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, tin cans, aluminum, other metals, ashes, street leaves, special wastes (in-clouding bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires), household hazardous wastes
Commercial	Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops, etc.	Paper, cardboard, plastics, wood, food waste, glass, metals special wastes (see above), hazardous wastes, etc.
Institutional	Schools, hospitals, prisons, governmental centers	As above in commercial
Construction and demolition	New construction sites, road repair/renovation sites, razing of buildings, broken pavement	Wood, steel, concrete, dirt, etc.
Municipal services (excluding treatment Facilities)	Street cleaning, landscaping, catch basin cleaning, parks and beaches, other recreational areas	Special wastes, rubbish, street sweepings, landscape and tree trimmings, catch basin debris, general wastes from parks, beaches, and recreational areas

Table 2-1 Sources of solid wastes within a community (continued)

Source	Typical facilities, activities, or locations where wastes are generated	Types of solid wastes
Treatment plant sites; municipal incinerators	Water, wastewater, and industrial treatment processes, etc.	Treatment plant wastes, principally composed of residual sludge
Municipal solid waste [a]	All of the above	All of the above
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Industrial process wastes, scrap materials, etc. Non-industrial wastes including food wastes, rubbish, ashes, demolition and construction wastes, special wastes, hazardous wastes
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlots, farms, etc.	Spoiled food waste, agricultural wastes, rubbish, hazardous wastes

[a] The term municipal solid waste (MSW) normally is assumed to include all of the wastes generated in a community with the exception of industrial process wastes and agricultural solid wastes.

2.1.3 Classification of Solid Wastes

According to the above definition of municipal solid wastes can be classified as presented in Table 2-2.

Table 2-2 Classification of Materials comprised in Municipal Solid Wastes

Components	Description
Food wastes	The animal, fruit, or vegetable residues (also called garbage) resulting from the handling, preparation, cooking, eating of foods. Because food wastes are putrefiable, they decompose rapidly, especially in warm weather.
Rubbish	Combustible and noncombustible solid wastes, excluding food wastes of other putrefiable materials. Typically, combustible rubbish consists of materials such as paper, cardboard, plastics, textiles, rubber, leather, wood furniture, and garden trimmings. Noncombustible rubbish consists of items such as glass, crockery, tin cans, aluminum cans, ferrous and non-ferrous metals, dirt, and construction wastes.
Ashes and residues	Materials remaining from the burning of wood coal, coke and other combustible wastes. Residues from paper plants normally are not included in this category. Ashes and residues are normally composed of fine, lowery materials, cinders, clinkers, and small amounts of burned and partially burned materials.
Demolition	Wastes from razed buildings and other structures construction wastes are classified as demolition wastes. Wastes from the construction, remodeling, and similar structures are classified as construction wastes. These wastes may include dirt, stones, concrete, bricks, plaster, lumber, shingles, and plumbing, heating and electrical parts.

Table 2-2 Classification of Materials comprised in Municipal Solid Wastes (continued)

Components	Description
Special wastes	Wastes such as street sweeping, roadside litter, catch-basin debris, dead animals and abandoned vehicles are classified as special wastes.
Treatment-plant wastes	The solid and semi-solid wastes from water, wastewater, and industrial waste treatment facilities are included in this classification.

Source: Peavy, Rowe, and tchobanoglous (1988).

2.1.4 The Factors that There are Effect on Amount and Character of Solid Waste

From case study of Narong NaChiangmai (1987) can see amount and character of solid waste relate with influence of any factors as follow:

1. Climate

If climate are more difference amount and type of solid waste also difference such as in case of country in tropical zone, many fresh solid waste more easy to rotten than the same types in cold climate zone.

2. Season

It means the season that happens by nature. In case of countries that located in cold climate zone, have more an ash than in normal conditions. At the same way in autumn season, there is dry solid waste increasing.

3. Geographical location

It means any place in each source, as beside sea have more remains of fish or shell than other solid wastes. In case of landform that is forest and tableland as Northeast of Thailand have more leaf remainder than other solid wastes.

4. Habit and scale of living

It means habit of each person. In case of persons who like beauty and clean, they always disposal solid waste. But in persons who are careless man, they are opposite.

5. Nature of community

It means general condition Appearance of these communities as types and amount of solid waste are much in shopping center or communities where there are non-facility communication, dense population and population in these communities have no knowledge in correct method for get rid of solid waste.

6. Economic period

It means economic condition of people in that time. When the economic have a good dissection, people have much money for buying service and goods therefore, remain will increase.

7. Efficiency of collection service

Municipality or sanitation manages this case. If solid wastes are frequency collected, its amount will decrease.

2.1.5 Solid Waste Collection System

General solid waste management is considered by the activities associated with the management of solid wastes from the point of generation to final disposal have been grouped into the six functional elements (Tchobanoglous, Theisen and Vigil, 1993):

1. Generation of solid waste
2. Onsite handling storage
3. Collection of solid waste
4. Transfer and Transport
5. Processing and Recovery
6. Disposal of solid waste

Since this research is solid waste collection routing study, therefor, in this research doesn't refer to processing, recovery, and disposal of solid waste.

Character or form of collecting are comprise with:
1. House to Can
2. Can to Truck
3. Truck form House to House
4. Truck to Transfer or Disposal Points

Thus, in case of solid waste collection system, it is activities that begin at produce or desert a solid waste to a vessel, then work lead that vessel to truck may be they transfer that vessel to disposal points or collecting at transfer station. After that, those solid wastes are disposed.

Solid waste collection routing system operation

This system has a procedure as follows:

1. Studying basic data as areas, route, and amount of solid waste. These data are necessary before hand.

　　1.1 Responsible zone as:

　　　　- All areas of that community

　　　　- Density of population in each areas

　　　　- Activity's character of population in each areas as domestic source, commercial areas, and industry zone, etc.

　　1.2 Amount of solid waste as:

　　　　- Amount of solid waste in each collection points

　　　　- Amount of collection point on each areas each ways

　　1.3 Route

　　　　- Wide, long of each way

　　　　- Routing character on each ways such as zone of one ways, don't turn, etc.

　　　　- Density of traffic in normal time and rush hours

2. Collection point limiting

　　After studying that data, then apply it in collection point limiting consideration for surely way: where are road that can limit garbage can, or where are home that worker must to collect a waste form there, a garbage can should be totally single: how many its capacity, distance between each points.

3. Method of solid waste collection limiting

　　After limit points for collecting should to limit method for collecting. Incase of country in Asia always use 4 types that are:

3.1 Collecting from total garbage can

In this case, local provided garbage can on many by appropriation such as the place where located on cross road, it necessary to use total garbage can.

3.2 Collection from domestic source

In this case, the truck always parking at one point, then people in these sources will give up their waste. This method, it mustn't have garbage can and comfortable for worker.

3.3 Collection from vessels on foot-path

In this case, people take their vessels to footpath before collecting this method, it isn't polite.

3.4 Workers take solid waste from each home and pouring it to the truck

In this case, it's expensive and use more time but it has no lose garbage can problem and polite.

4. Routing

It's important procedure difficult. Shoal use more the time and many techniques help operation.

Solid Waste Collection Routing

1. Signification of Solid waste collection routing

When community had expanded, responsible areas of these communities were increase. If the ways aren't adjusted, some waste truck were will have responsibility and use more times on their work.

For those reasons, the results of it will not balance or may be overlap ways will happens, it lead to taking times and use expensive of the expenditure.

In case of capable solid waste collection routing, all of workers must have as some as time and responsible areas on solid waste collection.

2. Characters of routing problem

Routing problem is the problem that responds requirement of any points of transportation net work by travelling by automobile. This problem has characters as follows:

2.1   Amount of customer from any where want a goods that there are surely amount from some where

In this implication, it is amount of collection points at anywhere and amounts of solid wastes that there are standing amount at that points which waiting that collection by waste truck.

2.2   One automobile can't respond requirement of all point since there are limit of capability on loading and time for work.

In this implication, waste truck can't collect whole solid waste because it is limited on capability of loading, that enter to collection points and operating time.

2.3 Objective of problem in order to finding amount of waste truck and planning ways of these waste truck. All of this, it for respond customer's requirement at any points under shortest ways.

In this implication, it's limiting amount of waste truck and planning ways for collecting solid waste at anywhere under shortest ways or routing in case of amount of waste which are limited in order to the most collecting solid waste under shortest ways.

3. Factors that there are effect on solid waste collection routes

Solid waste collection routing has a concerned factors and effect on many factors of operation as:

3.1 Amount of solid waste

In case of amount of solid waste on each point, many rounds must collect many solid wastes. It's expensive expenditure.

3.2 Capacity of waste truck

Much capacity of waste truck led too much capability of collecting. It expand scope of collecting, there fore the way will be changed.

3.3 Amount of collecting round on each day

More solid waste contribute to more rounds for collecting

3.4. Frequency of collecting per week

Frequency of collecting depends on amount of solid waste. If some where has more solid waste (raw-food market, shopping mall) may be it must to collecting to 2

rounds under everyday. But some communities where there are a little of solid waste, it must to collecting only 1-2 times per week.

3.5 Amount of collecting points

More collecting point lead to overlap ways and longer distance especially dissipated collection points

3.6 Traffic condition

Traffic condition has and effect on routing. Thus, it should be studied about traffic condition before hand as waste truck run follows traffic route. If the traffic is changed, that way for collecting will be changed. In case of selecting way for collecting, always choose the roads that there are dexterously.

3.7 Collection behavior

In this case, habit and operation method of worker are comprised with an accident during working, a simple on operating, material using, harmony with user, solid wastes separating, collecting method lose time during collecting.

Besides Bodin and his team (1983) separated character of routing and manage timetable for use to be concept on studying as table 2-3

Table 2-3 Character of routing problem

Character	Conditions
1. Amount of waste truck	- 1 - More than 1
2. Type of waste truck	- 1 type - More than 1 types
3. Office	- 1 point - More than 1 points
4. Character of service requirement	- Deterministic - Stochastic
5. Service point for user	- Node - Arc - Mixed

Table 2-3 Character of routing problem (continued)

Character	Conditions
6. Character of network	- Have no direction - Have direction - Mixed
7. Capacity of waste truck	- 1 - more than 1 - none
8. maximum time	- Same in all route - Differential each route - none
9. Operating	- Pickup - Deliveries - Mixed
10. Expenditure	- Variable cost - Fixed cost
11. Objective	- Finding minimum expenditure on routing - Finding variable cost and fixed cost - Finding minimum of amount of waste truck

Analysis of Collection System (Tchobanoglous, Theisen and Vigil, 1993)

To establish vehicle and labor requirements for the various collection systems and methods, the unit time required to perform each task must be determined. By separating the collection activities into unit operations, it is possible to develop design data and relationships that can be used universally and to evaluate both the variables associated with collection activities and the variables related to, or controlled by, the particular location. The discussion that follows is intended to serve as an introduction to the types of information and data that are needed to evaluate waste collection operations and systems properly.

Definition of Terms

Before the relationships for collection systems can be modeled effectively, the component tasks must be delineated. The operational tasks for the hauled container and stationary container systems are shown schematically in Figs. 2-1 and Figs. 2-2, respectively. The activities involved in the collection of solid wastes can be resolved into four unit operations:

      1. Pickup

      2. Haul

      3. At-site

      4. Off-route

Pickup. The definition of the term *pickup* depends on the type of collection system used.

1. For hauled container systems operated in the conventional mode (see Fig. 2-1a), *pickup* refers to the time spent driving to the next container after an empty container has been deposited, the time spent picking up the loaded container, and the time required to redeposit the container after its contents have been emptied. For hauled container systems operated in the exchange-container mode (see Fig. 2-1b), pickup includes the time required to pick up a loaded container and to redeposit the container at the next location after its contents have been emptied.

2. For stationary container systems (see Fig. 2-2), *pickup* refers to the time spent loading the collection vehicle, beginning with stopping the vehicle before loading the contents of the first container and ending when the contents of the last container to be emptied have been loaded. The specific tasks in the pickup operation depend on the type of collection vehicle as well as the collection methods used.
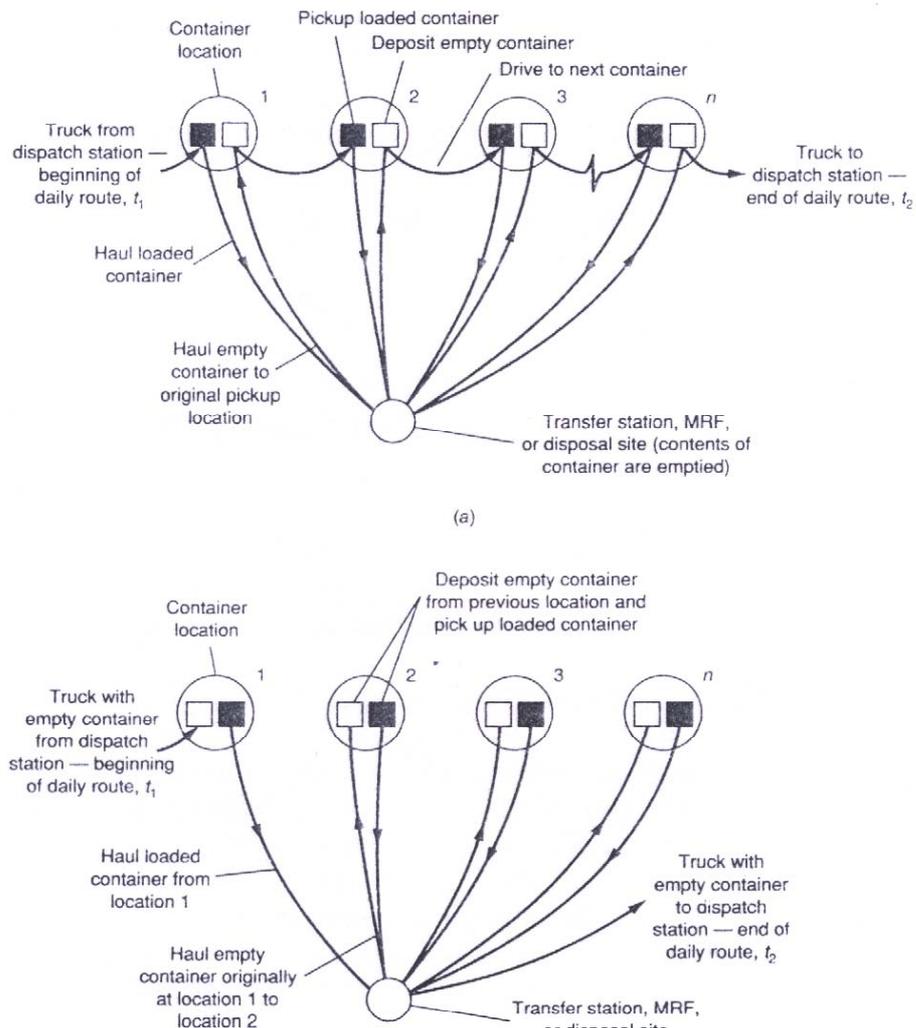
Figure 2-1 Schematic of operational sequence for hauled container system:
(a) conventional mode and (b) exchange container mode.

At-Site. The unit operation *at-site* refers to the time spent at the location where the contents of the container (hauled container system) or collection vehicle (stationery container system) are unloaded (e.g., transfer station, MRF, or disposal site) and includes the time spent waiting to unload as well as the time spent unloading the wastes from the container or collection vehicle.
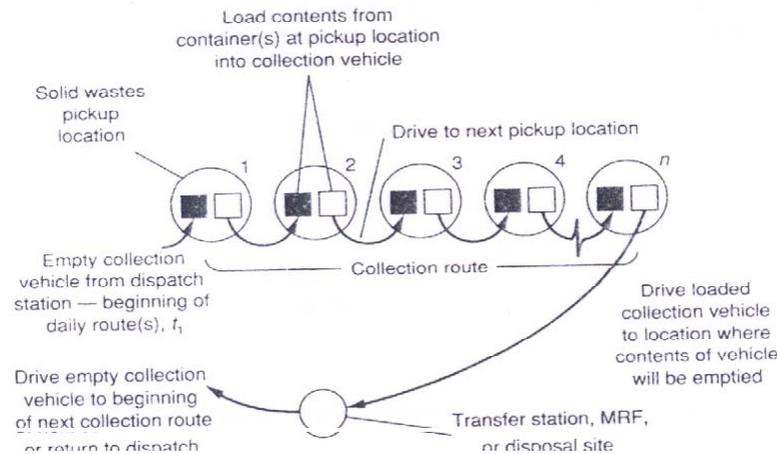
Figure 2-2 Schematic of operational sequence for stationary container system

Haul. The definition of the term *haul* depends on the type of collection system used.

1. For hauled container systems, *haul* represents the time required to reach the location where the contents of the container will be emptied (e.g., transfer station, MRF, or disposal site), starting when a container whose contents are to be emptied has been loaded on the truck and continuing through the time after leaving the unloading location until the truck arrives at the location where the empty container is to be redeposit. Haul time does not include any time spent at the location where the location where the contents of the container are unloaded.

2. For stationary container systems, haul refers to the time required to reach the location where the contents of the collection vehicle will be emptied (e.g., transfer station, MRF, or disposal site), starting when the last container on the route has been emptied or the collection vehicle is filled and continuing through the time after leaving the unloading location until the truck arrives at the location of the first container to be emptied on the next collection route. Haul time does not include the time spent at the location where the contents of the collection vehicle are unloaded.

Off-Route. The unit operation *off-route* includes all time spent on activities that are nonproductive from the point of view of the overall collection operation. Many of the activities associated with off-route times are sometimes necessary or inherent in the operation. Therefore, the time spent on off-route activities may be subdivided into two categories: necessary and unnecessary. In practice, however, both necessary and unnecessary off-route times are considered together because they must be distributed equally over the entire operation.

Necessary off-route time includes time spent checking in and out in the morning and at the end of the day, time lost due to unavoidable congestion, and time spent on equipment repairs, maintenance, and so on. Unnecessary off-route time includes time spent for lunch in excess of the stated lunch period and time spent on taking unauthorized coffee breaks, talking to friends, and the like.

Hauled Container Systems

The time required per trip, which also corresponds to the time required per container, is equal to the sum of the pickup, at-site, and haul time and is given by the following equation:

$$T_{hcs} = (P_{hcs} + s + h) \qquad\qquad (2\text{-}1)$$

where　　T_{hcs}　= time per trip for hauled container system, h/trip

P_{hcs}　= pickup time per trip for hauled container system, h/trip

s　　= at-site time per trip, h/trip

h　　= haul time per trip, h/trip

For hauled container systems the pickup and at-site times are relatively constant, but the haul time depends on both haul speed and distance. From an analysis of a considerable amount of haul data for various types of collection vehicles (see Fig. 2-3), it has been found that the haul time h may be approximated by the following expression:

$$h = a + bx \qquad\qquad (2\text{-}2)$$

where h = total haul time, h/trip

   a = empirical haul-time constant, h/trip

   b = empirical haul-time constant, h/mi

   x = average round-trip haul distance, mi/trip
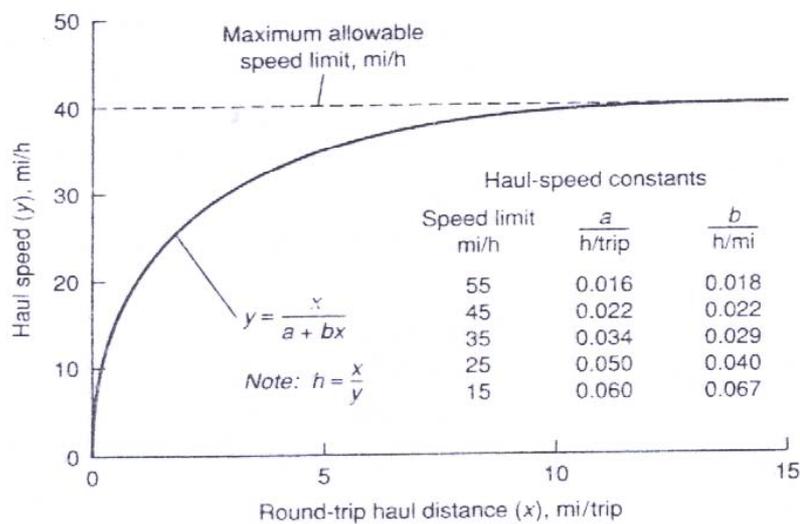
Figure 2-3 Correlation between average haul speed and round-trip haul distance
            for waste collection vehicles

For places where a number of pickup locations are located in a given service area, the average round-trip haul distance from the center of gravity of the service area to the disposal site can be used in Eq. (2-2). Determination of the haul-time constants is illustrated in Example 2-1, presented at the end of this discussion.

Substituting in Eq. (2-1) the expression for h given in Eq. (2-2), the time per trip can be expressed as follows:

$$T_{hcs} = (P_{hcs} + s + a + bx) \qquad\qquad (2\text{-}3)$$

The pickup time per trip, P_{hcs}, for the hauled container system is equal to

$$P_{hcs} = pc + uc + dbc \qquad\qquad (2\text{-}4)$$

where P_{hcs} = pickup time per trip, h/trip

   pc   = time required to pick up loaded container, h/trip

   uc   = time required to unload empty container, h/trip

   dbc = time required to drive between container locations, h/trip

If the average time required driving between containers is unknown, the time can be estimated by using Eq. (2-2). The distance between containers is substituted for the round-trip haul distance and the haul-time constants for 15 mi/h (see Fig. 2-3) should be used.

The number of trips that can be made per vehicle per day with a hauled container system, taking into account the off-route factor W, can be determined by using Eq. (2-5):

$$N_d = [H\,(1 - W) - (t_1 + t_2)]/T_{hcs} \qquad\qquad (2\text{-}5)$$

Where N_d = number of trips per day, trips/d

   H = length of work day, h/d

   W = off-route factor, expressed as a fraction

   t_1 = time to drive from dispatch station (garage) to first container location
     to be serviced for the day, h

   t_2 = time to drive from the last container location to be serviced for the
     day to the dispatch station (garage), h

   T_{hcs} = pickup time per trip, h/trip

In deriving Eq. (2-5), it is assumed that off-route activities can occur at any time during the day. Data that can be used in the solution of Eq. (2-5) for various types of hauled container systems are given in Fig. 2-3 and Table 2-5. The off-route factor in Eq. (2-5) varies from 0.10 to 0.40; a factor of 0.15 is representative for most operations. Application of Eqs. (2-3) through (2-5) is illustrated in Example 2-1.

The number of trips that can be made per day, computed from Eq. (2-5) can be compared with the number of trips required per day (or week), which can be computed using the following expression:

$$N_d = V_d/(cf) \qquad\qquad (2-6)$$

where N_d = number of trips per day, trips/d

V_d = average daily quantity of waste collected, yd^3/d

c = average container size, $yd^3/trip$

f = weighted average container utilization factor

As noted previously, the container utilization factor may be defined as the fraction of the container volume occupied by solid wastes. Because this factor will vary with the size of the container, a weighted container utilization factor values obtained by multiplying the number of containers in each size by their corresponding utilization factor by the total number of containers.

Table 2-4 Representative data to use for computing equipment and labor requirements for various collection systems [a]

Collection data			Time required to pick up loaded container and to deposit empty container, h/trip	Time required to empty contents of loaded container, h/container	At-site time, h/trip
Vehicle	Loading method	Compaction ratio, r			
Hauled container system					
Hoist truck	Mechanical	-	0.067		0.053
Tilt-frame	Mechanical	-	0.40		0.127
Tilt-frame	Mechanical	2.0-4.0 [a]	0.40		0.133
Stationary container system					
Compactor	Mechanical	2.0-2.5		0.008-0.05 [b]	0.10
Compactor	Manual	2.0-2.5		-	0.10

[a] Containers used in conjunction with stationary compactor.

[b] Time required varies depending on the size of the container.

Example 2-1 Determination of haul-speed constants. The following average speeds were obtained for various round-trip distances to a disposal site. Find the haul-speed constants *a* and *b* and the round-trip haul time for a site that is located 11.0 mi away.

Round-trip distance (*x*), mi/trip	Average haul speed (*y*), mi/h	Total time (*h=x/y*),h
2	17	0.12
5	28	0.18
8	32	0.25
12	36	0.33
16	40	0.40
20	42	0.48
25	45	0.56

Solution

1. Linearize the haul-speed equation given in Fig. 2-3. The basis haul-speed equation (a rectangular hyperbola) is

$$y = \frac{x}{a + bx}$$

The linearized form of this equation is

$$\frac{x}{y} = h = a + bx$$

2. Plot x / y, which is the total haul travel time versus the round-trip distance as shown below.
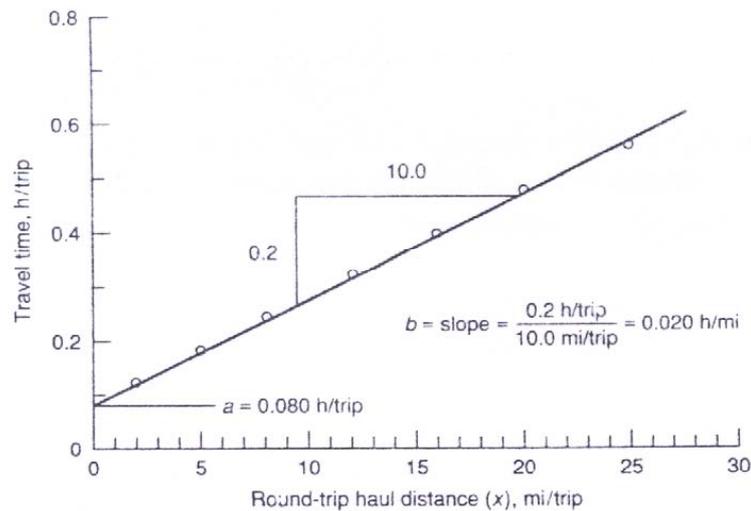
3. Determine the haul-time constants a and b. When $x = 0$, a = intercept value = 0.080 h/trip, b = slope of line = (0.2 h/trip) / (10 mi/trip) = 0.020 h/mi (0.012 h/km).

4. Find the round-trip haul time for a site that is located 11.0 mi away.

Round-trip distance = 2(11.0 mi/trip) = 22 mi/trip

Round-trip haul time h　= $a + bx$

$= 0.080$ h/trip + (0.020 h/mi) (22 mi/trip)

$= 0.52$ h/trip

Stationary Container Systems

　　Because of differences in the loading processes, mechanically and manually loaded stationary container systems are considered separately in the following discussion.

　　Mechanically Loaded Collection Vehicles. For systems using self-loading collection vehicles, the time per trip is expressed as

$$T_{scs} = (P_{scs} + s + a + b \quad) \qquad\qquad (2\text{-}7)$$

where T_{scs} = time per trip for stationary container system, h/trip

P_{scs} = pickup time per trip for stationary container system, h/trip

s = at-site time per trip, h/trip

a = empirical constant, h/trip

b = empirical constant, h/mi

x = average round-trip haul distance, mi/trip

As with the hauled container system, if no other information is available the average round-trip distance from the center of gravity of the service area to the disposal site can be used in Eq. (2-7).

The only difference between Eq. (2-7) and Eq. (2-3) for hauled container systems is the pickup term. For the stationary container system, the pickup time is given by

$$P_{scs} = C_t(\text{uc}) + (n_p - 1)(\text{dbc}) \qquad (2\text{-}8)$$

where P_{scs} = pickup time per trip for stationary container system, h/trip

C_t = number of containers emptied per trip, containers/trip

uc   = average unloading time per stationary container for stationary
          container systems, h/container

n_p = number of container pickup locations per trip, locations/trip

dbc = average time spent driving between container locations, h/location

The term $(n_p - 1)$ accounts for the fact that the number of times the collection vehicle will have to be driven between container locations is equal to the number of container locations less 1. As in the case of the hauled container system, if the time spent driving between container locations is unknown, it can be estimated by using Eq. (2-2) where the distance between containers is substituted for the round-trip haul distance and the haul-time constants for 15 mi/h (see Fig. 2-3) are used.

The number of containers that can be emptied per collection trip is related directly to the volume of the collection vehicle and the compaction ratio that can be achieved. This number is given by

$$C_t = vr \,/\, cf \qquad\qquad\qquad (2\text{-}9)$$

where C_t = number of containers emptied per trip, containers/trip

           v = volume of collection vehicle, yd^3/trip

           r = compaction ratio

           c = container volume, yd^3/container

           f = weighted container utilization factor

The number of trips required per day can be estimated by using the following equation:

$$N_d = V_d \,/\, vr \qquad\qquad\qquad (2\text{-}10)$$

where N_d = number of collection trips required per day, trips/d

          V_d = average daily quantity of waste collected, yd^3/d

The time required per day, taking into account the off-route factor W, can be expressed as follows:

$$H = [(t_1 + t_2) + N_d\,(T_{scs})] \,/\, (1\text{-}\,W) \qquad\qquad (2\text{-}11)$$

where t_1 = time to drive from dispatch station (garage) to the location of the first

                container to be picked up on the first route of the day, h

         t_2 = time to drive from the approximate location of last container pickup

                on last route of the day to the dispatch station (garage), h

other terms   = as defined previously

In defining t_2, the term *approximate location* is used because in the stationary container system, the collection vehicle is normally driven directly back to the dispatch station after the wastes collected on the last route have been emptied. If the travel time from the disposal site (or transfer point) to the dispatch station is less than

one half the average round-trip haul time, t_2 is assumed to be equal to zero. If the travel time from the disposal site (or transfer point) to the dispatch station is greater than the travel time from the last pickup location to the disposal site, the time t_2 is assumed to be equal to the difference between the time to drive to the dispatch station from the disposal site and one half the average round-trip haul time.

Where an integer number of trips are to be made each day, the proper combination of trips per day and the size of the vehicle can be determined by using Eq. (2-11) in conjunction with an economic analysis. To determine the requited truck volume, substitute two or three different values for N_d in Eq. (2-11) and determine the available pickup times per trip. Then, by successive trials, using Eqs. (2-8) and (2-9), determine the truck volume required for each value of N_d. From the available truck sizes, select the ones that most nearly correspond to the computed values. If available truck sizes are smaller than the required values, compute the actual time per day that will be required using these sizes.

Once the labor requirements for each combination of truck size and number of trips per day have been determined, the most cost-effective combination can be selected. For example, where long haul distances are involved, it may be more economical to use a large collection vehicle and make two trips/day (even though some time at the end of the day may not be used) than to use a smaller vehicle and make three trips/day by using all the available time.

Manually Loaded Vehicles. The analysis and design of residential collection systems using manually loaded vehicles may be outlined as follows. If H hours are worked per day and the number of trips to be made per day is known or fixed, the time available for the pickup operation can be computed by using Eq. (2-11) because either all the factors are known or they can be assumed. Once the pickup time per trip is known, the number of pickup locations from which wastes can be collected per trip can be estimated as follows:

$$N_p = 60 P_{scs} n \, / \, t_p \qquad\qquad (2\text{-}12)$$

where N_p = number of pickup locations per trip, locations/trip

60   = conversion factor from hours to minutes, 60 min/h

P_{scs} = pickup time per trip, h/trip

n = number of collectors, collectors

t_p = pickup time per pickup location, collector-min/location

The pickup time t_p per location depends on the time required to drive between container locations, the number of containers per pickup location, and the percent of rear-of-house pickup locations. The corresponding relationship is

$$t_p = \text{dbc} + k_1 C_n + k_2(\text{PRH}) \qquad\qquad (2\text{-}13)$$

where t_p = average pickup time per pickup location, collector-min/location

dbc = average time spent driving between container locations, h/location

k_1 = content related to the pickup time per container, min/container

C_n = average number of containers at each pickup location

k_2 = constant related to the time required to collect waste from the

backyard of a residence, min/PRH

PRH= rear-of-house pickup locations, percent

Once the number of pickup locations per trip is known, the proper size of collection vehicle can then be estimated as follows:

$$v = V_p N_p / r \qquad\qquad\qquad (2\text{-}14)$$

Where v = volume of collection vehicle, yd^3/trip

V_p = volume of solid wastes collected per pickup location, yd^3/location

N_p = number of pickup locations per trip, locations/trip

r = compaction ratio

Collection Routes

Once equipment and labor requirements have been determined, collection routes must be laid out so that both the collectors and equipment are used effectively. In general, the layout of collection routes involves a series of trials. There is no universal set of rules that can be applied to all situations. Thus, collection vehicle routing remains to day a heuristic (common sense) process.

Some heuristic guidelines that should be taken into consideration when laying out routes are as follows:

1. Existing policies and regulations related to such items as the point of collection and frequency of collection must be identified.

2. Existing system characteristics such as crew size and vehicle types must be coordinated.

3. Wherever possible, routes should be laid out so that they begin and end near arterial streets, using topographical and physical barriers as route boundaries.

4. In hilly area, routes should start at the top of the grade and proceed downhill as the vehicle becomes loaded.

5. Routes should be laid out so that the last container to be collected on the route is located nearest to the disposal site.

6. Wastes generated at traffic-congested locations should be collected as early in the day as possible.

7. Sources at which extremely large quantities of wastes are generated should be serviced during the first part of the day.

8. Scattered pickup points (where small quantities of solid waste are generated) that receive the same collection frequency should, if possible, be serviced during one trip or on the same day.

Layout of Collection Routes

The general steps involved in establishing collection routes include:

1. Preparation of location maps showing pertinent data and information concerning the waste generation sources.

2. Data Analysis and, as required preparation of information summary tables.

3. Preliminary layout of routes

4. Evaluation of the preliminary routes and the development of balanced routes by successive trials.

Step 1, as discussed below, is essentially the same for all types of collection systems. Because the application of Steps 2, 3, and 4 is different for the hauled and stationary container systems, each is discussed separately.

Collection route layout-Step 1. On a relatively large-scale map of the commercial, industrial, or residential housing area to be served, the following data should be plotted for each solid waste pickup point: location, collection frequency, number of containers. If a mechanically loaded stationary container system is used for commercial and industrial services, the estimated quantity of wastes to be collected at each pickup location should also be entered on the map. For residential sources it is generally assumed that approximately the same average quantity of waste will be collected from each source. Often, for residential sources only the number of homes per block will be shown.

Because the layout of collection routes involves a series of successive trials, tracing paper should be used once the basic data have been entered on the work map. Depending on the size of the area and the number of pickup points, the area should be subdivided into areas corresponding roughly to similar land-use areas (e.g., residential, commercial, industrial). For locations with less than 20 to 30 pickup points, this step is usually not necessary. For larger areas it may be necessary to subdivide further each of the similar land-use areas into smaller areas, taking into account factors such as waste generation rates and collection frequency.

Collection route layout-Steps 2, 3, and 4 for Hauled Container Systems. Steps 2, 3, and for the hauled container system can be outlined as follows.

Step 2. On a spreadsheet program first enter the following headings: collection frequency, times/wk; number of pickup locations; total number of containers; number of trips, trips/wk; and a separate column for each day of the week during which wastes will be collected. Second, determine the number of pickup locations requiring multiple pickups during the week (e.g., Monday through Friday or Monday, Wednesday,

Friday) and enter the information on the spreadsheet. Start the listing with the locations requiring the highest number of pickups per week (e.g., 5 times/wk). Third, distribute the number of containers requiring once per weed service so that the number of containers emptied per day is balanced for each collection day. Preliminary collection routes can be laid out once this information is known.

Step 3. Using the information from Step 2, the layout of collection routes can be outlined as follows. Starting from the dispatch station (or where the collection vehicles are parked), a route should be laid out that connects all the pickup points (containers) to be serviced during each collection day. The next step is to modify the basic route to include the additional containers that will be serviced on each collection day. Each daily route should be laid out so it begins and ends near the dispatch station. The collection operation should proceed in a logical manner, taking into account the guidelines cited previously and specific local constraints.

Step 4. When preliminary routes have been laid out, the average distance to be traveled between containers should be computed. If the routes are unbalanced with respect to the distance traveled (> 15 percent), they should be redesigned so that each route covers approximately the same distance. In general, a number of collection routes must be tried before the final ones are selected. When more than one collection vehicle is required, collection routes for each functional-use or service area must be laid out, and workloads for each driver must be balanced.

Collection route layout-Steps 2, 3, and 4 for Stationary Container System (with mechanically loaded collection vehicles). Steps 2, 3, and 4 for stationary container systems that are loaded mechanically can be outlined as follows.

Step 2. On a spreadsheet program first enter the following heads: collection frequency, times/wk; number of pickup locations; total waste, yd^3/wk; and a separate column for each day of the week during which wastes will be collected. Second, determine the amount of waste to be collected from pickup locations requiring multiple pickups during the week (e.g., Monday through Friday or Monday,

Wednesday, Friday) and enter the information on the spreadsheet. Start the listing with the locations requiring the highest number of pickups per week (e.g., 5 times/wk). Third, using the effective volume of the collection vehicle (nominal collection vehicle volume x compaction ratio), determine the amount of additional waste that can be collected each day from locations receiving once per week service. Distribute the amount of waste collected so that the amount of waste collected (and the number of containers emptied) per trip is balanced for each collection route. Preliminary collection routes can be laid out once this in formation is known.

Step 3. Once the foregoing information is known, the layout of collection routes can proceed as follows. Starting from the dispatch station (or where the collection vehicles are parked), a route should be laid out that connects all the pickup points to be serviced during each collection day. Depending on the quantity of waste to be collected, several basic routes may have to be laid out.

The next step is to modify the basic route (routes) to include the additional pickup locations that will have to be serviced to complete the load. These modifications should be made so that the same general area is serviced with each collection route. For large areas that have been subdivided and that are serviced daily, it will be necessary to establish basic routes in each subdivided and that are serviced daily, it will be necessary to establish basic routes in each subdivided area; in some cases, between them, depending upon the number of trips to be made per day.

Step 4. When the collection routes have been laid out, the quantity of waste to be collected and the haul distance for each route should be determined. In some cases it may be necessary to readjust the collection routes to balance the workload. After the routes have been established, they should be drawn on the master map.

Collection route layout-Steps 2, 3, and 4 for Stationary Container System (with manually loaded collection vehicles). Steps 2, 3, and 4 for stationary container systems that are manually loaded can be outlined as follows.

Step 2. Estimate the total quantity of wastes to be collected from pickup locations serviced each day that the collection operation is conducted. Using the effective volume of the collection vehicle (nominal collection vehicle volume x compaction ratio), determine the average number of residences from which wastes are to be collected during each collection trip.

Step 3. Once the foregoing data are known, the layout of collection routes can proceed as follows. Starting from the dispatch station (or garage) lay out collection routes that include all of the pickup locations to be serviced during each collection route. These routes should be laid out so that the last of these locations is nearest the disposal site.

Step 4. When the collection routes have been laid out, the actual container density and haul distance for each route should be determined. Using these data, the labor requirements per day should be checked against the available work time per day. In some cases it may be necessary to readjust the collection routes to balance the workload. After the routes have been established, they should be drawn on the master map.

2.2 Geographic Information System

2.2.1 Information System

Information system is a collection of data related to human resources and technical resources through the process of data manipulation by an organization whose responsibility is to produce information which will be useful for decision making. This information is processed (ordered, classified, connected, calculated or summarized) in order to be specific and easy to use.

Information system can be classified into 2 classes as the following.

2.2.1.1 Non-Spatial Information System such as management information systems

2.2.1.2 Spatial Information System such as Resource Information System which consists of geographic information system (GIS), land information system (LIS).

2.2.2 Database

Database is a collection of data arranged for ease and speed of search and retrieval or a set of data stored in a database software structure.

GIS Database consists of 2 components as the following;

2.2.2.1 Spatial Data

Spatial data is a data with defined coordinates or Geo-referenced such as a dam coordinates, urban boundary. It can be represented in terms of point, line, polygon or area. See Figure 2-4.

2.2.2.2 Non-Spatial Data

Non-spatial data is a descriptive information or attribute data of that particular object for example soil properties, agriculture type, landuse or statistic data. See Figure 2-5.

The relationship between these 2 data is shown in Figure 2-6 which spatial data represents position of point, line or polygon and non-spatial data describes the characteristic or properties of point, line or polygon for example a land parcel consists of owner's name, area, property value. The connection of these 2 data is done using the same identification number.

Aronoff (Aronoff, 1989) has commented that GIS database is the heart of GIS. The completion and accuracy of data plays critical role in the success of the project. Database is a set of geographic information collection and provides a suitable structure for a particular project or many projects. It should be done appropriately by a database system. Therefore, GIS database is a system to collect, manipulate data to be used for a particular purpose.

2.2.3 GIS Definition

Geographic Information System or GIS has not yet been officially defined however, there were many definitions given as the following;

Aronoff defined GIS as the computer system with its capability to manage geographic information , the procedure for collecting, manipulation, analyzing and representing data.

Sumeth (Sumet, 1991) defined GIS as the system of a powerful tool to collect, analyze, manipulate and represent data in terms of location with the purpose of data management to support decision making or development.

Pipob (Pipob, 1991) defined GIS as a computer aided system for processing, analyzing and representing data or information system related to geographically referenced data. It can also involve in the distribution of natural resources and pollution, the infrastructure, landuse, public health services, properties, labor management, immigration, transportation and communication. The analysis for each category can be done separately or simultaneously for a particular purpose and created the analyzed model.

Sura (Sura, 1990) defined GIS as a tool for analyzing spatial context by relations of each information which depends on type, details of data which will provide the most accurate result as required.

In conclusion, GIS can be defined as the computer aided system for to managing spatial information and descriptive information. It can assist in managing and decision making such as environment and resources planning and management, hazardous prevention.
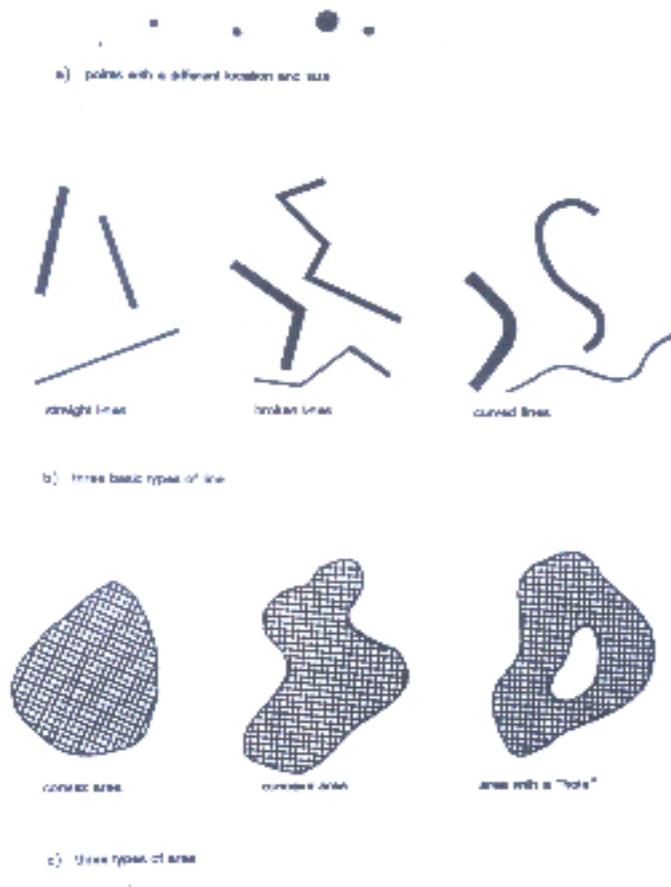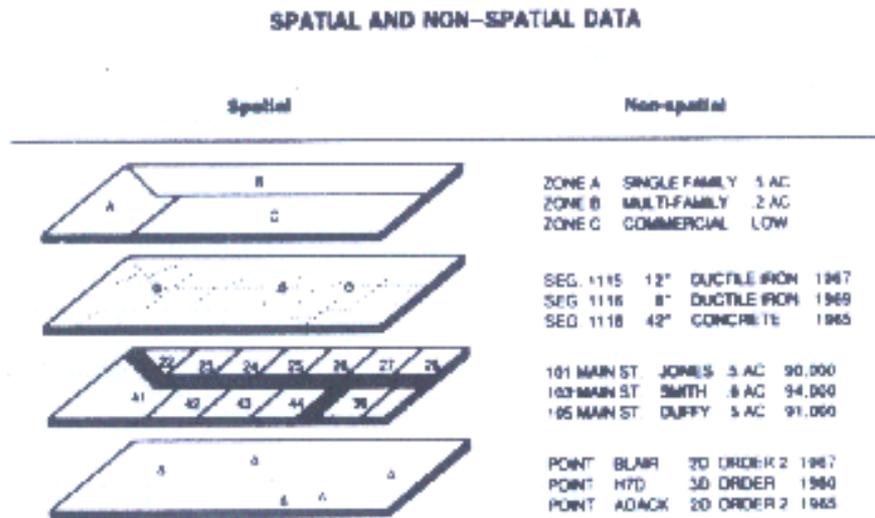
Figure 2-4 Spatial data pattern

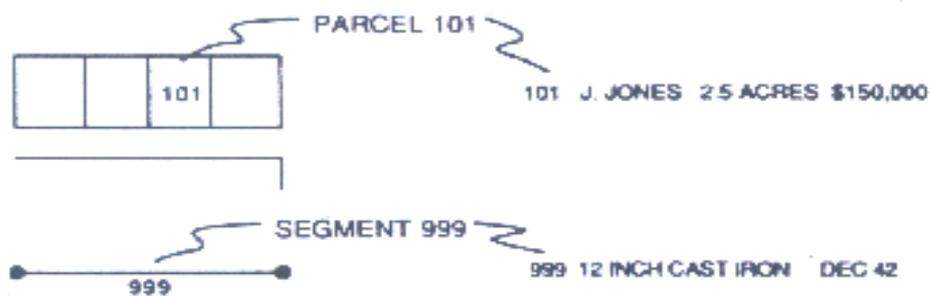Figure 2-5 Spatial and Non-Spatial pattern

Figure 2-6 Spatial data and attribute data relationship

2.2.4 Geographic Information System Model

2.2.4.1 Manual Approach

This manipulation technique requires line features copied onto transparency sheets, then overlay them together to get a result. This technique is called overlay technique. However, this method has a limited number of data layers to be overlaid due to the capability of eye interpretation. It also requires a large number of storage and materials to capture data.

2.2.4.2 Computer Assisted Approach

This manipulation technique analyzes digital data by transferring line features map to a digital data then over them together to get a result using mathematical and logical principles. This technique can reduce data storage and easily retrieve data to be manipulated.

GIS component consists of 4 factors namely,

- Data
- Computer hardware
- Computer software
- Proper organization context

2.2.5 Data Structure in GIS

It can be classified into 2 classes as the following:

2.2.5.1 Vector Structure

The method of representing geographic features by the basic graphical elements of points, lines and polygon is said to be the *vector method* or *vector data model*, and the data are called *vector data*. The series of points connectivity forms a line called arc. It is the main component to be used in order to represent line features such as rivers, road. The series of arc connectivity forms polygon represented by x,y coordinates to form the extent of polygon. This is the characteristics of Arc/Info software.

2.2.5.2 Raster Structure

The method of representing geographic features by pixels is called the *raster method* or *raster data model*, and the data are described as *raster data.* The grid size or pixel size depends on the pixel resolution as required by the user or data such as satellite image resolution. In each pixel contains digital number, the series of pixels indicated by row and column. A point is represented by one pixel. A line is represented by a series of connected pixels. Polygon or area is represented by relation of digital number distributed in neighboring pixels. The raster structure is easily handled to collect, calculate and represent data. This is the structure model in ILWIS (Integrated Land and Watershed Management Information System), SPAN, IDRISI, ERDAS. Figure 2-7 shows the structure of vector and raster data. Table 2-5 shows the comparison between vector and raster structure.
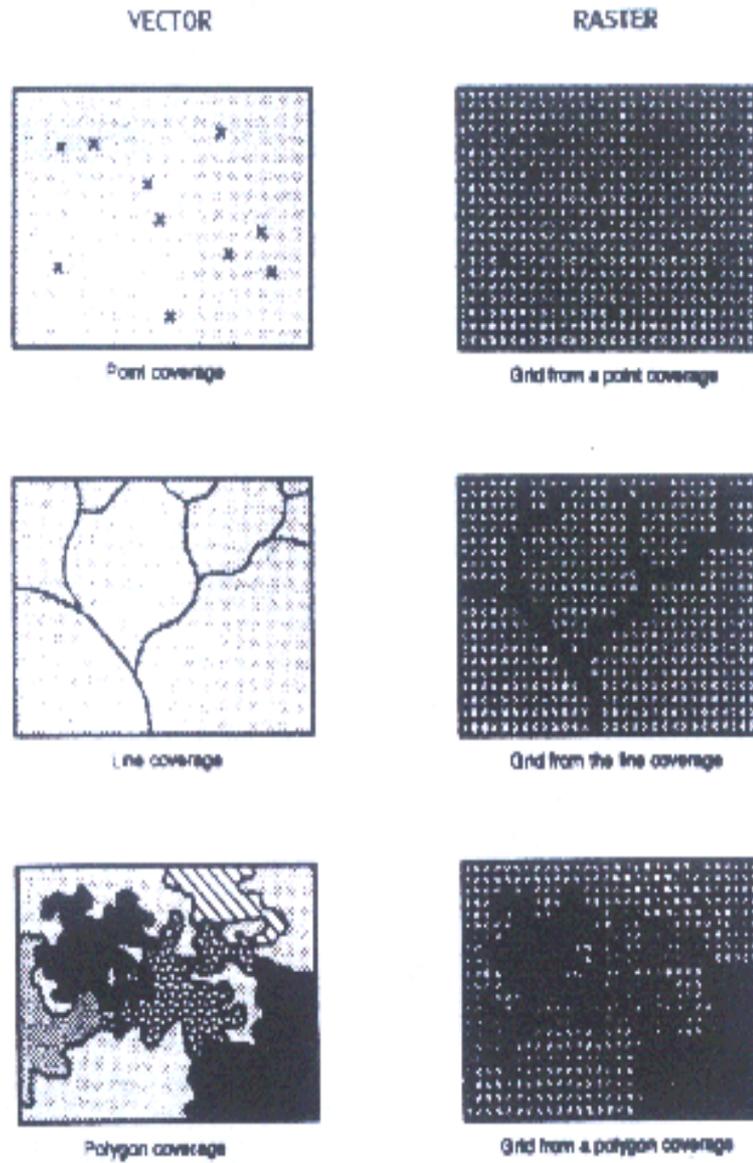
Figure 2-7 Raster and Vector data structure

Table 2-5 The comparison between vector and raster structure.

Vector Structure	Raster Structure
Advantages	**Advantages**
The accuracy of data is higher than with raster structure	The data structure is easy
It can represent good geographical features .	Easy to do overlay technique
It can explain the geographical data by joining with database conveniently	Spatial data analysis can be done flexibly and quickly
It can be easily updated.	
There is no limitation in overlaying different data resolution	
The output map is similar to handmade map	
Disadvantages	**Disadvantages**
The data structure is quite complicated	The amount of information is greatly
The overlay technique is complicated and time consuming	The connectivity of spatial data and attribute data is not quite good.
The data representation is costly	The data update is difficult
The use of data is limited only the existed line features information.	The analysis has to be made with the same resolution
	The output map is not quite beautiful

Source : Geographic Information Systems : A Management Perspective,

(Stan Aronoff 1989).

2.2.6 GIS Procedure

GIS procedure involves 4 main components as the following.

2.2.6.1 Data Input

It transfers spatial data such as map or raster image into digital data using a digitizer. This method is called digitizing process. The attribute data is input by key punching. It is considered to be important in GIS database because it reflects the quality of GIS database when used in analysis

2.2.6.2 Data Management

This involves storage, data update and data retrieve steps. This step is to prepare data in an appropriate format for further analysis . It also creates spatial data and attribute data relationship.

2.2.6.3 Data Manipulation and Analysis

This step is to manage data in order to achieve the required objective using various principles and techniques. Normally, overlay technique is used to analyze data.

Overlay technique in GIS is the method of calculation using digital data by the sum of grid factor values in each layer. The result is called scores as the formulae below

$$P'_{r,c} = P1_{r,c} + P2_{r,c} + \ldots + Pn_{r,c}$$

when $P'_{r,c}$ = score, Row = r, Column = c

     $P1_{r,c}$ to $Pn_{r,c}$ = grid factor value

2.2.6.4 Data Output and Representation

It represents the final output of data analysis which can be represented in terms of table, graph or diagram.

See Figure 2-8 for the flow chart of GIS Procedure for more details

```
┌─────────────────────────┐
│    Basic Information     │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│     Data Collection      │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│     Data Input and       │
│        Storing           │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│   Database Management     │
└─────────────────────────┘
       │              │
       ▼              ▼
┌──────────────┐  ┌──────────────┐
│ Spatial Data │  │ Attribute Data│
└──────────────┘  └──────────────┘
       │              │
       └──────┬───────┘
              ▼
      ┌───────────────┐
      │ Data Analysis │
      └───────────────┘
              │
              ▼
   ┌───────────────────────┐
   │   Data Output and      │
   │  Data Representation   │
   └───────────────────────┘
       │              │
       ▼              ▼
┌──────────────┐  ┌──────────────┐
│   Graphic    │  │  Number and  │
│              │  │     Text     │
└──────────────┘  └──────────────┘
```
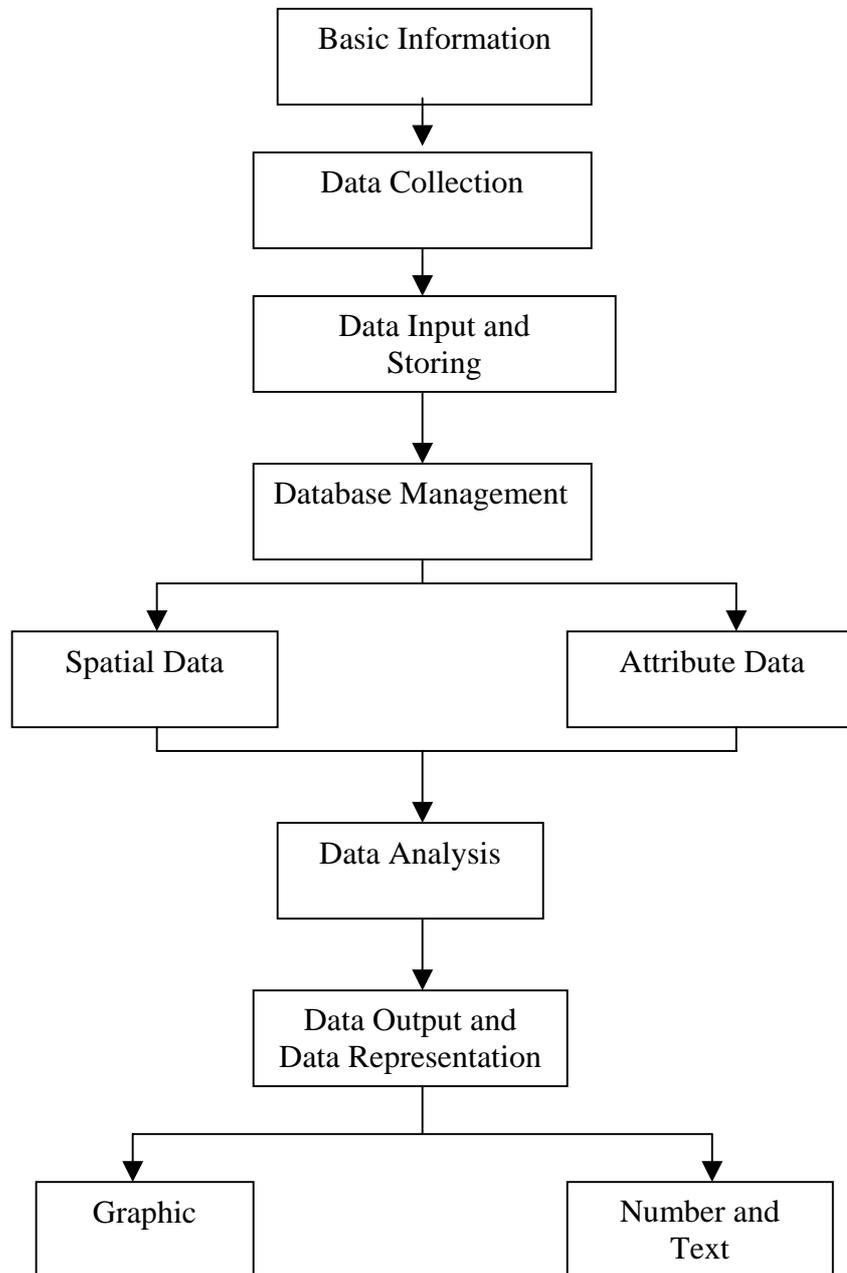
Figure 2-8 The flow chart of GIS Procedure

2.2.7 Capability of GIS Analysis

The capability of GIS analysis as required by users can be defined as the following;

2.2.7.1 Capability of Re-Classification

Various map can be represented in many ways depending on data classification and stored in many coverages. It involves spatial data and attribute data relationship such as the suitability of soil type for agriculture map that needs to specify the appropriate crops for each soil classification level.

2.2.7.2 Overlay Procedure

This can be done using 2 or more vector layers to overlay for creating new data layer. This method is similar to light table.

However, the combination of various spatial data do require other relevant analysis techniques especially base map and fundamental data in the earlier stage of resource management. For example, distance data is used to solve for time and cost in many GIS application such as the identification of truck route, the identification of bank location etc.

GIS in statistical analysis involves frequency, arithmetic mean, data distribution such as the distribution of acidity and alkalinity of water courses, the average width of footpath etc.

2.2.8 Advantage of GIS

In Thailand, there are many GIS applications such as town planning, natural resource management, traffic planning, land reform etc as it has many advantages over other method. These can be summarized as the following.

2.2.8.1 The ability to improve spatial data and update data

2.2.8.2 GIS data retrieval is fast and accurate. It can be used in planning and easily updating data.

2.2.8.3 It can create geographical model to represent the real world and assist in visualization.

2.2.8.4 It can provide solutions by modeling the situation so that problems can be seen and solved.

2.2.9 Information System Conceptual

2.2.9.1 The ability to analyze spatial data such as it can forecast the trend of interested object for example the potential of rubbish production in area, the distribution of community etc.

2.2.9.2 Easily present spatial data result as map due to graphical representation is understandable and related to general planning processes. It can be displayed to many people groups such as public users, government officers, executives etc.

2.2.9.3 It relates to the existing data as the database development involves in updating and completing the existing data. Therefore the database model must be based on the existing data and the need of present users.

2.2.9.4 Database can be maintained and updated in the future as user's requirement and objectives or the change in situation of environmental problems.

2.2.10 GIS Management Procedure

Prior to proceed GIS , there are some specifications that need to be clarified such as what information to be collected, what is database structure, who is the user and what is the application. The following is the details of GIS management procedure.

2.2.10.1 User Need Assessment

Once the policy and objectives of the project has been set up, the user need assessment has to be carried out in order to identify the need from information system. This would assist the developer to create the most appropriate system for the organization. There are some consideration in the area of type of information needed, limitation of software and hardware etc.

2.2.10.2 Database Design and Development

Next step is to design database structure and development. This has to be coherent with the required output result and time saving. This could be done using relational database structure which item is linked by identical item. Dbase III plus is a database software used in pcARC/INFO.

2.2.10.3 User Interface Design

The GIS software development has given users opportunity to implement with great flexibility such as pcARC/INFO the user can customize interface menu without difficulties.

2.2.10.4 Data and Data Input

There are 2 main data types in GIS mainly spatial data and attribute data. The attribute data can be input to the system by other software or the GIS software itself for instance population density (join with district or sub-district boundary), amount of solid waste from a factory (join with an industrial site) etc.

2.3 Information Systems

Presently, information technology is developed very quickly and efficiently. Most organizations use computers for information processing which is readily and accurately contributing to the operation, management and decision making.

Information systems consist of subsystems, including hardware, software, and data storage for files and database (Senn,1989).

2.3.1 Information System Capabilities

Long (Long, 1989) said an information system possesses the same four capabilities as a computer system, i.e. input, processing, storage and output.

Input : The information system input capability includes

- data source, usually, a record of a transaction or an event;
- an inquiry, a request for an information;
- a response to a prompt, for example, "Y" or "N";
- an instruction, for examples, "store file" or "print record";
- a message to another user on the system;
- a change, for example, editing a word processing document.

Processing : The information system processing capability encompasses

- sorting, an arrangement of data or records in order;
- accessing, recording, and updating data in storage;

- summarizing, a presentation of information in a condensed format, oftenly to reflect total and subtotal;
- selecting, a selection of records by given criteria;
- manipulating, performed arithmetic and logic operations.

Storage : The information system storage capability permits the system

information to store data, text, images)graphs, pictures, and etc.) and other digital information (e.g. vocal messages) in order to be retrieved easily for further processing.

Output : The information system output capability permits the system to produce output in a variety of formats including :

- Hard copy, for example, printed reports, documents and messages;
- Soft copy, for example, temporary displays on computer screens;
- Control, for example, instructions to industrial roots or automated processes.

2.3.2 Fundamental Types of Information Systems (Krocnke, 1992)

There are a number of information systems known to date.

1) Transaction Processing System (TPS) supports day-to-day operations. A few examples are ticket reservation system, order-entry system, cheque processing system, accounts payable system, account receivable system and payroll system. All of these systems assist a company to conduct its operations and keep track of its activities.

2) Management Information System (MIS) is a formal method of making information or data available for management (Stoner, 1982). MIS is also defined as a formalized computer information system that can integrate data from various sources to provide the information necessary for management and decision making (Hicks.JO,1987).

MIS is proposed as a given multilevel organization having groups of components that perform a variety of functions to accomplish a unified objective. The MIS is also an integrated structure of databases and information flow over all levels

and components, whereby the collection, transfer and presentation of information are optimized to meet the needs of the organization (Long, 1989).

The structure of MIS is described as a pyramid (Figure 2-9) in which the bottom level consists of information for transaction processing, status inquiries, etc.; the next level from bottom consists of information resources which supports day-to-day operations and control; the third level consists of information system resources to aid tactical planning and decision making for management control; and the top level consists of information resources to support strategic planning and policy making by higher levels of management. Each level of information processing may make use of data provided for lower levels; but new data may also be introduced (Davis and Olson, 1985).
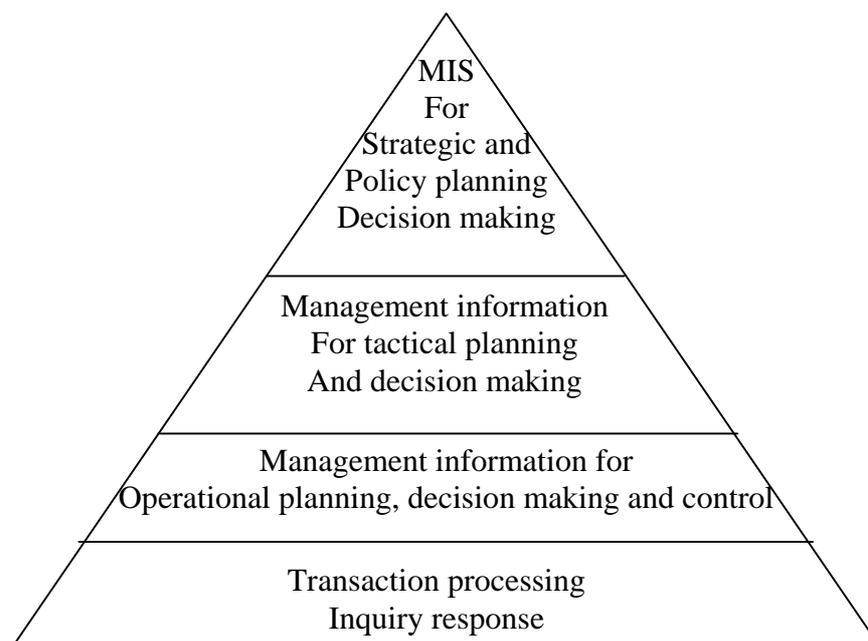
Figure 2.9 Structure of Management Information System.

Source: Davis and Olson (1985) : 7

Krocnke (1992) stated the MIS may also be used to store and maintain data of its own. Some MIS applications may have simple models for business activities that are used for processing data to generate information for a manager.

3) Decision Support System (DSS) is an interactive, computer-based system which facilitates and assists human in making decision. DSS differs from TPS and MIS in that DSS does not always support an ongoing process. Oftenly, DSS is created to solve particular problems on an ad hoc processing basis. Unlike MIS, which is regular and recurring whereas DSS can be irregular. In all cases, DSS is designed to facilitate the solutions of problems with less structured than those of MIS and TPS.

4) Office Automation System (OAS) is one of the information system that create, store, modify, display and communicate business correspondences, either in forms of written, verbal, or video.

Long (1989) defined OAS as a system generally associated with office automation. The term "office automation" refers collectively to those computer-based application associated with general office work. Office automation application includes office information systems, word processing, electronic mail, image processing, voice processing, and telecommunication.

5) Executive Support System (ESS) in another information system that supports the information needed by senior executives. ESS summarizes and presents data at the highest level of aggregation. Usually, it involves presentation of reports in standard formats and it often involves graphics.

Although ESS is the newest among the five categories, but the system is least used. One reason for this s that most executives started their careers prior to the widespread use of computer-based information systems. Many, in fact, still consider the use of a keyboard as secretarial work. Furthermore, there are a number of extremely capable assistants who can prepare written reports to meet the information needs of the executives. Therefore, executives may prefer a printed report rather than just touch some buttons on a keyboard to see a report on a computer monitor. Even thought, the printed report may take more time than on screen report one.

2.4 Database System

Watson (1996) defined database as a collection of different types of data organized in such a way to minimize redundancies and to facilitate the manipulation of the data or the collection into one or more files which is treated as a whole unit. On the other hand, database can be a set of organized data, under the control of a database management system. Most often, the database consists of one or more files of related information (Stamper and Price, 1990).

In conclusion, database is the collection of related data which are systematically organized and presented in a simple understanding pattern for a particular user in order to easily retrieve and maintain data.

The advantages of database are data redundancy is minimized, one database is for ass applications, the system is consistent, extendible and flexible, physical and logical data is independent and the system allows data to be normalized, standardized and updated (Bisland, 1989).

Database Management System (DBMS)

The DBMS consists of a collection of interrelated data and a collection of programs to access those data, which contains information on one particular enterprise. The primary goal of DBMS is to provide an environment for convenience enterprise. The primary goal of DBMS is to provide an environment for convenience and efficiency in retrieving and storing information (Korth, Silberschatz, 1985).

The advantages of DBMS are data redundancy and programming efforts are reduced, time response is short, data is independent, data structure can be easily changed, information is protected and the system supports multi-users (Litton, 1987).

2.5 Relational Database

Hawryszkiewycz (1990) stated that the definition of a "relation" was first derived from mathematical relational theory, which can be used to precisely define formal design criteria. Presentation of this theory has been simplified over time into a form that is acceptable to a wider community. Thus, the simplest way to define the relation is as a table with data values stored in table rows.

The basic structure for the relational model is a relation of data. The relation is a two-dimensional structure that contains data. As mention previously, the term "relation" is derived from the mathematical theory of sets, but it is not necessary with the fact that the data stored in the relation is related. The relation is an abstract concept that is implemented through tables. The tables are closest data structural tool to represent the relations that are available. In most cases, it is acceptable to use the terms "relation" and "table" interchangeably as tables are implementation forms of relations (Bisland, 1989).

2.5.1 Data Models

Underlying the structure of a database is the concept of a data model, a collection of conceptual tools for data description in, data relationships, data semantics and consistency constraints. Various data models that have been proposed fall into three different groups: object-based logical models, record-based logical models, and physical data models (Korth, Silberschatz, 1985).

The relational data model is then a formal model for demonstrating relationships among attributes of an entity set and the associations between entity sets (Codd, 1970). It also represents the data in a database as a collection of relations.

2.5.2 Definitions

The definitions of terminology involved in the system are defined according to Watson (1996):

- a domain is a set of values for all the same data type;

- a relation is a table of n columns (or attributes) and m rows (or tuples). Each column has a unique name and all values in a column are drawn from the same domain. Each row of the relation is uniquely identified. The order of columns and rows is immaterial;

- a relational database is a collection of relations;

- primary key is uniquely identifier of each row in a table;

- candidate key is an attribute or a group of attributes that is a potential primary key for a table;

- foreign key is an attribute that is a primary key in the same table or different table. It is the method of recording relations in a relational database.

In addition, Korth and Silberschatz (1985) defined an entity as an object that exists and is distinguishable from other objects, an entity set as a set of entities of the same type, a relationship as an association among several entities and a relationship set as a set of relationships of the same type.

2.6 Entity-Relationship

The Entity-Relationship (E-R) model has been most successful as a tool for communication between the designer and the end user during the requirement analysis and conceptual design phases of its ease of understanding and its convenience in representation. One of the reasons for its effectiveness is a top-down approach using the concept of abstraction (Teorey, Yang and Fry, 1986).

The E-R data model is based on a perception of a real world which consists of a collection of basic objects called entities and relationships among these objects. An entity is an object that is distinguishable from other objects by a specific set of attributes ((Korth, Silberschatz, 1985)).

Summary of conventions for E-R diagrams is enphasized on representation of the schemas rather than the extension. This is more useful because a database schema is rarely changed whereas the extension may be changed frequently. Also, the schema is usually easier to display than the extension of a database because it is much smaller (Figure2-10)

Symbol   Meaning

Entity type

Relationship type

Attribute

Key attribute

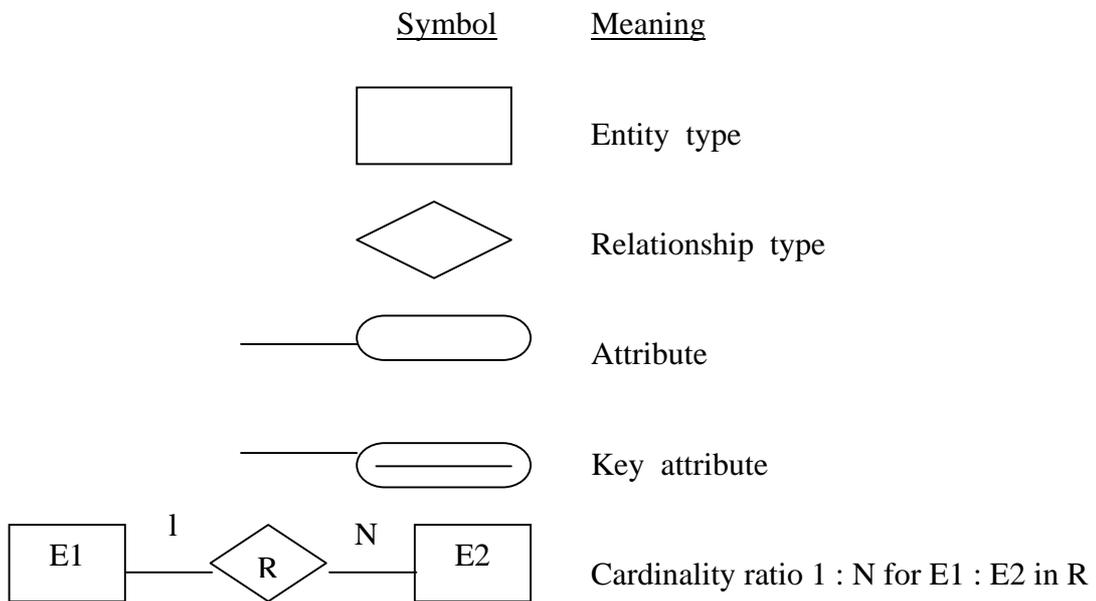Cardinality ratio 1 : N for E1 : E2 in R

Figure 2.10 E-R diagram notation

Source: Elmasri and Shamkant (1989) : 57

2.6.1 Mapping Constraints

An E-R enterprise schema may be defined as certain constraints to which the contents of a database must be conformed. One important constraint is mapping cardinalities, which express the number of entities to which another entity can be associated via a relationship set (Figure 2-10).

Mapping cardinalities are most useful in describing binary relationship sets, although occasionally they contribute to the description of relationship sets that involve more than two entity sets.

For a binary relationship between entity sets A and B, then mapping cardinality would be one of the following : (Korth, Silberschatz, 1985)

One-to-one: an entity in A is associated with at most one entity in B, and an entity in B is associated with at most one entity in A (Figure 2-11)
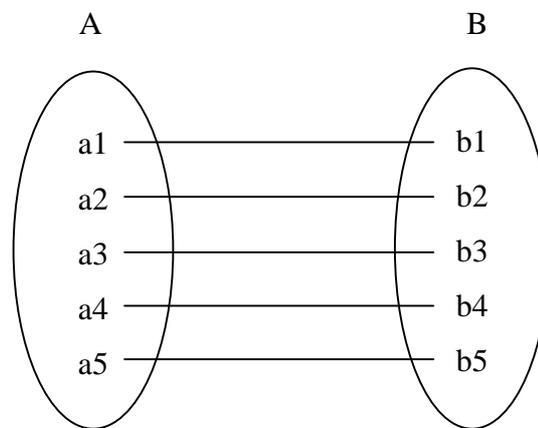
Figure 2-11 One-to-one relationship.

Source: Korth and Silberschatz (Korth, Silberschatz, 1985): 28

One-to-many: an entity in A is associated with any number of entities in B, and an entity in B, however, can be associated with at most one entity in A (Figure 2-12).
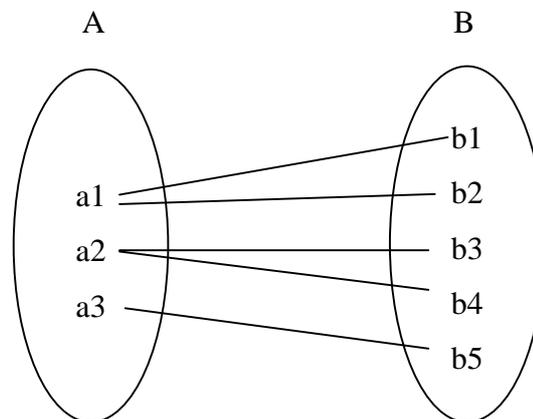

Figure 2-12 One-to-many relationship.

Source: Korth and Silberschatz (Korth, Silberschatz, 1985): 28

Many-to-one: an entity in A is associated with at must one entity in B, and an entity in B, however, can be associated with any number of entities in A (Figure 2-12)
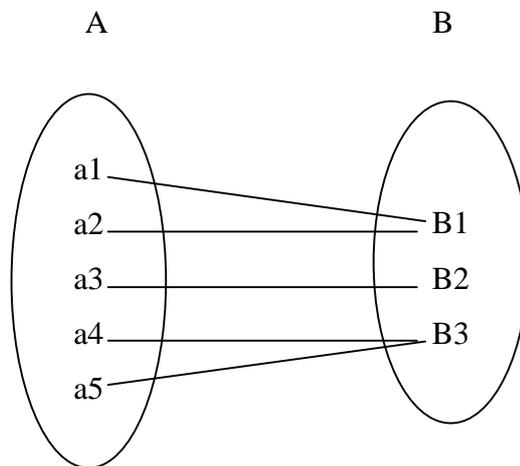
A   B

Figure 2-13 Many-to-one relationship.

Source: Korth and Silberschatz (Korth, Silberschatz, 1985): 29

Many-to-many: an entity in A is associated with any number of entities in B, and an entity in B is associated with any number of entities in A (Figure 2-14).
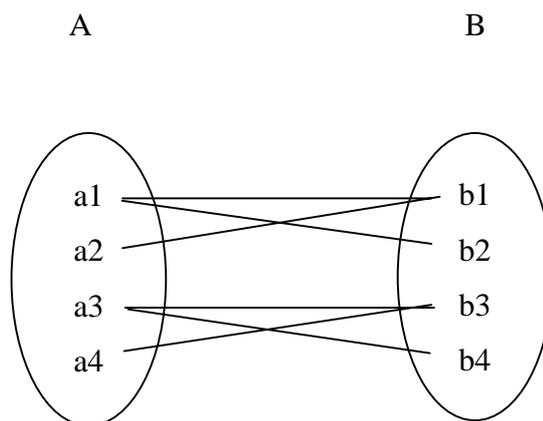
A   B

Figure 2-14 Many-to-many relationship.

Source: Korth and Silberschatz (Korth, Silberschatz, 1985): 29

2.6.2 Database Design

There are a number of steps involved in the database design using E-R model. These include identify database entities by inspecting the user views, relationships between entities, the attributes of entities, particularly many-to-many relationship that new attributes derived (not all of them do) and identify entity keys (Korth, Silberschatz, 1985).

2.7 Normalization

Senn (Senn, 1989) described normalization as a process to simplify the relationship between data elements in a record. Through normalization, a collection of data n a record structure is replaced by successive record structures that are simpler and more predictable and therefore more manageable. Normalization is carried out for four reasons:

1)   To construct the data so that any pertinent relationships between entities can be presented.

2)   To permit simple retrieval of data in response to query and report requests.

3)   To simplify the maintenance of the data through updates, insertions, and deletions.

4)   To reduce the need to restructure or reorganize data when new application requirements arise.

This process can improve the quality of design for an application by the following:

1)   Decompose all data groups into two-dimensional records.

2)   Eliminate any relationship in which data elements do not fully depend on the primary key of the record.

3)   Eliminate any relationship that contain transitive dependencies.

There are three normal forms involved in normalization process and are described as follows (Senn, 1989).

First Normal Form : First normal form is achieved when all repeated groups of records are removed so that a record is of fixed length.

Second Normal Form : Second normal form is achieved when a record is in first normal form and each item in the record is fully dependent on the primary record key

for identification (in storage and retrieval). Every data item in the record that is not dependent on the primary key of the record should be removed and used to form a separate relation.

Third Normal Form : Third normal form is achieved when transitive dependencies are removed from a record design. The general case is as follows (Figure 2-15).

General case
    Data item A, B and C constitute a record structure.
    If C is functionally dependent on B and
    B is functionally dependent on A and
    There is a transitive dependence between items in the record

Conversion to third normal form remove transitive
Dependence by splitting the relation into two relations.

A reason to be concerned:
    When there is transitive dependence, deleting A will cause
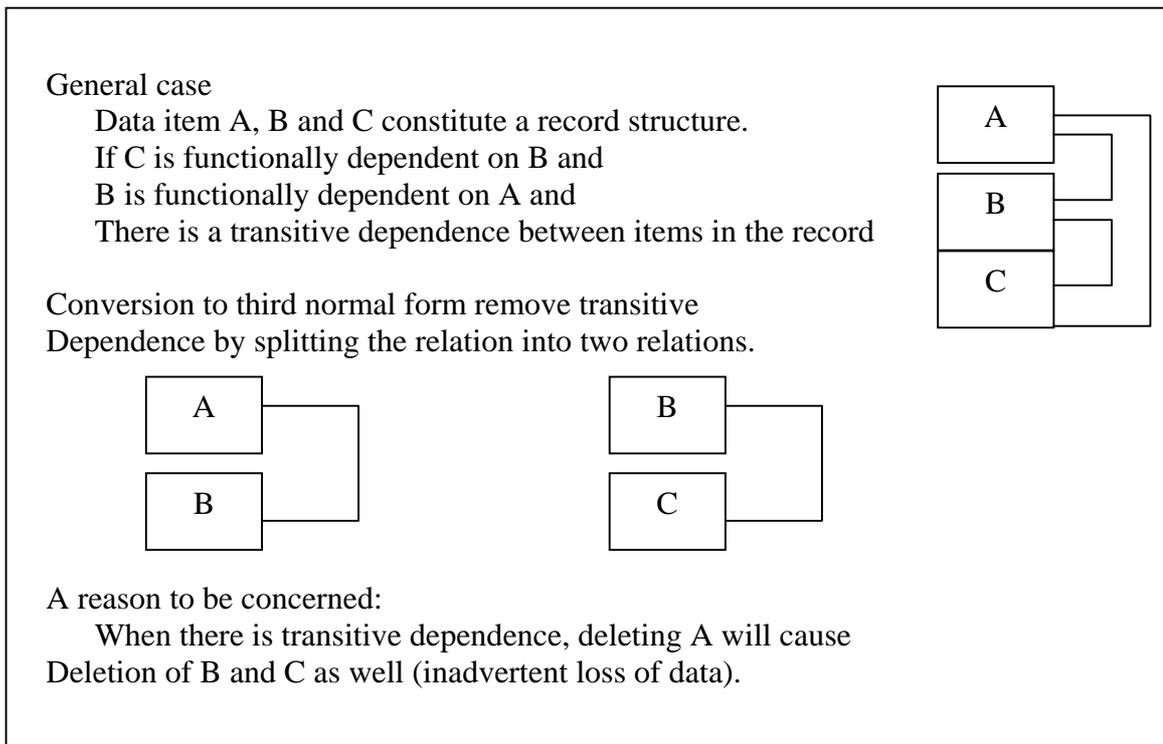Deletion of B and C as well (inadvertent loss of data).

Figure 2-15 Third normal form

Source : Senn, 1989: 597

In data management, transitive dependency is a concern because data can inadvertently be lost when the relationship is hidden. Conversion to third normal form removes the transitive dependency by separation into two separate relations.

2.8 Database Design

The goals of database design are multifold: to satisfy the information content requirements of the specified users and applications; to provide a natural and easily understandable structure of the information; to support the processing requirements and any performance objectives such as response time and storage space.

Elmasri and Shamkant (34) stated that there are six main identified phases of the database design process:

2.8.1 Phase 1 : Requirements Collection and Analysis

Before a database can design effectively, the expectations of the users and the intended uses of the database must be known in as much detail as possible. The process of identifying and analyzing the intended uses is called requirements collection and analysis. The following activities are parts of the requirements collection and analysis phase:

- Identification of user groups and application areas:
- Review of existing documentation:
- Analysis of the operating environment and the processing requirements:
- Questionnaires an interview:

2.8.2 Phase 2 : Conceptual database design

The second phase of database design involves two parallel activities. The first activity, which is called conceptual schema design, examine the data requirements of the database resulting from phase 1 and produces a conceptual database schema in a DBMS-independent high-level data model. The second activity, which is called transaction design, examines the database applications whose requirements are analyzed in phase 1 and produces high-level specifications for these transactions.

2.8.3 Phase 3 : Choice of a DBMS

The choice of a DBMS is governed by a number of factors. Some factors are technical, others are economic and some cases are concerned with politics of organizations. The technical factors are concerned with the suitability of the DBMS for the task at hand. Issues to be considered here are the type of DBMS (relational,

network, hierarchical, other), the storage structures and across paths that the DBMS supports, the types available for user and programmer interfaces, the types available for high-level query languages and so on.

2.8.4 Phase 4 : Data model mapping

This is also called a logical database design. During this phase, (or transform) the conceptual schema from the high-level data model used in phase 2 is mapped into the data model of the DBMS chosen in phase 3. This phase can be started after a choice of an implementation data model rather than waiting for a specific DBMS to be chosen.

2.8.5 Phase 5 : Physical database design

During this phase, the design is specified for the stored database in terms of physical storage structures, record placement and access paths. This corresponds to the design of the internal schema in the terminology of the three-level DBMS architecture.

2.8.6 Phase 6 : Database system implementation

After the logical and physical designs are completed, one can implement the database system. Language statements in the DDL (Data Definition Language) and SDL (Storage Definition Language) of the selected DBMS are compiled and used to create the database schemas and database files.

The database transactions must now be implemented by the application programmers. The conceptual specifications of transactions are examined, and corresponding program code with embedded DML (Data Manipulation Language) commands is written and tested.

2.9 System Development Life Cycle (SDLC)

Senn (1989) stated tat the SDLC method (Figure 2-16) is classically thought of as a set of activities that analysts, designers, and users carry out to develop and implement an information system.
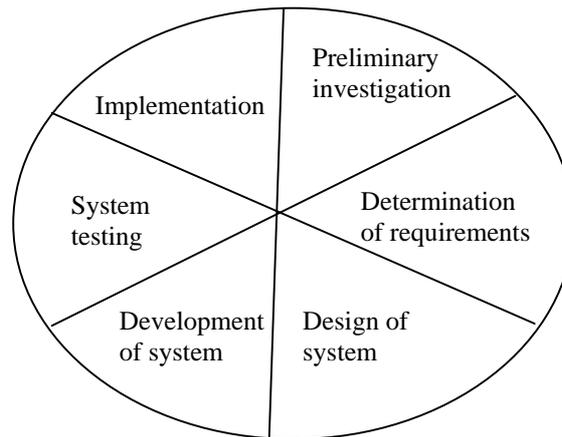

Figure 2-16 Activities in classical system development life cycle

Source : Senn 1989: 29

The system development life cycle method consists of the following activities:

1)   Preliminary investigation

A request for assistance from information systems can be made for many reasons, but each, a manager, an employee, or a systems specialist initiates the request.

2)   Determination of system requirements

A detailed understanding of all important facets is the heart of system analysis. The analysts study the requirements of data to identify features of the new system.   There should be the information system that will produce operational features, such as processing controls, response times, input and output methods.

3)   Design of system

The design of an information system produces the details that state how a system will meet the requirements identified system analysis. System specialists often do this stage as logical design.   In contrast, the process of developing software program is referred to as physical design.

Documents containing the design specifications portray the design in many different ways, such as charts, tables, and special symbols. The detailed design information is passed on to the programming staff so that software development can begin.

Designers are responsible for providing programmers with complete and clearly outlined software specifications.

4) Development of software

Software developers may install (or modify and then install) purchased software or they may write new, custom-designed programs.

Programmers are also responsible for documenting the program, providing an explanation of how and why certain procedures are coded in specific ways. Documentation is essential to test the program and carry on maintenance once the application has been installed.

5) Systems testing

During systems testing, the system is experimentally used to ensure that the software does not fail. In many organizations, testing is performed by persons other than those who write the original programs to ensure more complete and unbiased testing and more reliable software.

6) Implementation and evaluation

Implementation is the process of having system personnel check out and put new equipment into use, train users, install the new application, and construct any files of data needed to use it.
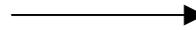
2.10 Data Flow Diagram

A graphic tool is used to describe any analyze the movement of data through a system including the processes, stores of data, and delays in the system.
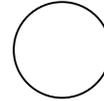
2.10.1 Notation

Logical data flow diagrams can be complete using only four simple notations (Senn, 1989).

1) Data flow.

It represents data that move in a specific direction from an origin to a destination.

2) Processes.

They represent people, procedures, or devices that use or produce data.

3) Source or destination of data.

It represents external sources or destinations of data, which may be people, programs, organizations, or other entities, interact with the system but are outside is boundary.

4) Data store.

It represents data that is stored or referenced by a process in the system.

There are advantages of data flow analysis as follows :

1)   The notations are easily understood by users, 2) users can make suggestions for modifications of the diagrams to more accurately describe the activity, 3) it can examine problems quickly so that it can be corrected before other design work begins, 4) it can examine the data that enter the process and seeing how it is changed when it leave the process and 5) it is developed and is sued progressively from the general to the specific for the system (Senn, 1989).

2.11 Related Research

Breidenbach A.W. and Clarke R.M. (1974) stated that the waste / rubbish information collection to design waste management database should be as the following;

- Location of waste production, waste type and amount of waste collection and disposal site

- Organization resources such as people equipments infrastructure, budget etc that needs to be used in waste management including waste collection, waste reduction and waste disposal.

- Transportation, waste disposal and disposal site and other infrastructure Statistics data plays an important role in waste management planning for

example population, economics, road network , industrial production trend etc. Computer software can provide flexible specific presentation and support decision making. It utilizes all collected and stored data, then it provide useful and significant information based on those information such as the increase of cost in rubbish collection and disposal, the trend of population etc.

It can be concluded that the data survey should be carefully done especially with the basic information of rubbish management of local administration and industry, law/ACT and regulations related to rubbish collection and disposal, the study of rubbish production from households, business district and industry including details of rubbish collection procedure, route network and disposal procedure.

From the rubbish and waste management of a municipality survey report, 1983 by Environment committee, the objectives of the report was to collect basic information and analyze it to plan the rubbish management procedure effectively. The following suggestions are detailed below;

- General information such as population, number of households, reas of responsibility and population density etc.

- Rubbish collection, to study the area of rubbish collection, amount of rubbish collection which depends on method of collection, the frequency of collection and the effectiveness of collection, number of trucks used for the rubbish collection and other related equipments such as number of cars or trucks, years in service and the rate of service per day etc.

- Rubbish disposal such as rubbish disposal method, disposal site (i.e. distance from the community, project area etc.)

- The administration human resource and budget for the responsible organization such as the actual income of the responsible organization (only for the

rubbish collection fee) , the actual expense of the rubbish disposal (excluding monthly salary) etc.

From Chonthicha's thesis (Chunticha, 1992), the study was to identify the potential area site of closed disposal site using GIS for the Saraburi municipality . The related geographical factors used in this study was slope, soil depth, underground water level, landuse and others factor such as road network, waterways etc. These information layers were then used in overlay technique to find the potential disposal site.

The road network was used to design the accessibility of rubbish trucks for the disposal site. The waterways was used to find the distance of disposal site and the water feature as the distance is too short it would contaminate the water resources.

Environmental Quality Information Systems (EQUIS) in Samutprakarn Province 1992 by TDRI and JICA. It described the importance of information system management for pollution control planning. As in the present there is lack of information system and pollution monitoring from the originated source and its surrounding. Therefore it is necessary to acquire the basic information such as pollution type, amount pollution created per day, pollution originated source, the polluted responsive area, the severity of the problem etc. The system of acquiring information can be used to calculate and forecast the outcome of the problem then it can be used to support decision making or pre-planning also preparing budget and resources according to the severity of the problem.

The study revealed the industrial location map and industrial management database, waste water information, solid waste from the industry, air pollution, and waste from the community. It was represented by a graphic showing the density of waste originated sources in the problem area and the present and future problem situations.

Krisada Tongudom (2001) indicated his research "Application of Geographic Information System for Solid Waste Collection Routing: A case study of Prachathipat Municipality, Pathumthani Province". The objectives of this research were to collect data and information concerning solid waste collection system in Prachathipat Municipality, in order to propose data analyzing techniques for waste collection routing, and to develop and application program to determine waste collection routing based on equal amount of waste for each truck and the shortest path for each truck.

The results of waste collection routing showed that, for the 5 trucks of HCS, the range of the number of trips per week per truck had decreased from 18-39 to 24-35. The total travel distance had not changed because the truck routes were the shortest distances. For the 13 trucks of SCS, the total trips of waste collection had decreased by 10 trips per week, or the total travel distance had decreased 256.87 kilometers per week.

Chaiyasit Aranyasathat (2003) presented his research "An Application of Geographic Information System for Solid Waste Collection System Management: A case study of Laksi District, Bangkok". The objective of this research was to create and apply the geographic information system (GIS) for solid waste collection system management of the Laksi District to find suitable solid waste collection routes. The target of this research was to select a new route, which is shorter in distance and covers the present area of the waste management district. Moreover, this research can be used for selecting site, which has the capability to be the mini solid waste transfer station of the Laksi district.

The results of the solid waste collection routes analysis can be summarized as follows: length of the route of the 21 trucks of SCS can be decreased from 11,097 Kilometers/week to 7,932.45 Kilometer/week (a reduction of 3,164.55 kilometers/week). The route of the 7 trucks of HCS can be decreased 4,462 kilometers/week to be 3,285.99 kilometers/week (a reduction of 1,176.01 kilometers/week), and the total trips distance of the five 2 ton compactor trucks (SCS trucks) "shall be decreased 783.34 kilometers per week when the mini transfer station has been setup.

2.12 Case Study Area

    2.12.1 Geography

        2.12.1.1 Location

        Salaya Sub-district has office building no. 65/35-37, Putthamonthon District. The distance is 32 kms from Nakonprathom Province and it's far from Bangkok about 20 kms.

        2.12.1.2 Area

        Total area 13 km^2

        2.12.1.3 Boundary

North	Connected to 5, Salaya Sub-district, Putthamonthon, Sai-noi district, Nakonprathom province.
South	Connected to Bangteuy, Bangrateuk, Trongkanong, Homgret and Sampran district, Nakonprathom Province.
East	Connected to Saladang Sub-district, Taweewatthana, Bangkok.
West	Connected to 1, Salaya Sub-district, Putthamonthon district.

        2.12.1.4 Landscape

        This area, which is 5 meter high from sea level, is plain. In general conditions are clay.

        2.12.1.5 Climate

        There are 3 seasons in Salaya Sub-district. Average temperature all year about 32 °C.

    2.12.2 Population

    The amount of population in Salaya Sub-district by following the residence registration of Putthamonthon district are totally 7,724 people in the end of September, 2542 which is classify by

    Male 3646 people

    Female 3760 people

    Amount of residence 1549

    Average of density about 594 people per km^2

2.12.3 Economy

2.5.3.1 *Agriculture*: land used for agricultural such as field, mango, coconut, pomelo gardening and farming.

2.5.3.2 *Commerce*: There are many retail shops which consumers consume about 70 shops.

2.5.3.3 *services*: There are 5 restaurants in Salaya Sub-district, 1 hotel, but it doesn't have any theater or any places of amusement.

2.5.3.4 *Labor*: there is enough agricultural labor on staffs.

2.5.3.5 *Tourism*: At present, there is many attracting places such on Putthamonthon.

2.12.4 Education: There are many educational parks at Salaya Sub-district such as.

Primary school	total 1 places
Secondary school	total 2 places
Department of Non-formal Education	total 1 places
Vocational Education	total 2 places
University	total 2 places

2.12.5 Religion:

Putthamonthon Place	total 1 places

2.12.6 Public Health

Health center	total 1 places
Public health's official	total 3 persons

2.12.7 Public Support

Electricity:	There is Putthamonthon regional electrical work which service at municipality
Water supply:	at Salaya Sub-district service water supply to local people and outside some related areas.
Communication:	Post office of Putthamonthon
Transportation:	There are 3 main streets such as:

1. Salaya - Nakonchaisri distance about 20 kms.

2. Salaya - Bangpasre distance about 15 kms.

3. Putthamonthon 4th distance about 25 kms.

There are three regular ways, which is minibus service. There are car pools no 124, 125 and air conditioning bus no 515 to serve in Salaya Sub-district by running between Bangkok to Putthamonthon and bus no 84, Bangcare to Putthamonthon.

2.12.8 The Quantity of Waste Transportation from Salaya Municipal

Table 2-6 The quantity of waste and routing cost for waste transportation

Transportation Route	Quantity kg/day	Distance (km.) Route Trip	Size of car m^3	Cost Baht/day
1. Salaya Municipal - the conner 4 road – Salaya market – Old Salaya market – Sahapond village – damping area	4,684.28	41	10	1,898.84
2. Salaya Municipal – Kew restarant – Soi So Poonsub – Some part of Mu 6 – Knon Tavi damping area	2,460.42	30	4	959.4
3. Salaya Municipal – Salay raiway – Salawan School – Soi Wat Salawan – The edge of a canal – damping area	2,631.42	39	4	1,026.25
4. Salaya Municipal – Mahidol Anuson School – Salaya village – Bank of Siam - Putthamonthon – damping area	4,434.33	37	10	1,729.38
Total	14,210.45	147		5,613.87
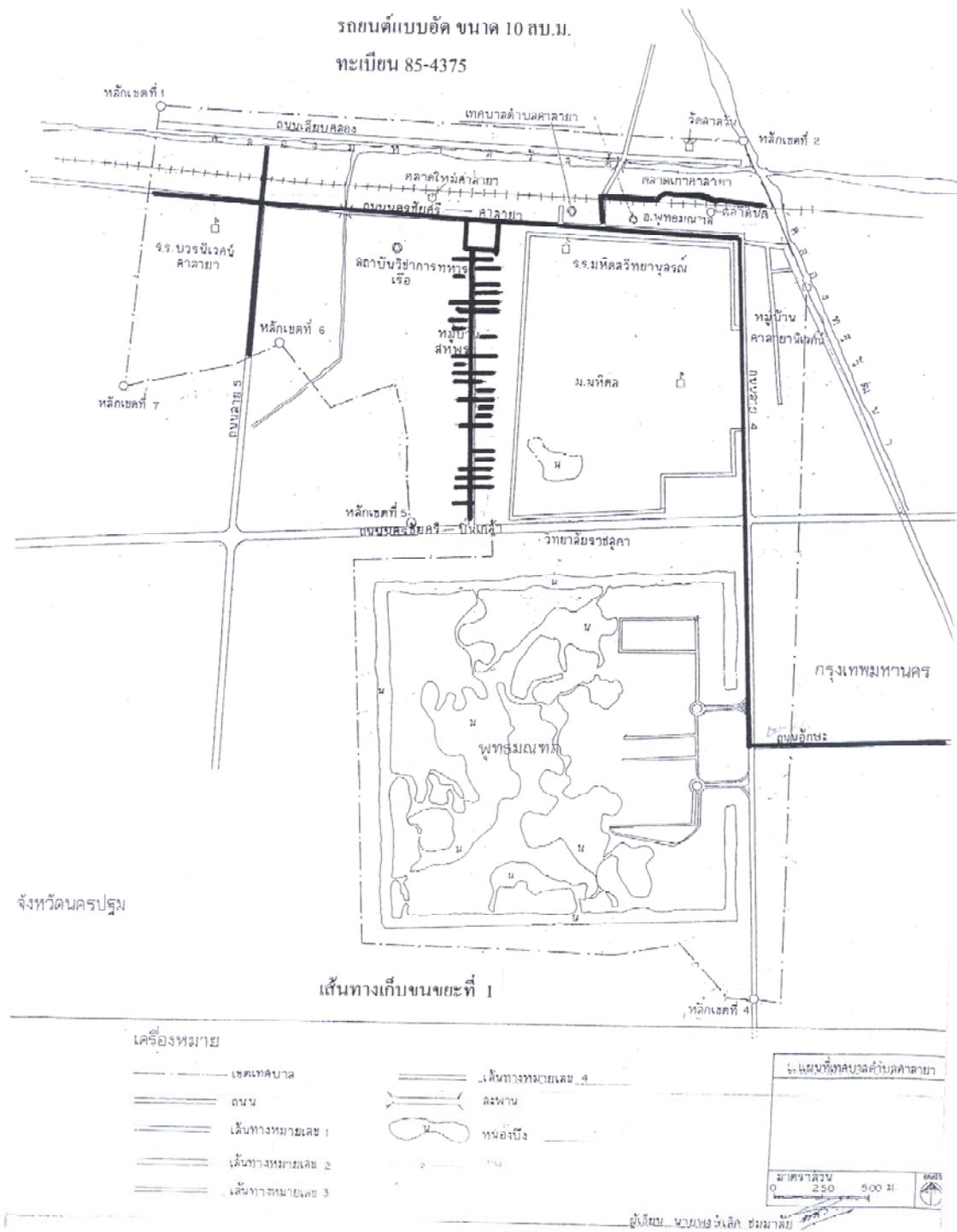
Figure 2-17 First Routing

Figure 2-18 Second Routing
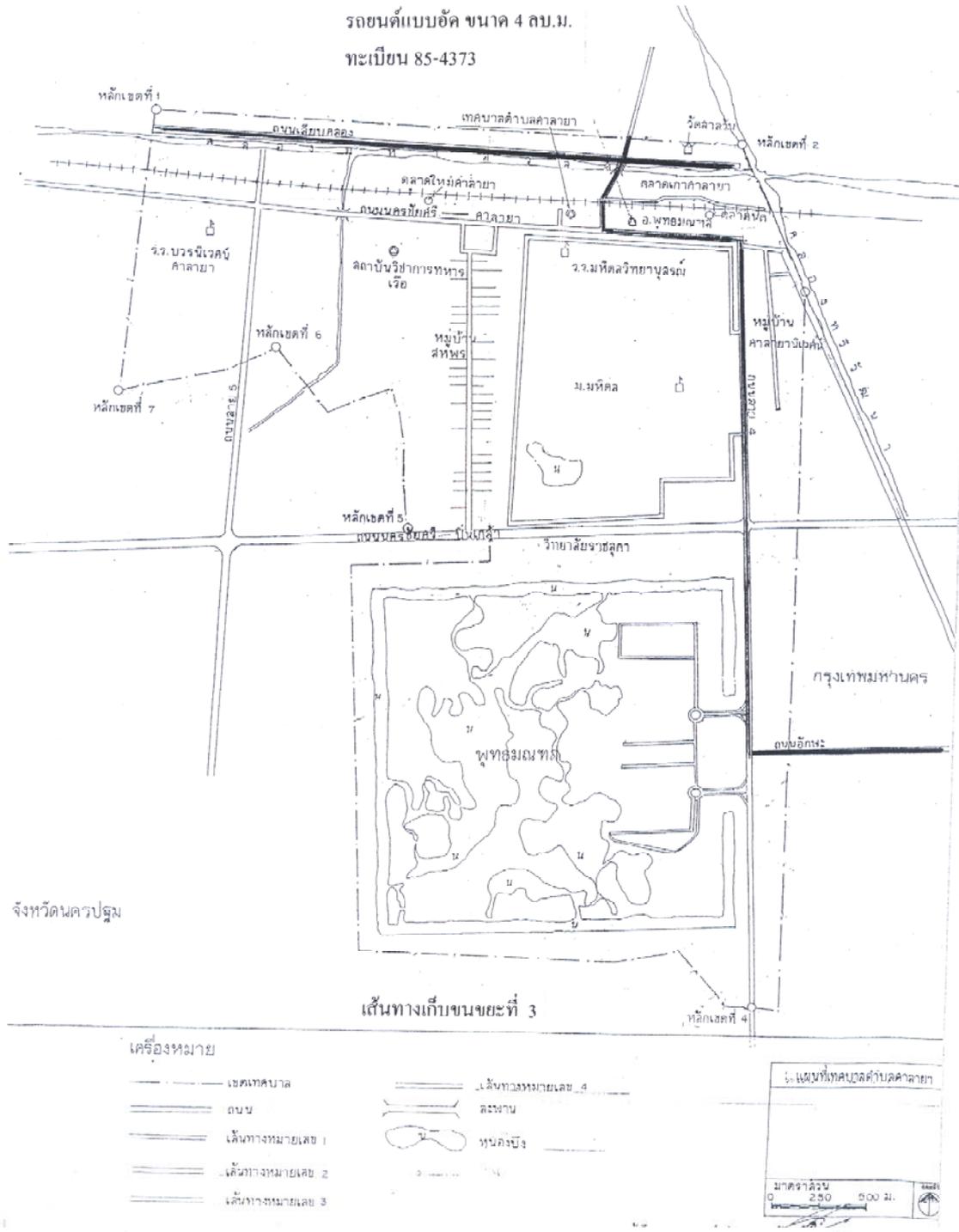
Figure 2-19 Third Routing
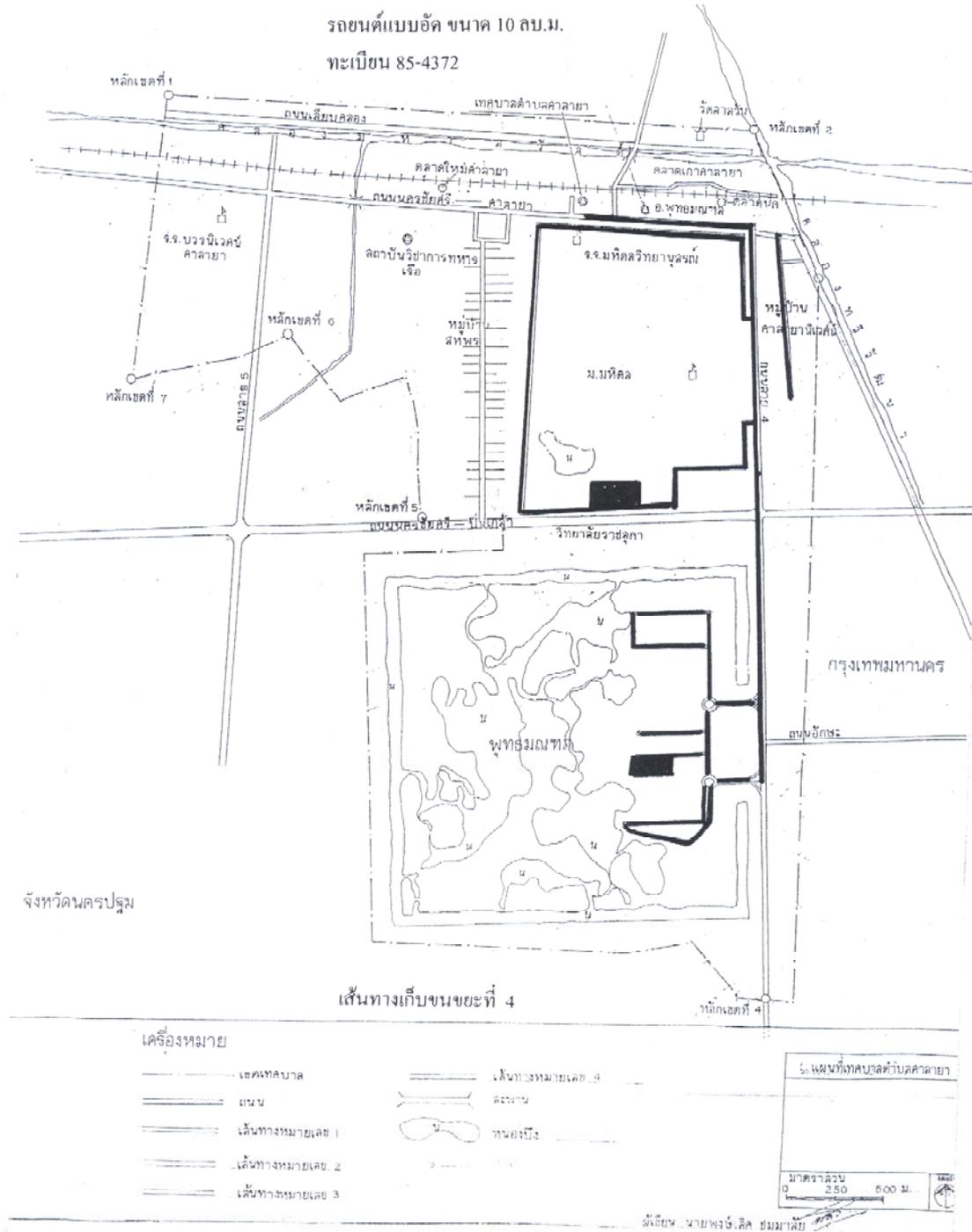
Figure 2-20 Fourth Routing

CHAPTER 3
RESEARCH METHODOLOGY

From the study of rubbish collection solution to present, the author has collect the deficiency and problems of the previous application. As the result, it was found that the main problem arose from the developed tools or application was not applicable to users. Therefore, the author aimed to implement the information system to solve this problem and propose the new presentation pattern of rubbish collection route. The information system would assist the related staffs and increase the effectiveness of rubbish collection. The thesis methodology has been outlined as the following.

3.1 Data Collection

All collected data were from

3.1.1 Primary Data

The data was mainly from the field survey form which was the record of rubbish truck collection daily performance. It was designed to accumulate the required information that would be used to design database structure. It would record the all steps used in rubbish collection for each collection point i.e. from departing the station to till the final step of rubbish collection and other related information.

- Rubbish Collection Route for each truck
- Rubbish Collection point
- Amount of rubbish at each collection point
- Frequency of rubbish collection at each point
- Truck collective volume
- Number of collecting trips per day, per week for each truck
- Traffic condition

3.1.2 Secondary Data

The secondary data was from the study and report, research and statistics data revision related to the study area including map and other related information collected from many organization. The details were as the following.

- Salaya Municipality development plan ,2545 Municipality Office, Salaya Municipality, Putthamonthon, Nakornpathom
- Road Network in Salaya Municipality by Civil Works and Town Planning Department
- Landuse Map from City and Town Planning Department, The ministry of Interior.
- The statistic of the amount of rubbish production from Salaya Municipality, Putthamonthon, Nakornpathom
- Details of rubbish trucks, Salaya Municipality, Putthamonthon, Nakornpathom

3.2 Research Methodology

The methodology of information system development was detailed as the following.

3.2.1 Identification of Problem and The Feasibility Study

Once we had identified the problems of rubbish collection, then the solution was proposed. The research had created information systems and studied to see of the system could be used to solve these problems. The questionnaires were created to collect information from the officers. The data analysis was then carried out to evaluate the possibility of creating the information system. The feasibility study was done in 3 methods as stated below.

1) *Technical Feasibility Study* – the study involved bringing about the latest technology to be part of the application such as hardware, software and considering the knowledge base and expertise of the local officers in computer. This research introduced GIS to analyze the problems by identifying the responsibility of each truck for a certain area and identify collection route and number of collection points as all trucks had to have equal responsibility.

2) *Practical Approach Feasibility Study* – This would assess the capability of the users in the organization. It would focus on the methods to response to the user requirement and the effects of the system to the nature of work.

3) *Economics Approach Feasibility Study* - The study would identify the cost involving the system installation including hardware and software cost. It would consider using the appropriate software whether or not the organization is ready to use the system and identify the limitation if any.

3.2.2 The System Analysis

Once the problems and user requirement had been identified through the interview and questionnaires form. All collected information was analyzed in order to design the database structure and the information system using Context Diagram. It could display the outline of the whole system where each information is related to one another. Figure 3-1 shows the Context Diagram

Context Diagram
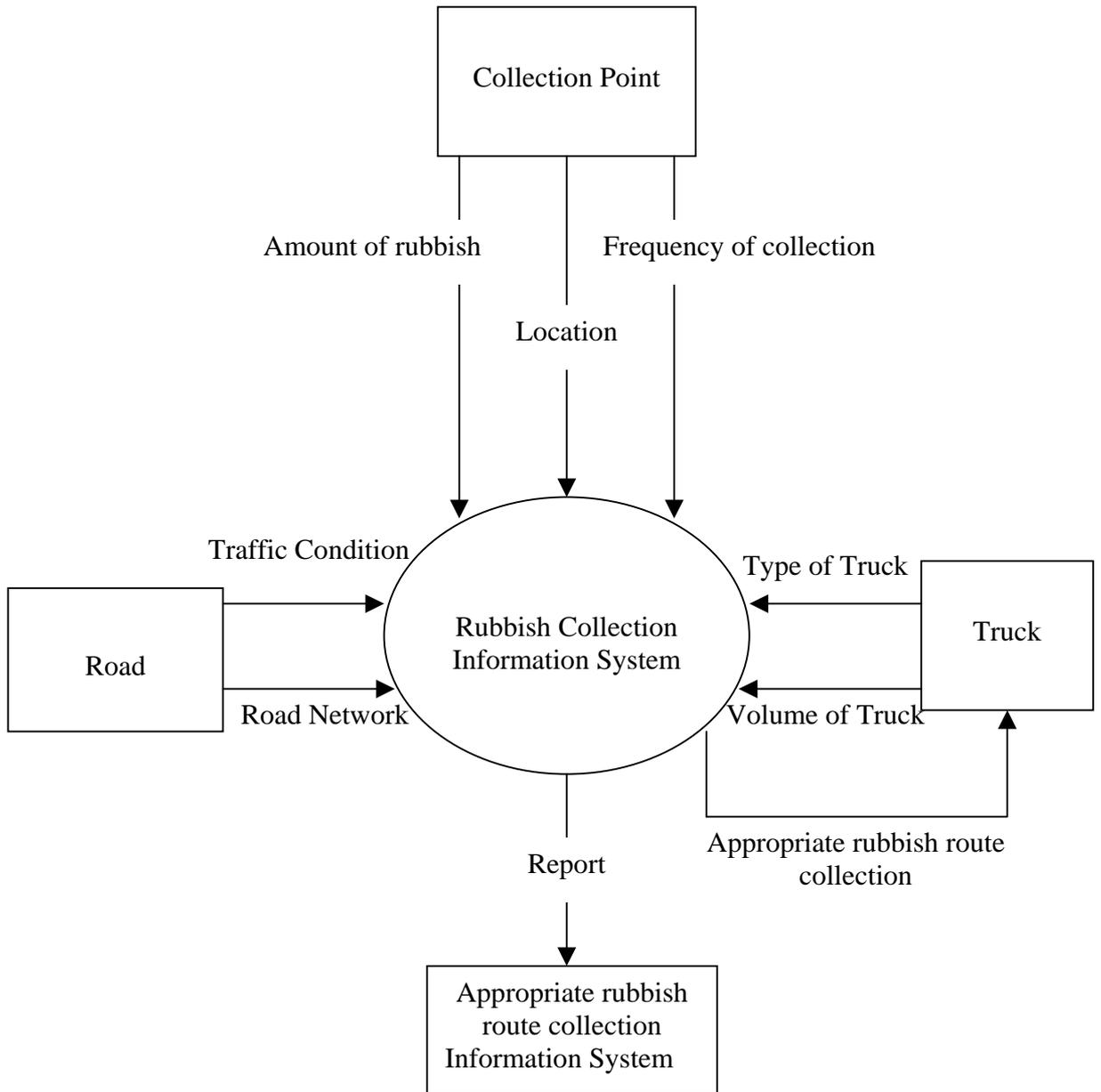
Figure 3-1 Context Diagram

From Figure 3-1, the context diagram could be explained as below

   1) The Collection Point – display the details of collection point's name, location, amount of rubbish to be collected and frequency of rubbish collection. All data was from the field survey.

   2) Road- display the road network and traffic condition using information from Civil Works and Town Planning Department and field survey.

   3) Truck – display the characteristic of trucks such as type of truck, volume of truck, theses data were from questionnaires and report, documentation from Salaya Municipality, Putthamonthon, Nakornpathom

   4) Appropriate Rubbish Collection Information System – the output result of report done by the system. It is used to assist the officers in rubbish collection operation planning.

3.3 The System Design

   Once the information system procedure had been analyzed the design state had then started. The Flow chart diagram was created and detailed and the context diagram was finalized. The detail of context diagram were as the following.

   a) The output presentation – consists of report with graphics and tables and could be displayed both on screen and printing out.

   b) The data input design – data collection form from many sources prior data entry.

   c) The database and data structure design – using E-R diagram to create relational database and prepared data dictionary to explain the data components within the system.

   d) The connection design – create the user interface on screen which is user friendly . There was a need to ask the user requirement what they want to be appeared on screen what is the outline of report etc.

3.4 Design and Test The System

After finishing the system design structure, the system was created and implemented using Microsoft Access 98 with its properties RDBMS (Relational Database Management Systems) as it has object base characteristics which includes table, query, form, report and macro and module.

The information systems designed for the rubbish route collection, the author created the GUI (Graphic User Interface) by Visual Basic as the user can record, change and update and analyze data as required. The data representation was in the form of graphic, map and tables which were related and can be presented in both on screen and in a report.

Then the system test was carried out to test the system performance whether it run as designed or not. The test included the ability of command bottom as selected and the accuracy of data processing report and the debugged the system.

The user manual was prepared and distributed to the users.

3.5 System Assessment

The objective of system assessment was to evaluate the performance of the implemented information system in order to collect user opinion and comments. The target user group was the public health officers in Salaya Municipality who is responsible for rubbish collection and is the direct users. The assessment form queried for the fulfillment of data collection, the suitability of the application, and the friendliness of the system. Then the result was analyzed and concluded in percentage. The questionnaires were closed ends and open ends which would get some comments and suggestions from the user so that they could be used to further implementation.

3.6 Equipments and Tools

1) Hardware

- CPU, Pentium IV 1.8 GHz

- Memory (Ram 256 MB)

- Harddisk 40 GB

- Monitor 15"(1024 X 768)

- Keyboard, Mouse

- Scanner

- Printer

- CD-Writer

2) Software

- Microsoft Windows XP

- Visual Basic6.0

- Microsoft Access2000

- ArcView

3) Assessment Form for opinion and comments in terms of effectiveness and user appreciation to the system. The detail can be found in Appendix A.

CHAPTER 4
RESEARCH RESULTS

The development of geographic information system to support the garbage collection has been done using methodology as stated below.

4.1 Problem Identification and Feasibility Study

It was well known that accurate data and systematic data management can be used to calculate or forecast the solution to environmental problems. It can lead to decision making and planning including budget and resources planning according to the severe of each problem. Therefore the use of geographic information system is applied to administrate environment and resources for community. In order to reduce the severity of the problem and degrade all means development from the downsides of environmental quality, this latest GIS technology is introduced.

From the case study, the garbage collection problem, it is founded that the organization faces many problems regarding suitable garbage collection system and lack of proper data storage and retrieval including the application in administration and planning in future garbage collection

When the problems are identified, the solution is then sought and proposed to facilitate the problems. In this research, the author has proposed the development of geographic information system to support garbage collection. The feasibility study of the proposed system has to be carried out to testify the possibility in reality. This is done by questionnaires form to acquire information from the local officers. Then the results are calculated and summarized to propose the information system to the organization. The result of feasibility study in 3 areas are as the following.

1) *Technical Feasibility Study* : The author has found that the Public Health Division of Salaya Municipality has 2 computers : Pentium IV Harddisk 40 GB, Microsoft Office 2000 on Window XP. The local officers are familiar with basic computer skill and they are able to be trained in advanced computer literature.

2) *Practical Approach Feasibility Study* : The author has studied how the new system will be used in the workplace which changes from manual mode to computerized mode. From the questionnaires, the local public health officers in Salaya Municipality have a positive attitude to the new proposed system and expect convenience working environment such as no replication of data collection, no time consuming, fast retrieval and processing, quick report and no complication. In the first stage of the system introduction, there will be time for adjustment and in no time they will be accustomed to the new system.

3) *Economics Approach Feasibility Study* : The author has considered the cost of new system. It is founded that the investment in computer and software is not very high as the organization has its own computer and software. It can be integrated to the existed platform and on the fly. This leads to low investment when compares with the benefit from the system which is invaluable. However, when considering the fast and accurate work performance which results in better services and produce quick report and plan, the system is very attractive to the organization.

4.2 System Analysis

The author has collected data after the feasibility study was carried out. It is considered that the new system cane be proceeded. Therefore, more detailed information is gathered to get in depth information about the present garbage collection system. The data is then used to analyze the work system. Methods used to gather this information are stated below.

1. Questionnaires

The author gathers information and opinion from local public health officers and head of public health officer whom are responsible for the new introduced system.

They are informed details of the new system in terms of the system operation for the organization, relationship between inter-organization, personnel, new equipments and database relation.

2. Documentation Study

The author has collected related documentations such as registration, report, related records form. Then they are classified to identify the information flow, context and type of information and the use of information including the efficiency of work. From this analysis, the author has designed a new system and represented it in a flow chart as shown in figure 4-1 below.

```
                    ┌─────────────┐
                    │    Start    │
                    └─────────────┘
                           │
                           ▼
                    ┌─────────────┐
                    │ Record Form │
                    └─────────────┘
                           │
                           ▼
                ┌─────────────┐          ┌─────────────┐
                │ Data record │────────▶ │  Database   │
                └─────────────┘          └─────────────┘
                       │                        │
                       ▼        ▼               │
                ┌─────────────┐
                │    Data     │
                │ Processing  │
                └─────────────┘
              │                    │
              ▼                    ▼
        ┌──────────┐         ┌──────────┐
        │  Report  │         │  Report  │
        └──────────┘         └──────────┘
              │                    │
              ▼                    ▼
                  ┌─────────────┐
                  │     End     │
                  └─────────────┘
```
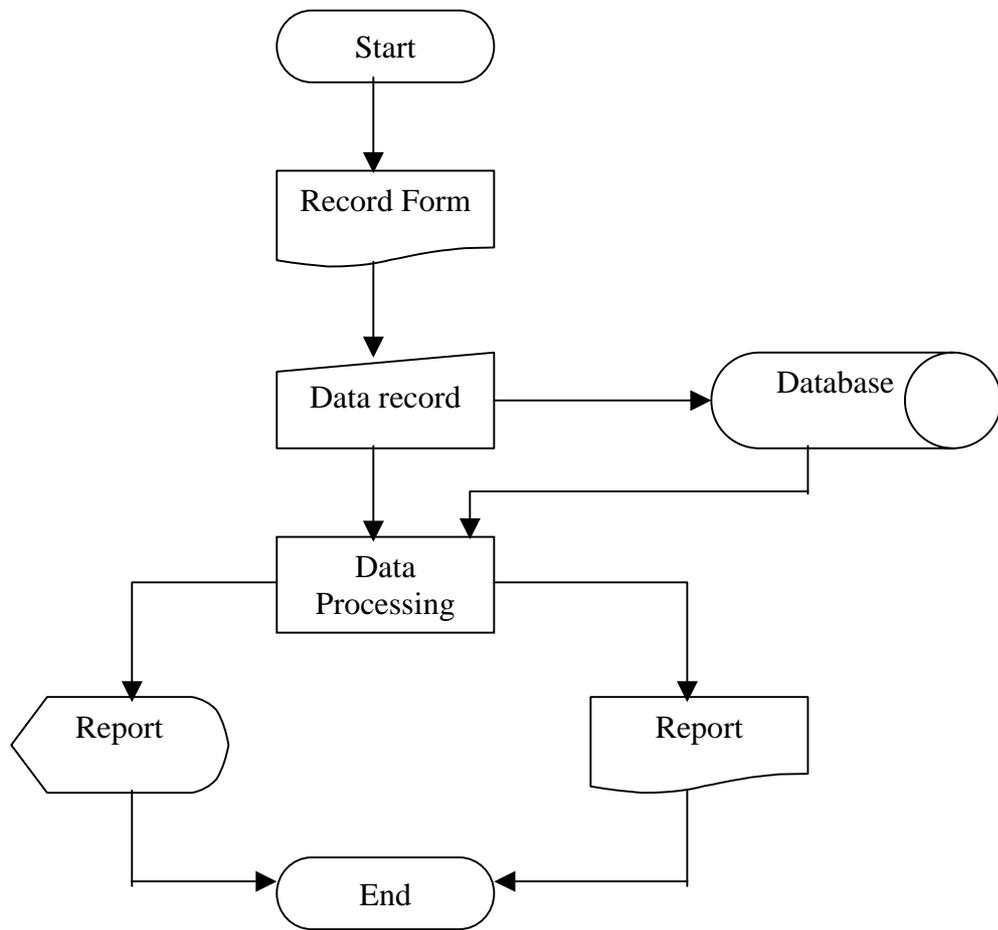
Figure 4-1 The new system Flow Chart

4.3 System Design

4.3.1 Data Representation Design

Report representation is divided into 2 parts namely on screen and printer. They consist of :

- Garbage bins data Report
- Garbage Collection Point Report
- Garbage truck data Report
- Garbage route collection Report
- Volume of garbage daily collection report
- Volume of garbage yearly collection report
- Graphic represent trend of garbage volume Report
- Officers Report

4.3.2 Data Entry Design

The author has designed data entry form from source document by using the previous record forms and adjusting and rearranging them to proper classes. So that , it will be convenient to entry data. The screen will be displayed according to the data structure for each data table. There are some part that the user can fill in the form by selection pull down menu to save time and reduce errors.

4.3.3 Database Design

The author has designed database structure using data analysis theory with E-R Diagram. It shows the data structure and information details and relationship of data structure. Normalization is the method used to reduce replication of data when data editing occurs i.e. add, delete and edit. E-R diagram is shown in figure 4-2
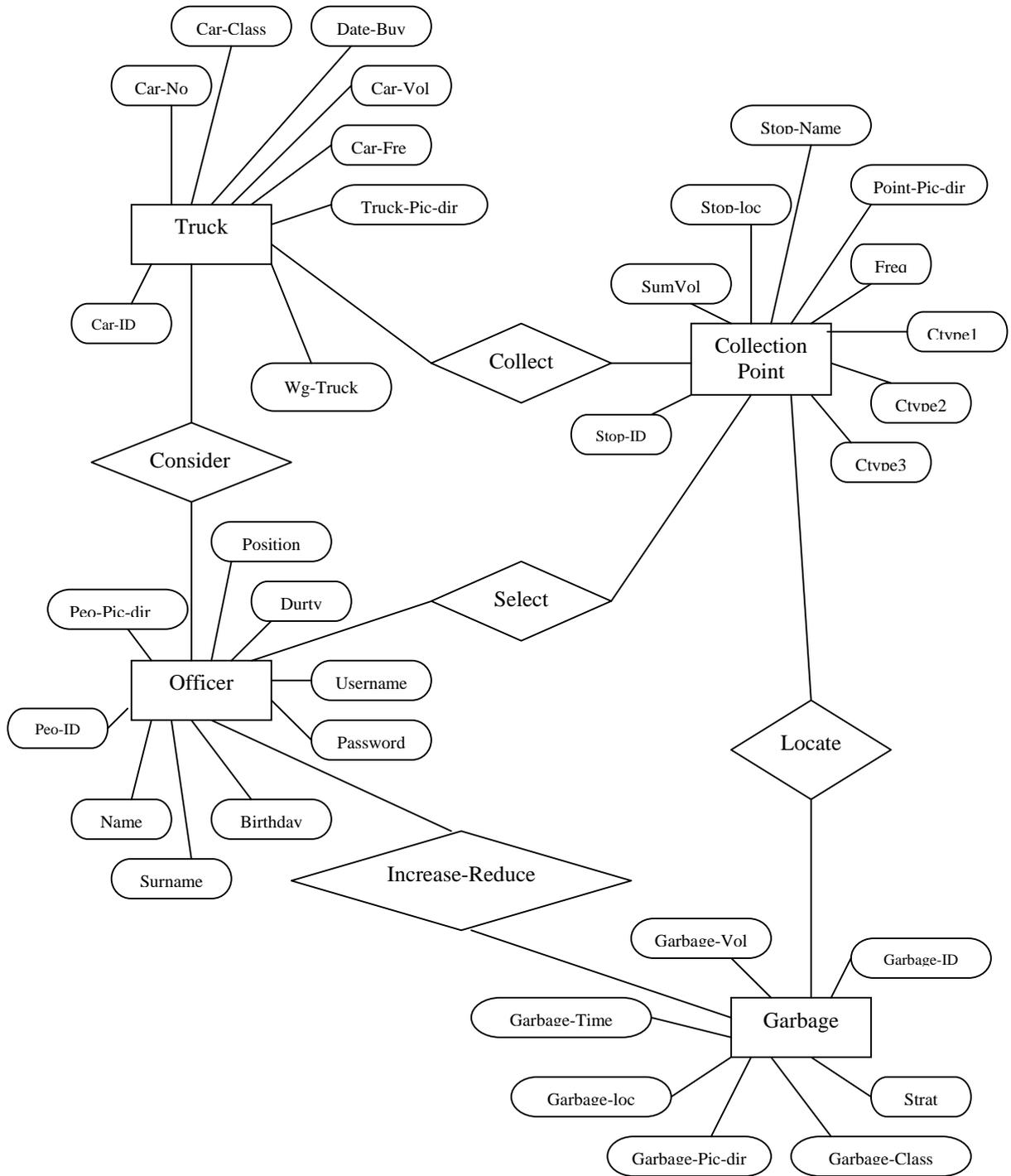
Figure 4-2 E-R Diagram of Database Structure

Symbols used for data structure are

Symbol	Meaning
▢	Entity
⬭	Attribute
◇	Relationship
──	Key

From the E-R diagram figure 4-2 , we can arrange main data structure for this system into 8 tables where each table in the database has a relationship using key to ;

1) Link each table which shares relationship and ease for search data
2) Data value for each row does not replicate
3) Prior update data, when data has been edited in the main table, data in each table which has a relationship will be edited and updated by Integrity Rule. The data structure relationship for each table can be displayed as the following :

Sub Table1 : Garbage Bin , Key ID is garbage_ID

garbage_ID	garbage_Class	Gabage_Vol	Garbage_Time	Start	Garbage_loc	Pic_dir

Sub Table 2 : Collection Point or (Stop), Key ID is Stop_ID

Stop_ID	Stop_name	Ctype1	Ctype2	Sumvol	Freq	Stop_loc	Pic_dir

Sub Table3 : Garbage Truck or (Truck), Key ID is Car_ID

Car_ID	Car_Class	Car_Vol	Car_Fre	Car_No	Date_buy	Pic_dir	Wg_truck

Sub Table 4 : Route , Key ID is Route_ID

Route_ID	Road_name1	Road_name2	Road_Type	Tran	Dis_total	Car_len	Pic_dir

Sub Table5 : Volume of garbage collection (Q_Solid), Key ID is ID

Q_ID	Year	Weight	Month	Month_num	Recorder

Sub Table6: Statistic Data, Key ID is ID

S_ID	Date	Route_ID	Car_ID	Weight	Recorder

Sub Table7 : Regression Analysis (Linear), Key ID is ID

L_ID	Pred_Y	Y	Y_ID

Sub Table8 : Officers or (People), Key ID is ID

P_ID	Name	Sur_name	Nation	Nationality	Reg	Post	Age	Birthday	Birth_address

Now_address	Tel	Signature	Fa_name	Father_name	Mum_name	Pic_dir

4.3.4   Data Linkage Design

This step is to design the linkage within the system to interface with the user via screen under user friendly environment. This is done by survey poll asking the officers what they want the screen to look like, what type of report they prefer etc. However the design would accommodate the need together with the convenience when it is in use. The screen shall consist of :

1. Data Entry Screen : It is designed to be easy to use, all input boxes are distinctive displayed . The user can see all information and select which information to be input. See figure 4-3 for data entry screen display.

2. Search and Display Screen : It is designed for each database, there is a pull down menu for user to select which data to be searched. See figure 4-4 for searching database screen display

Figure 4-3 Data Entry Screen
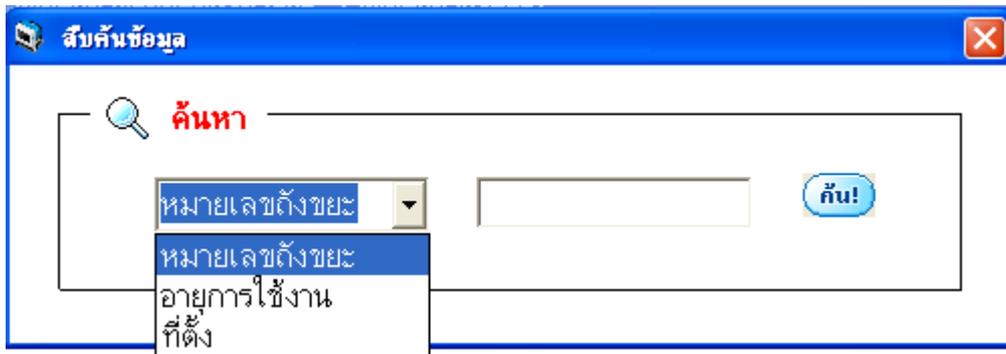
Figure 4-4 Search Screen

3. Menu : The user can select data using pull down menu which displays sub menu when the main menu is selected and graphic menu created from tool box. These 2 menus are convenient to use and tool bars are created on screen as well. See Figure 4-5 for too bars menu and Figure 4-6 for the system menus structure.

Figure 4-5 Menu Screen
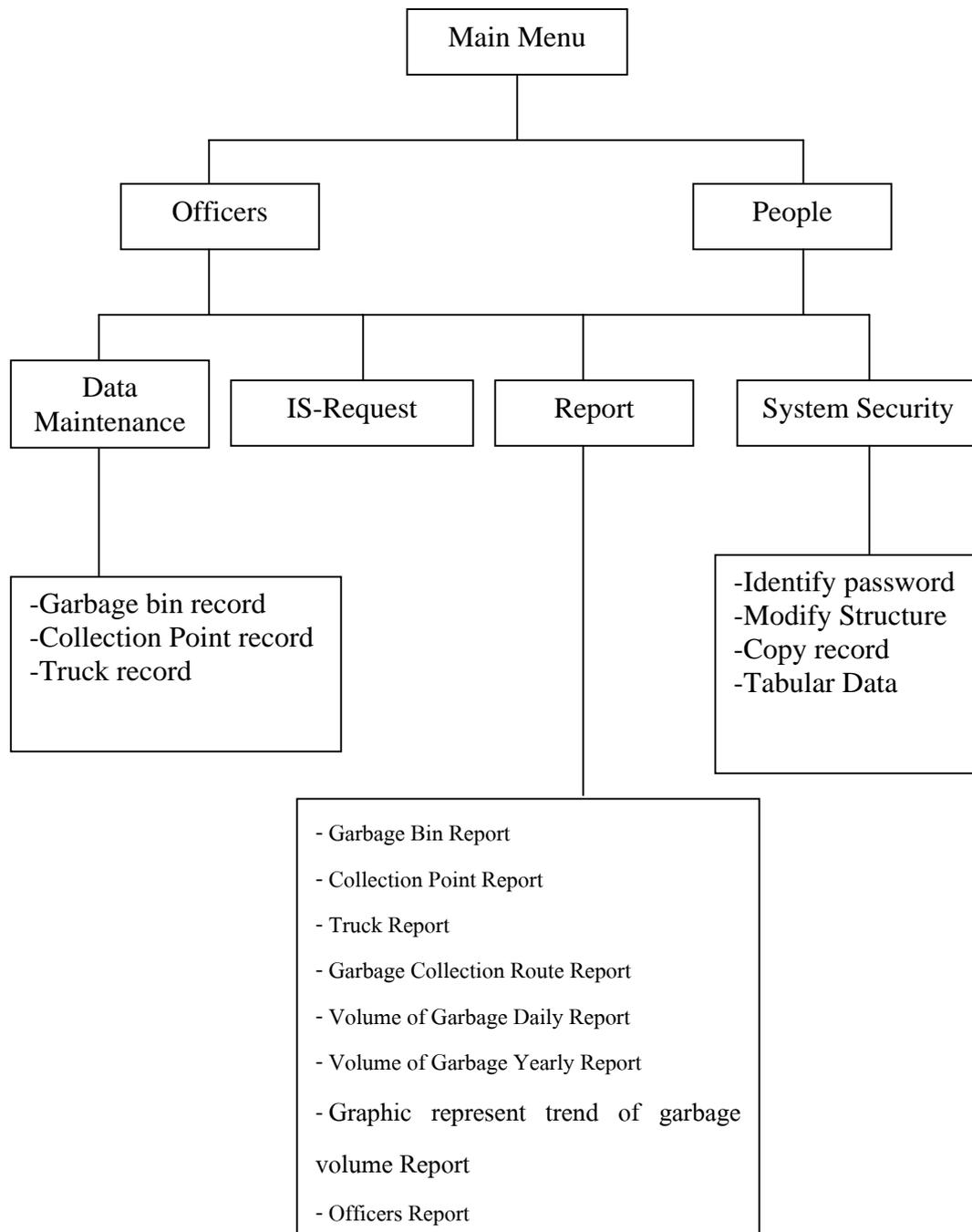
Figure 4-6 Menu System Structure

4) Error Message : It will display error message to notify user the status of interaction with the system if it is correctly performed i.e. when data is not properly recorded, the error message will be displayed. See Figure 4-7.
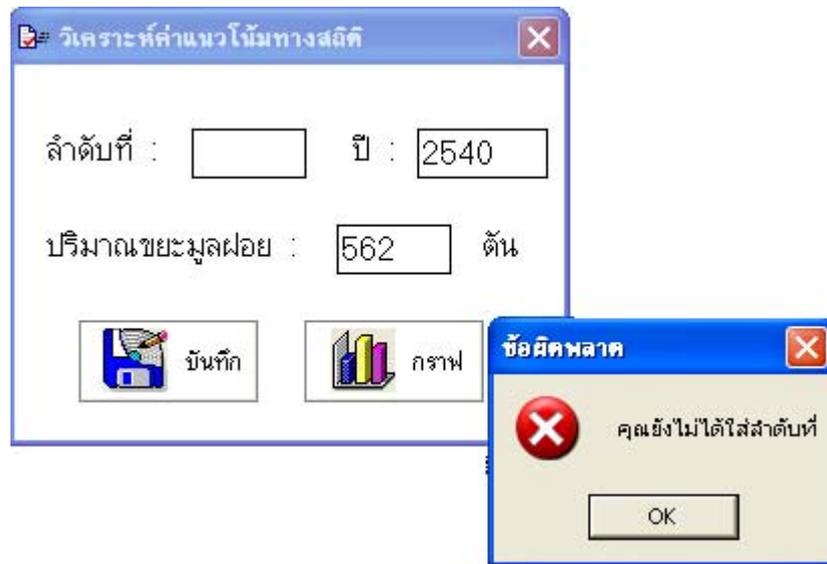
Figure 4-7 Error message Display

4.4 The System Implementation

The author uses Visual Basic 6.0 using Event procedure module to implement the system and Microsoft Access2000 to accomplish database on Windows XP. The graphic mode is linked using GUI : Graphic User Interface for convenience and easy to use. See Figure 4-8 for The system program chart. Sub program is created using Pseudocode. It explains the steps involved in the system. For the data maintenance part, the system includes Add, Edit, Delete records. It also applies to the whole system.
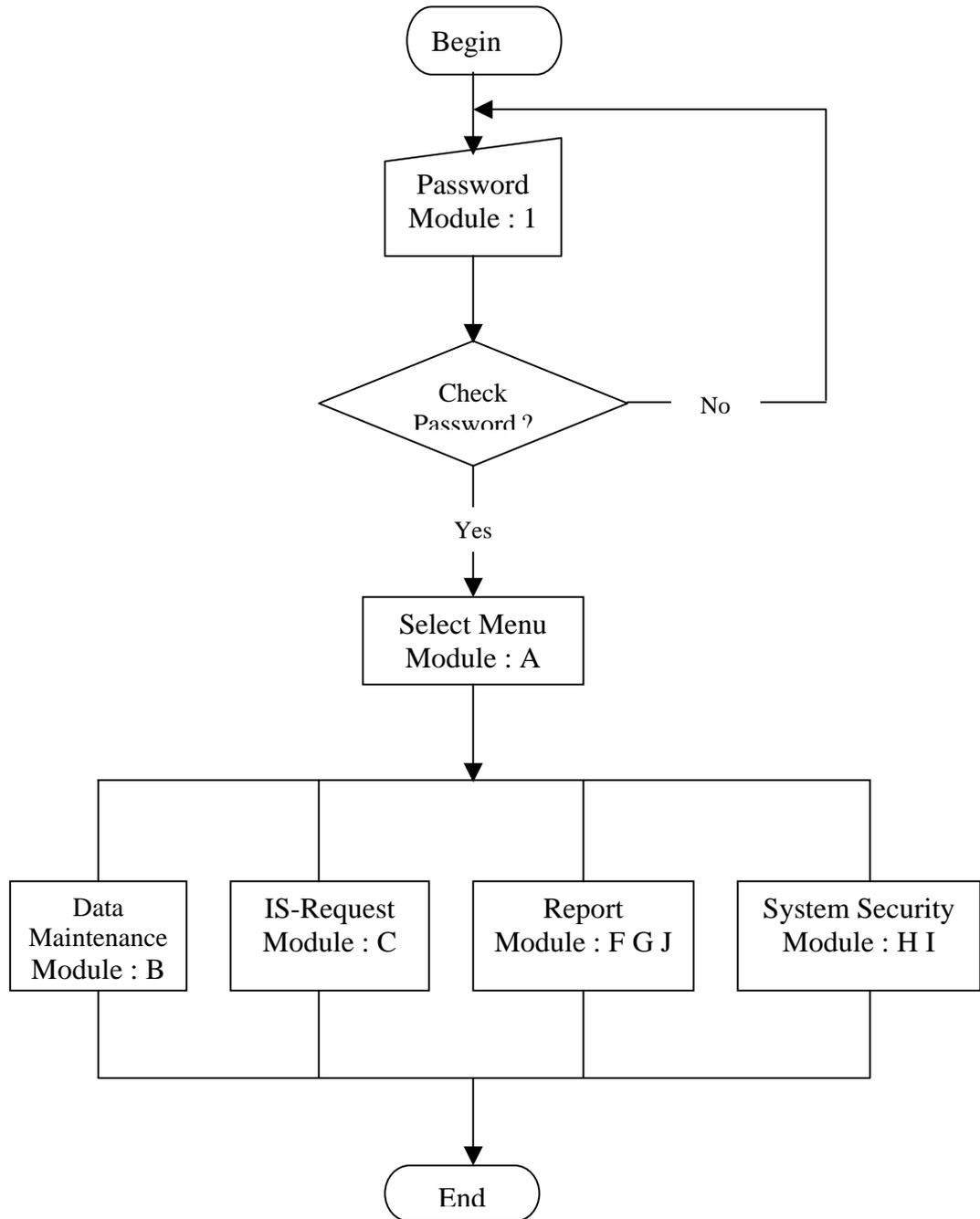
Figure 4-8 System Program Chart

The program is subdivided into modules details as the following :

Module A: The beginning of the program, It can select user level and main menu
          consists of Module B C D and E

Module B: Data Maintenance : ADD, Update, Delete and Search data

Module C: Data Processing , display table and graphic under user commands

Module D: Display result, it is divided into 2 user levels , consists of
          Sub Module F G J

Module E: System Security, consists of sub module H I

Module F: Sub module to display route analysis report

Module G: Sub module to display statistic analysis report

Module H: Sub module to system security, identify all user passwords

Module I: Sub module to system security to edit the data structure

Module J: Sub module to all displayed report

4.5 The System Performance Test

The author has tested the system performance whether it can perform accurately as designed by data entry, edit, update, delete, search , process data and report. It is tested to see the flow of the whole system and perform as per command. It can be checked by selecting a command and see if the system follow the command. The accuracy test is done by entering data and process it. The output result is tested if it is correct. If not, the program would be edited. Then user manual would be created to guide them to use the program.

4.6 Program Installation and User Manual Preparation

The author has installed the program for the real use and prepared user manual so that the user can understand and operate the program easily. Details of program installation and user manual can be found in Annex A and B respectively.

4.7 System Maintenance

When the system is in use for a period of time, there may be a need to change data structure for more details and delete some from the database. More reports may

be added to accomplish the need in the organization. The system maintenance can be done if the responsible officer has a knowledge in the system programming i.e Visual Basic6.0 and Microsoft Access2000. This can help them to edit the data structure and create new commands to work within the program such as add more data, display reports which then cannot harm the whole system.

4.8 The System Assessment

The system assessment has been carried out by 3 user groups namely the experts in design and development system, experts in garbage management and normal users. The result of system assessment are concluded as the following:

1. The Design and System Analysis Assessment: This is assessed by 3 experts namely Asst. Prof. Saranya Sucharitkul, Veerachat Chatpanyacharearn and Asst. Prof. Supetch Jirakhajornkul. The questionnaire involves the accuracy of steps used in system analysis, system design, and the suitability in tools selection for system design. The experts have agreed in the mentioned area as Good 66.67% and Moderate 33.33%. The accuracy of E-R Diagram is in Moderate level. The system design completion and test data, the experts agree that it is well suitable 66.67% and moderate 33.33%. There is additional comments for report representation in the area of more reports should be prepared to represent the summary of data to help in decision making in garbage management.

2. Garbage Management Assessment : There are 2 experts in garbage management namely Mr. Chingchai Boonprakong, The Public Health Officer 6 Salaya Municipality Putthamonton District Nakornpathom Province and Mr. Kritsada Thong-Udom, The Public Health Officer 6 MuangRangsit Municipality, Thanyaburi District Pathumthani Province. They have tested the system and assessed the system. They have commented that the developed system has covered all garbage information management. The management system is the vital part and it can be useful to integrate it in the workforce. The information representation is well suitable. The system interface is easy to use and convenience to search for information in well accepted

level. The data processing step is satisfactory sufficient.   The performance of data processing accuracy is in high level.

    3. Users Assessment: The users are divided into 2 groups as the officers and public users. The assessment focuses on the program interface, convenience, understanding , the data completion and data accuracy, the difficulty of the program when in use. The result of the assessment are stated below ;

        3.1 The Officers: The author has assessed the users preference in the public health office whom are related to garbage collection , 7 officers , 3 female officers 4 (57.14%) and 3   male officers   (42.86) . The education level varies from below undergraduate to master degree. Below undergraduate is 71.43%, Bachelor degree is 14.29% and Master degree is 14.29%. They all works for the Salaya Municipality. They are familiar with computer programs especially a commercial program.

        From the officer's point of view, they have agreed that the developed system has been fully designed to accommodate all data management in terms of garbage collection management and the program is easy to use and data entry , 85.71%. The data updating and data search is quick and data processing is accurate, 85.17%. There are a minority (14.29%) whom opposes that the system is not quite convenient and quick as expected. However, the majority has agreed that the system is easy to use and convenient and suitable to integrate in the workforce. They also give comments in the area of modifying the system to be used in a network and link to other organizations and add more information such as budget, purchasing and general management . If this can be modified , it will assist the officers and others whom are interested in garbage management.

        3.2 Public Users : The author has assessed the system to 20 public users who has a bachelor degree , 10 person, 5   male and 5 female, a master degree 10 person, 5 male and 5 female. They are familiar with computer programs especially a commercial program.

        From the public user's point of view , 80% of the public users have agreed that the garbage data management has been fully accommodated. There is only 20 % who comments that there should be more collection points and clearly identify the collection points. Ninety percent of public users point out that the system has accurate

data processing, very convenient and fast to search information. Eighty percent agrees that the system is easy to use and convenient. There is only 20% who comments that the system is moderately easy to use. The outstanding of the program is that it is easy to use and easy to search information and quick data processing.

It can be concluded from the above mentioned groups that the developed system implemented for the garbage collection management is fully accommodated the needs within the organization. It can be handled and operate with ease and convenient to use. The data processing is accurate and quick in search information mode. However, there are some suggestions on collection point information, budget, purchasing and general management. If the system is modified to include the mentioned information then the system will be perfectly in completion to efficiently integrate in the administration and management of garbage collection to officers and related organizations and interested public users.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The development of geographic information to support garbage collection is to assist in recording and data collecting which can be able to search and report garbage bin, garbage collection point, trucks, garbage collection route and garbage statistics. As to the present, this information has not yet been collected in a database. Therefore, it is a difficulty to search for mentioned information. This research has introduced the information system technology in database management and user interface to be integrated to serve users with convenience and quick response.

Information system to support garbage collection is designed to run on computer with its capability as Pentium IV 1.8 GHz, Memory 256 MB or better, Hard disk storage 40 GB or better under Windows XP and using commercial software Microsoft Access 2000 for database management. This program is used to design data table, data tables relation. This can prevent any mistake or error when performing data entry to database. The programming language used to implement the system is Microsoft Visual basic 6.0. It is used to create user interface to record, edit, search and report data.

From the study, it is found that the information system to support garbage collection can enable related garbage data management such as garbage bin, garbage collection point and trucks and related statistic value. It can be searched and reported in terms of paper report and graphic presentation. The author has created the user interface with ease of use and convenience. It can be used to assist in decision making and monitoring and planning for better garbage management.

Program assessment is carried out by experts in information system implementation and experts in garbage collection management and users. The opinion from experts in information system implementation has concluded that the system is in perfect condition. As from the experts in garbage collection management and users,

they have agreed that the system is easy to use and fast in processing, the garbage data is perfectly well captured and collected.

5.2 Recommendations

5.2.1 Recommendation in The Use of Research Result

1. Garbage collection data has to be updated regularly as it can represent the actual volume of garbage. It can also point out the trend of garbage volume in the future therefore the analysis can be accurate. The garbage collection point should be in order both with appropriate distance and number of garbage bins. This is to assist the officers to conveniently operate and keep the road in good condition. There is a need to ask for co-operation from local people to make it successful.

2. There should be a test for route collection from the officers to see if there is any problem during the operation. So that it can be adjusted. In addition, there should be a comment from truck drivers to manage and plan a garbage collection route.

5.2.2 Recommendation for Future study

1. This research has identified problems based on what happens in the garbage collection in Salaya Municipality. If there is any changes in the future that effects the route collection management. The modification has to be done to accommodate it. Furthermore, new conditions such as time, seasons, and traffic should be considered in route planning.

2. This implemented information system may have some limitation that cannot analyze data to suit user needs. Therefore, when using this system the user has to consider their need and the capability of the program itself together with conditions at that particular need. There should be a modification in the program to accommodate any future changes so that the program will serve the users according to their needs.

3. This implemented information system is based on a municipality provided data. However, it can be used to apply for another area using the same structure and analysis. It can be modified to suit for the problems in that particular area. It also can be linked to other databases within the local organization such as tax administration, garbage collection fee.

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APPENDIX

แบบประเมินผลผู้ใช้ระบบ
เรื่อง ระบบสารสนเทศเพื่อการจัดการเก็บขนมูลฝอย
ประชากรนิยาม- เจ้าหน้าที่หน่วยสาธารณสุขเทศบาลตำบลศาลายา (ผู้ใช้ระบบ)

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ส่วนที่ 1 ข้อมูลเกี่ยวกับผู้กรอกแบบสอบถาม
กรอกข้อมูล หรือ ทำเครื่องหมาย / หน้าข้อความที่เลือก

1. เพศ   ☐ หญิง   ☐ ชาย

2. การศึกษา   ☐ ต่ำกว่าปริญญาตรี   ☐ ปริญญาตรี

                     ☐ ปริญญาโท   ☐ ปริญญาเอก

3. ตำแหน่ง...

4. การใช้งานโปรแกรมฐานข้อมูล   ☐ ไม่เคย   ☐ เคย ระบุ.................

5. การใช้งานโปรแกรมอื่นๆ   ☐ ไม่เคย   ☐ เคย ระบุ.................

6. ความจำเป็นในการนำโปรแกรมเข้ามาช่วย

    ในการจัดการข้อมูลที่เกี่ยวข้องในการทำงานของท่าน ☐ ไม่จำเป็น   ☐ จำเป็น

7. ความต้องการโปรแกรมจัดการข้อมูล   ☐ ไม่ต้องการ   ☐ ต้องการ

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ส่วนที่ 2 ความคิดเห็นที่เกี่ยวข้องกับการใช้งานระบบ
กรุณาขีดเครื่องหมาย / ลงในช่อง ในหัวข้อที่ท่านเลือก

1. ระบบมีข้อมูลที่เกี่ยวข้องในการจัดการเก็บขนมูลฝอยครบถ้วนหรือไม่

    ◯ ครบ   ◯ ไม่ครบ   ควรเพิ่ม ....

2. ท่านมีความสะดวกในการป้อนข้อมูลเข้าสู่ระบบหรือไม่

    ◯ สะดวก   ◯ ไม่สะดวก   ควรเพิ่ม ....

3. ท่านมีความสะดวกในการแก้ไขข้อมูลในระบบหรือไม่

    ◯ สะดวก   ◯ ไม่สะดวก   ควรเพิ่ม ....

4. ท่านมีความสะดวกรวดเร็วในการค้นหาข้อมูลที่ต้องการจากระบบหรือไม่

    ◯ สะดวก   ◯ ไม่สะดวก   ควรเพิ่ม ....

5. ท่านคิดว่าการประมวลผลข้อมูลมีความถูกต้องหรือไม่

    ◯ ถูกต้อง   ◯ ไม่ถูกต้อง   ควรเพิ่ม ....

6. ท่านคิดว่าเมื่อนำระบบดังกล่าวมาใช้ในงานของท่านจะทำให้การปฏิบัติงานรวดเร็วขึ้นหรือไม่

  ○ รวดเร็ว   ○ ไม่แตกต่าง   ○ ช้าลง

7. ท่านคิดว่ารูปแบบการใช้งานของระบบโดยรวมเป็นอย่างไร

  ○ ใช้งานได้ดีง่ายและสะดวก   ○ พอใช้งานได้

  ○ ใช้งานได้ค่อนข้างยาก   โดยควรปรับปรุงในด้าน…………………………….

8. ท่านคิดว่าระบบที่พัฒนาขึ้นมีประโยชน์ในการทำงานของท่านหรือไม่

  ○ มี   ○ ไม่แน่ใจ   ○ ไม่มี

9. ท่านคิดว่าจุดเด่นของระบบที่พัฒนาขึ้นมีอะไรบ้าง (เลือกได้มากกว่า 1 ข้อ)

  ○ ความถูกต้องครบถ้วนของข้อมูล   ○ ความสะดวกรวดเร็วในการทำงาน

  ○ ใช้งานง่าย และสะดวก   ○ ระบบมีความน่าสนใจน่าใช้งาน

  ○ อื่นๆ ระบุ………………………………………………………

10. ท่านคิดว่าจุดด้อยของระบบที่พัฒนาขึ้นมีอะไรบ้าง (เลือกได้มากกว่า 1 ข้อ)

  ○ ทำให้การทำงานช้าลง   ○ ไม่มีข้อมูลที่ต้องการใช้งาน

  ○ ใช้งานยากและซับซ้อน   ○ มีข้อมูลไม่ครบตามที่ต้องการ

  ○ อื่นๆ ระบุ………………………………………………………

11. ถ้าจะปรับปรุงระบบให้ดีขึ้น ท่านคิดว่าควรจะปรับปรุงส่วนใด

  ○ ความสมบูรณ์ของฐานข้อมูล   ○ โครงสร้างของระบบข้อมูล

  ○ ความถูกต้องและทันสมัยของข้อมูล   ○ ความง่ายต่อการใช้งาน

  ○ ส่วนการประมวลผลข้อมูล   ○ ส่วนการค้นหาข้อมูล

  ○ อื่นๆ ระบุ………………………………………………………

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ส่วนที่ 3 วิจารณ์และข้อเสนอแนะ

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แบบประเมินผลผู้ใช้ระบบ
เรื่อง ระบบสารสนเทศเพื่อการจัดการเก็บขนมูลฝอย
ประชากรนิยาม- บุคคลทั่วไปที่สนใจข้อมูลเกี่ยวกับการจัดการเก็บขนมูลฝอย (ผู้ใช้ทั่วไป)

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ส่วนที่ 1 ข้อมูลเกี่ยวกับผู้กรอกแบบสอบถาม
กรอกข้อมูล หรือ ทำเครื่องหมาย / หน้าข้อความที่เลือก

1. เพศ   ☐ หญิง   ☐ ชาย
2. การศึกษา   ☐ ต่ำกว่าปริญญาตรี   ☐ ปริญญาตรี
                                             ☐ ปริญญาโท   ☐ ปริญญาเอก
3. การใช้งานโปรแกรมฐานข้อมูล   ☐ ไม่เคย   ☐ เคย ระบุ……………
4. การใช้งานโปรแกรมอื่นๆ   ☐ ไม่เคย   ☐ เคย ระบุ……………

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ส่วนที่ 2 ความคิดเห็นที่เกี่ยวข้องกับการใช้งานระบบ
กรุณาขีดเครื่องหมาย / ลงในช่อง ในหัวข้อที่ท่านเลือก

1. ระบบมีข้อมูลที่เกี่ยวข้องในการจัดการเก็บขนมูลฝอยครบถ้วนหรือไม่

    ○ ครบ   ○ ไม่ครบ   ควรเพิ่ม…………………………

2. ท่านมีความสะดวกรวดเร็วในการค้นหาข้อมูลที่ต้องการจากระบบหรือไม่

    ○ สะดวก   ○ ไม่สะดวก   ควรเพิ่ม…………………………

3. ท่านคิดว่าการประมวลผลข้อมูลมีความถูกต้องหรือไม่

    ○ ถูกต้อง   ○ ไม่ถูกต้อง   ควรเพิ่ม…………………………

4. ท่านคิดว่ารูปแบบการใช้งานของระบบโดยรวมเป็นอย่างไร

    ○ ใช้งานได้ดีง่ายและสะดวก   ○ พอใช้งานได้
    ○ ใช้งานได้ค่อนข้างยาก   โดยควรปรับปรุงในด้าน…………………………

5. ท่านคิดว่าจุดเด่นของระบบที่พัฒนาขึ้นมีอะไรบ้าง (เลือกได้มากกว่า 1 ข้อ)

    ○ ความถูกต้องครบถ้วนของข้อมูล   ○ ความสะดวกรวดเร็วในการทำงาน
    ○ ใช้งานง่าย และสะดวก   ○ ระบบมีความน่าสนใจน่าใช้งาน
    ○ อื่นๆ ระบุ……………………………………………………………

6. ท่านคิดว่าจุดด้อยของระบบที่พัฒนาขึ้นมีอะไรบ้าง (เลือกได้มากกว่า 1 ข้อ)

    ○ ทำให้การทำงานช้าลง   ○ ไม่มีข้อมูลที่ต้องการใช้งาน

    ○ ใช้งานยากและซับซ้อน   ○ มีข้อมูลไม่ครบตามที่ต้องการ

    ○ อื่นๆ ระบุ…………………………………………………………………………

7. ถ้าจะปรับปรุงระบบให้ดีขึ้น ท่านคิดว่าควรจะปรับปรุงส่วนใด

    ○ ความสมบูรณ์ของฐานข้อมูล   ○ โครงสร้างของระบบข้อมูล

    ○ ความถูกต้องและทันสมัยของข้อมูล   ○ ความง่ายต่อการใช้งาน

    ○ ส่วนการประมวลผลข้อมูล   ○ ส่วนการค้นหาข้อมูล

    ○ อื่นๆ ระบุ…………………………………………………………………………

ส่วนที่ 3 วิจารณ์และข้อเสนอแนะ

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แบบสอบถามความคิดเห็นของผู้เชี่ยวชาญ ด้านการพัฒนาระบบสารสนเทศ
เรื่อง ระบบสารสนเทศเพื่อการจัดการเก็บขนมูลฝอย
ประชากรนิยาม- ผู้เชี่ยวชาญทางด้านการออกแบบและวิเคราะห์ระบบสารสนเทศ

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ส่วนที่ 1 ข้อมูลเกี่ยวกับผู้กรอกแบบสอบถาม

กรอกข้อมูล หรือ ทำเครื่องหมาย / หน้าข้อความที่เลือก

1. ชื่อ-นามสกุล………………………………………………………..

2. เพศ   ☐ หญิง   ☐ ชาย

3. การศึกษา   ☐ ต่ำกว่าปริญญาตรี   ☐ ปริญญาตรี

                ☐ ปริญญาโท   ☐ ปริญญาเอก

4. ตำแหน่ง…………………………………………………………

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ส่วนที่ 2 ทัศนคติที่มีต่อการใช้งานระบบที่ทำการพัฒนา

กรุณาขีดเครื่องหมาย / ลงในช่องระดับของแต่ละหัวข้อ

เกี่ยวกับระบบที่ทำการพัฒนา	ระดับ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
1.ความถูกต้องของขั้นตอนการวิเคราะห์ระบบ					
2.ความถูกต้องของขั้นตอนการออกแบบระบบ					
3.ความเหมาะสมของการเลือกใช้เครื่องมือในการออกแบบ					
4.ความถูกต้องของการเขียน E-R Diagram					
5.ความเหมาะสมของข้อมูลที่ใช้ทดสอบ					
6.ความเหมาะสมของหน้าจอต่างๆในระบบ					
7.ความถูกต้องของการประมวลผลระบบ					

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ส่วนที่ 3 วิจารณ์และข้อเสนอแนะเกี่ยวกับระบบที่ทำการพัฒนา

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แบบสอบถามความคิดเห็นของผู้เชี่ยวชาญ ด้านการจัดการเก็บขนมูลฝอย

เรื่อง ระบบสารสนเทศเพื่อการจัดการเก็บขนมูลฝอย

ประชากรนิยาม- ผู้เชี่ยวชาญทางด้านการจัดการเก็บขนมูลฝอย

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ส่วนที่ 1 ข้อมูลเกี่ยวกับผู้กรอกแบบสอบถาม

กรอกข้อมูล หรือ ทำเครื่องหมาย / หน้าข้อความที่เลือก

1. ชื่อ-นามสกุล………………………………………………………………

2. เพศ   ☐ หญิง   ☐ ชาย

3. การศึกษา   ☐ ต่ำกว่าปริญญาตรี   ☐ ปริญญาตรี

              ☐ ปริญญาโท   ☐ ปริญญาเอก

4. ตำแหน่ง………………………………………………………………

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ส่วนที่ 2 ทัศนคติที่มีต่อการใช้งานระบบที่ทำการพัฒนา

กรุณาขีดเครื่องหมาย / ลงในช่องระดับของแต่ละหัวข้อ

เกี่ยวกับระบบที่ทำการพัฒนา	ระดับ				
	มากที่สุด	มาก	ปานกลาง	น้อย	น้อยที่สุด
1.ความครบถ้วนของรายละเอียดข้อมูลที่นำเสนอ					
2.ประโยชน์จากการนำข้อมูลไปใช้					
3.ความสะดวกในการค้นหาข้อมูลและการนำไปใช้					
4.ความเหมาะสมในการนำเสนอข้อมูล					
5.ความสำคัญของข้อมูลที่นำมาจัดเก็บ					
6.ความเพียงพอของการประมวลผลข้อมูล					
7.ความเหมาะสมในการนำเสนอรูปแบบรายงาน					
8.ความถูกต้องของการประมวลผลระบบ					

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ส่วนที่ 3 วิจารณ์และข้อเสนอแนะเกี่ยวกับระบบที่ทำการพัฒนา

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การกำหนดจุดเก็บขนรวมของแต่ละเส้นทางการเดินรถ

ในการศึกษาครั้งนี้ ผู้วิจัยได้ทำการสำรวจและเก็บข้อมูลจุดเก็บขนทุกจุดบนพื้นที่ ทั้งนี้เพื่อ
ใช้เป็นข้อเสนอแนะและเป็นแนวทางในการกำหนดพื้นที่สำหรับใช้เป็นจุดเก็บขนมูลฝอย และเพื่อ
ให้สามารถหาเส้นทางการเก็บขนมูลฝอยที่สั้นที่สุดและสามารถเก็บขนมูลฝอยได้ครบและครอบ
คลุมพื้นที่ทั้งหมดของเทศบาลตำบลศาลายา

ผู้วิจัยได้ทำการปรับแก้ข้อมูลเส้นทางการคมนาคมในพื้นที่ศึกษาให้มีความทันสมัยและเป็น
ปัจจุบันมากที่สุด โดยได้ทำการสำรวจพื้นที่จริงเปรียบเทียบกับแผนที่ดิจิตอลที่ได้มาจากกรมโยธาธิ
การและผังเมืองในมาตราส่วน 1:4000 แล้วทำการปรับปรุงโดยการ digitize ข้อมูลเส้นทางคมนาคม
เส้นใหม่ที่เกิดขึ้นในพื้นที่เข้าไปในแผนที่ และปรับแก้ฐานข้อมูลของแผนที่บางส่วน บนโปรแกรม
ArcView Version 3.1 ทำให้ได้แผนที่ดิจิตอลที่มีความเป็นปัจจุบันมากที่สุด ดังรูปที่ 1
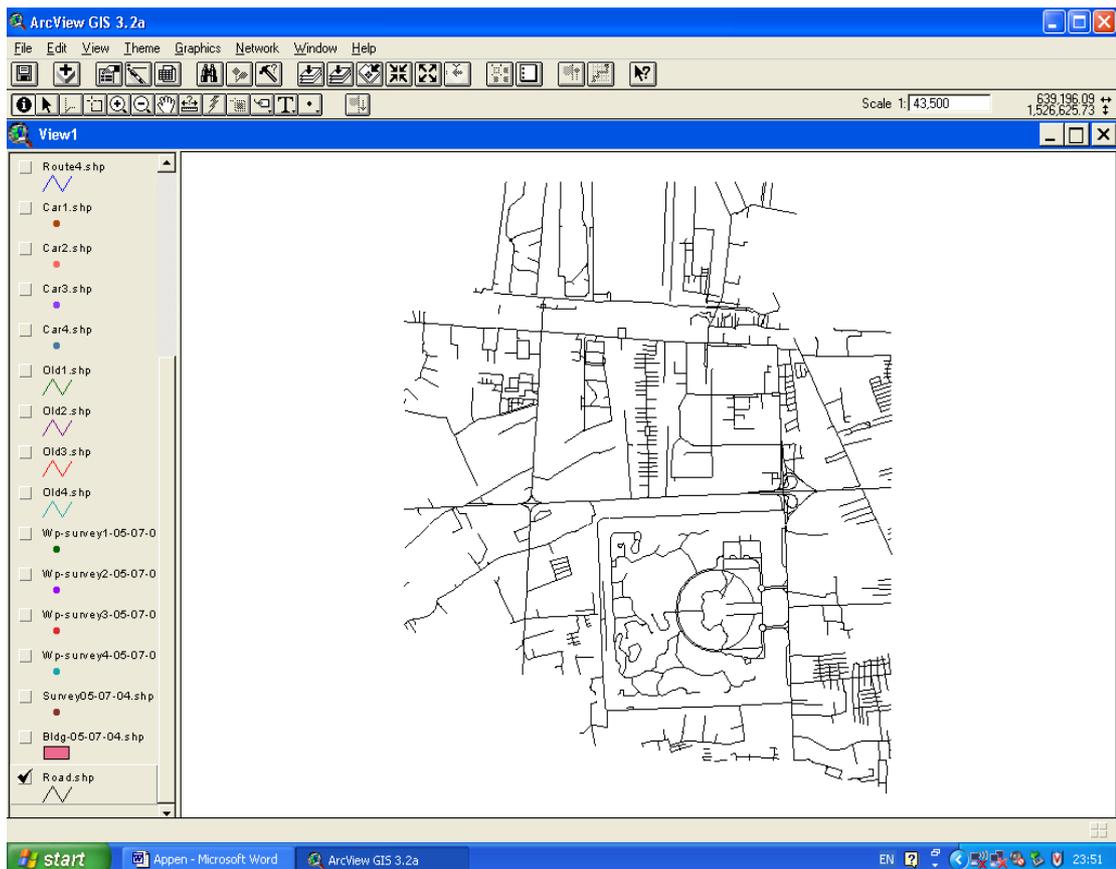
รูปที่ 1 แสดงแผนที่เส้นทางถนนของเทศบาลตำบลศาลายาที่ปรับปรุงแก้ไขเรียบร้อยแล้ว

　　　　　หลังจากได้ทำการปรับปรุงแผนที่เส้นทางการคมนาคมเรียบร้อยแล้วผู้วิจัยได้ทำการปรับ
ปรุงข้อมูลของอาคารสิ่งปลูกสร้างในพื้นที่บนโปรแกรม ArcView Version 3.1 ดังรูปที่ 2
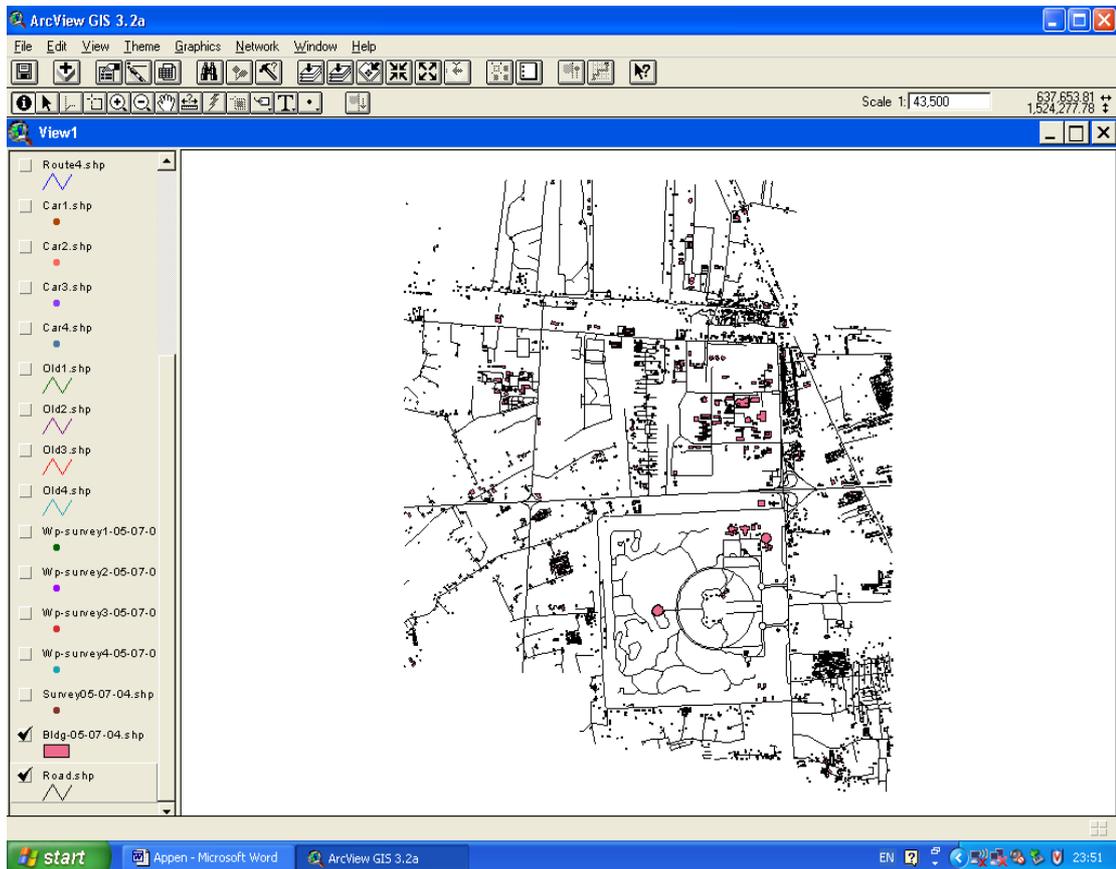
รูปที่ 2 แสดงแผนที่ถนนและสิ่งปลูกสร้างของเทศบาลตำบลศาลายาที่ปรับปรุงแก้ไขเรียบร้อยแล้ว

เมื่อได้แผนที่ที่ปรับปรุงแก้ไขเรียบร้อยแล้วผู้วิจัยได้ทำการเก็บรวบรวมจุดเก็บขนทุกจุดใน
พื้นที่เทศบาลตำบลศาลายา โดยใช้ GPS เข้าจับพิกัดตามจุดเก็บขนทุกจุดและทำการเก็บข้อมูลราย
ละเอียดเกี่ยวกับจุดเก็บขนทุกจุดในพื้นที่ โดยในพื้นที่เทศบาลตำบลศาลายามีจุดเก็บขนทั้งหมด 313
จุด ดังรูปที่ 3
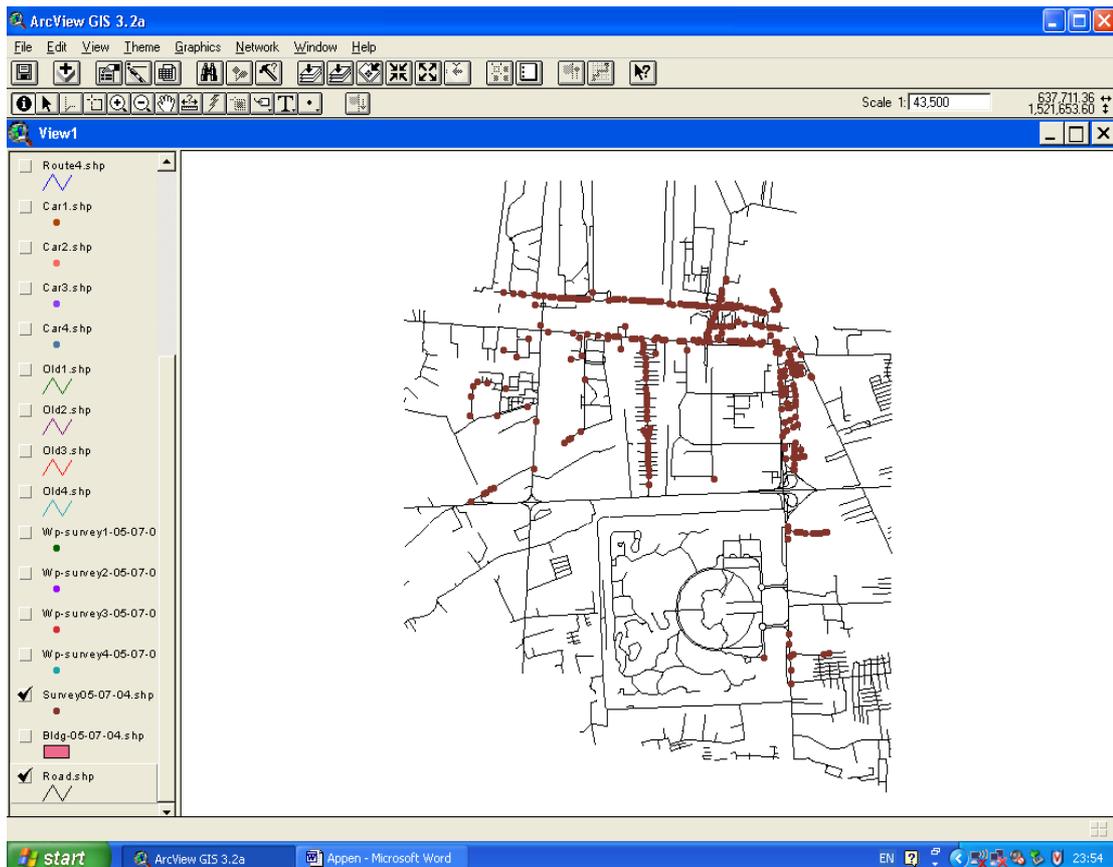
รูปที่ 3 แสดงจุดเก็บขนขยะมูลฝอยในเขตเทศบาลตำบลศาลายา จำนวน 313 จุด
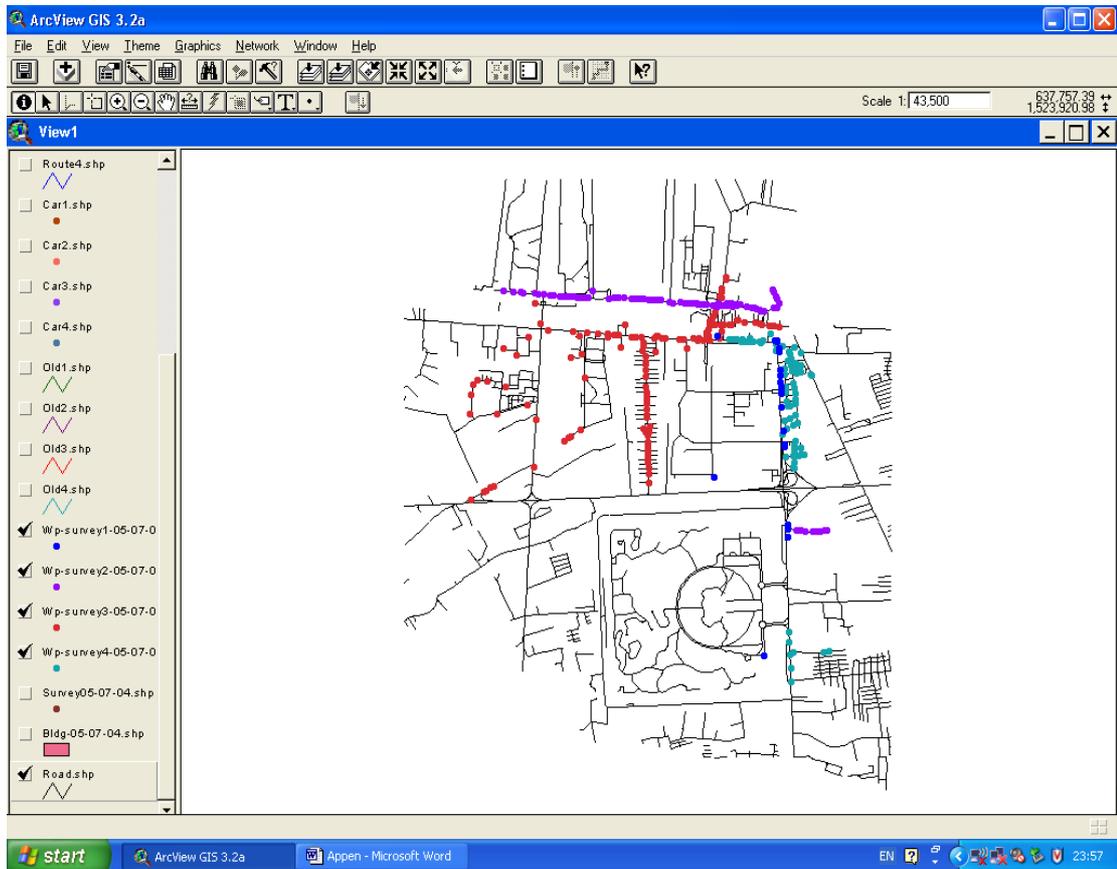
รูปที่ 4 แสดงการแบ่งเขตพื้นที่การเก็บขนในระบบเดิมของเทศบาลตำบลศาลายา

จากรูปที่ 4 จะเป็นการแสดงการแบ่งกลุ่มจุดเก็บขนหรือการแบ่งพื้นที่การเก็บขนให้กับรถแต่ละคันของเทศบาลตำบลศาลายา โดยในระบบเดิมจะมีการแบ่งออกเป็น 4 เขตการรับผิดชอบให้กับรถแต่ละคัน ซึ่งในการแบ่งแบบระบบเดิมนี้ได้ทำการแบ่งโดยเจ้าหน้าที่ที่รับผิดชอบในหน่วยสาธารณสุข และมีเส้นทางการเก็บขนดังรูปที่ 5 โดยมีระยะทางรวมในการเก็บขนทุกเส้น 80.48 กิโลเมตรต่อวัน
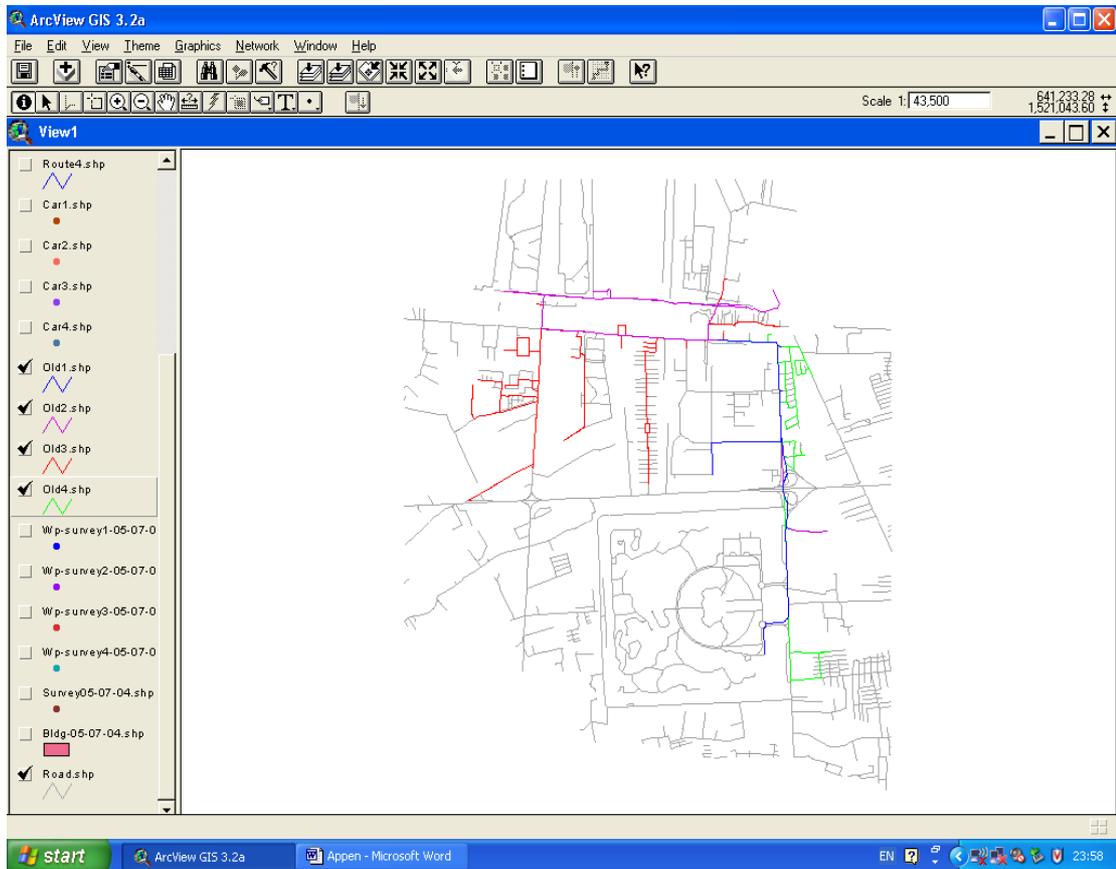
รูปที่ 5 แสดงเส้นทางการเก็บขนมูลฝอยในระบบเดิม

จากการแบ่งเขตข้อมูลเดิมของเทศบาลสามารถจัดหาเส้นทางการเก็บขนใหม่ของรถในเขตเดิม
ได้โดยทำการใช้โปรแกรม ArcView 3.1 ในการหาเส้นทางการเก็บขนในการแบ่งเขตแบบระบบเดิม
พบว่า มีระยะทางรวมในการเก็บขนทุกเส้น 66.73 กิโลเมตรต่อวัน ซึ่งช่วยในการลดระยะทางการ
เก็บขนไปได้ร้อยละ 17.08 จากเส้นทางเดิม สามารถเก็บจุดเก็บขนได้ครบและครอบคลุมพื้นที่ ดังรูป
ที่ 6
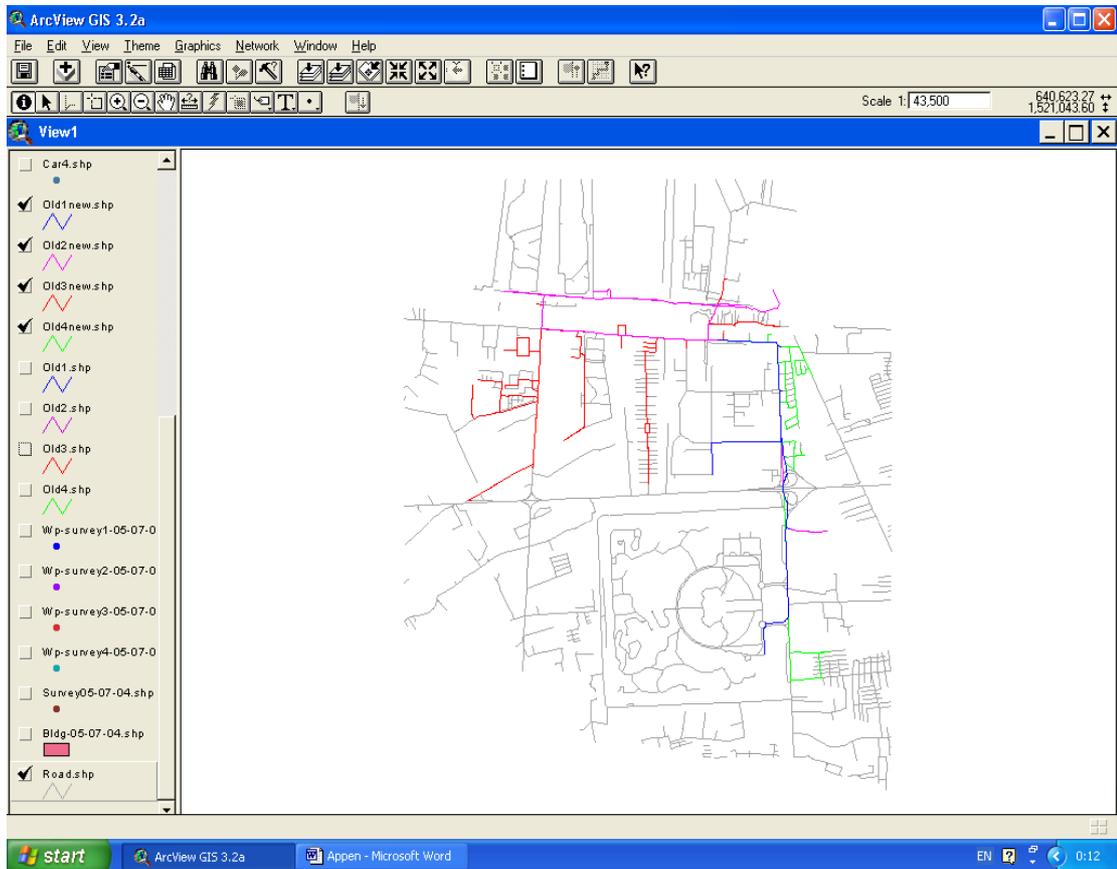
รูปที่ 6 แสดงเส้นทางการเก็บขนมูลฝอยใหม่ในระบบเขตเดิม

จากการเก็บข้อมูลในพื้นที่ประกอบกับข้อมูลทุติยภูมิที่ได้จากหน่วยงานสาธารณสุขเทศบาล ตำบลศาลายา ทำให้เมื่อนำข้อมูลเข้าไปทำการวิเคราะห์ผ่านระบบ network analyst ของโปรแกรม ArcView 3.1 ทำให้มีการแบ่งเขตพื้นที่การเก็บขนให้รถแต่ละคันใหม่ ดังรูปที่ 7
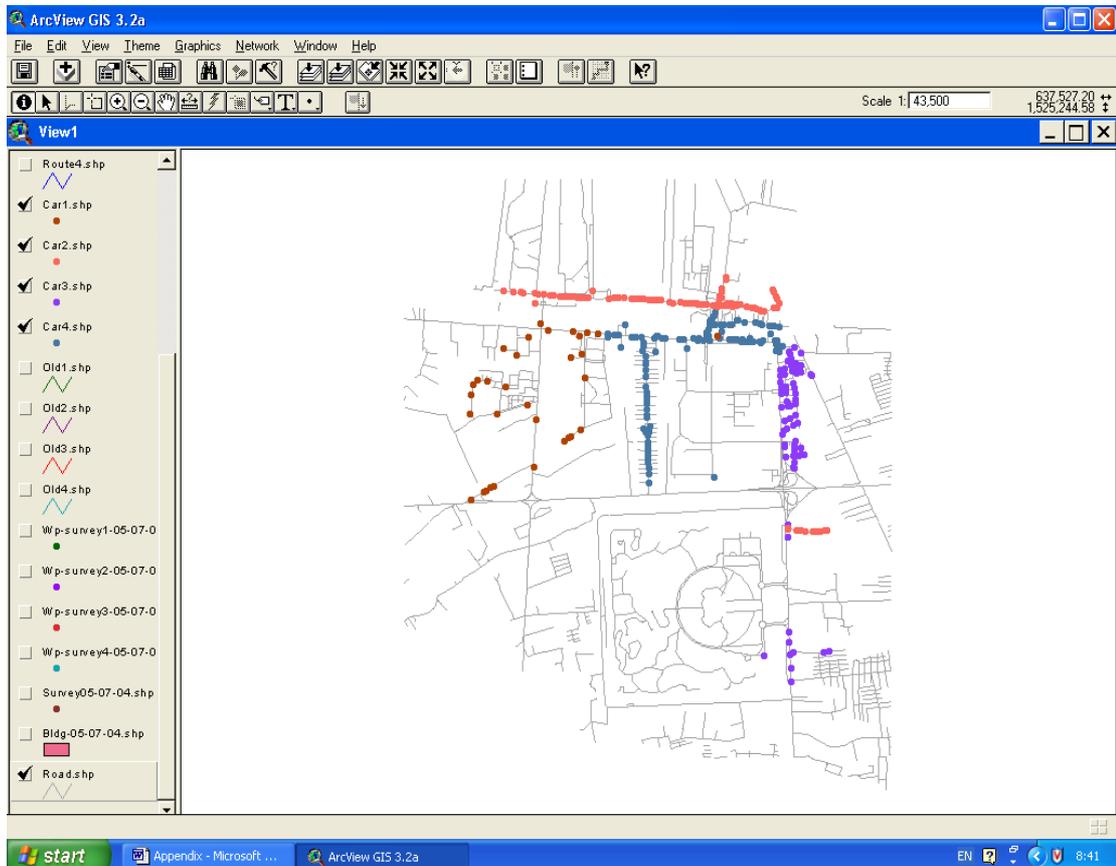
รูปที่ 7 แสดงจุดเก็บขนการแบ่งเขตพื้นที่การเก็บขนในระบบใหม่ของเทศบาลตำบลศาลายา

เมื่อทำการแบ่งเขตการเก็บขนใหม่แล้ว   ก็ทำการวิเคราะห์ระบบใหม่โดยการใช้ระบบ network analyst ของโปรแกรม ArcView 3.1 ทำให้ได้เส้นทางการเก็บขนที่สั้นที่สุดและสามารถ เก็บขนขยะมูลฝอยได้ครบและครอบคลุมพื้นที่ทั้งหมดของเทศบาลตำบลศาลายา ดังรูปที่ 8 โดยมี ระยะทางรวมในการเก็บขนทุกเส้น 64.60 กิโลเมตรต่อวัน เส้นทางเดินรถเก็บขนใหม่ที่ได้ ช่วยลด ระยะทางรวมในการเดินรถได้ 5796.20 กิโลเมตรต่อปี คิดเป็นร้อยละ 19.73
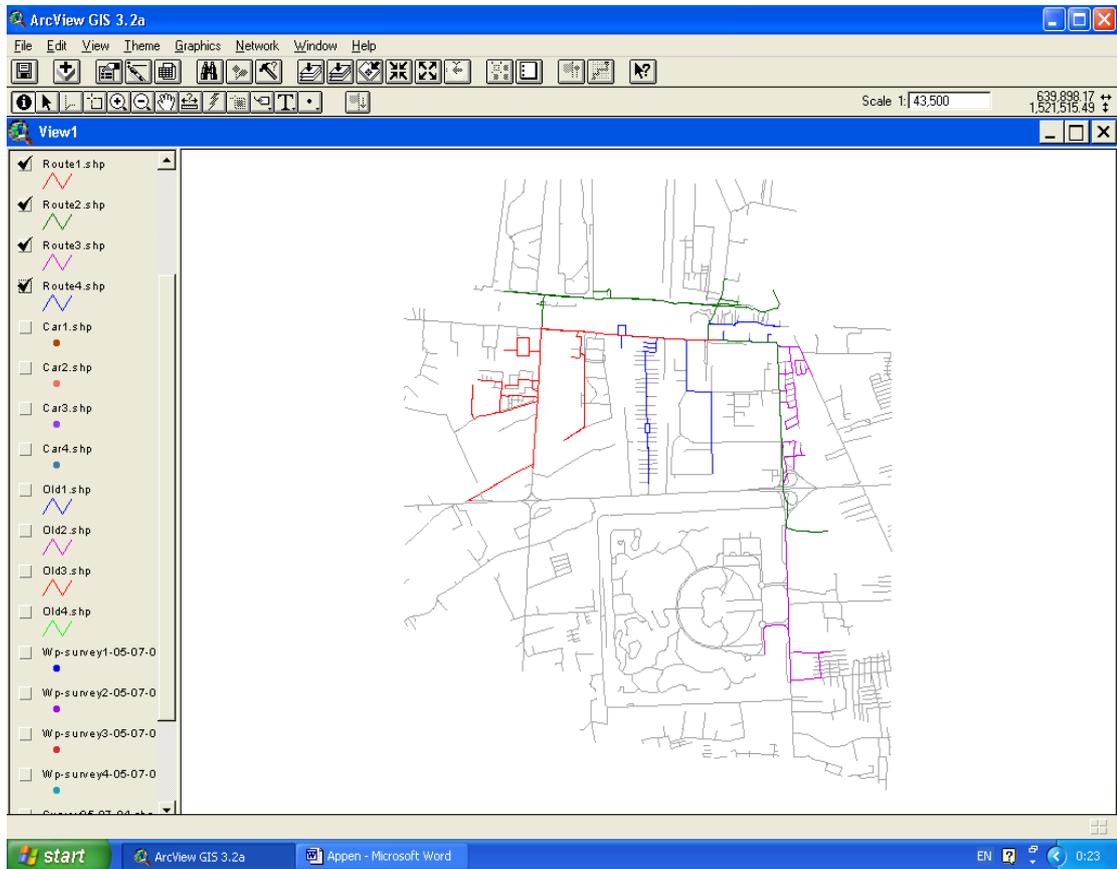
รูปที่ 8 แสดงเส้นทางการเก็บขนมูลฝอยในระบบใหม่

คู่มือการติดตั้งโปรแกรมจัดการระบบเก็บมูลฝอย

การติดตั้งโปรแกรม Solid waste 1.0

โปรแกรม จัดการระบบขนส่งมูลฝอย (Solid waste 1.0) จะสามารถติดตั้งได้เฉพาะระบบ
ปฏิบัติการ window เท่านั้น โดยการติดตั้งโปรแกรมมีขั้นตอนดังต่อไปนี้

1. ทำการ Double click ที่ไอคอน Setup ในแผ่น CD-ROM

2. click ปุ่ม OK เพื่อทำการติดตั้งโปรแกรม
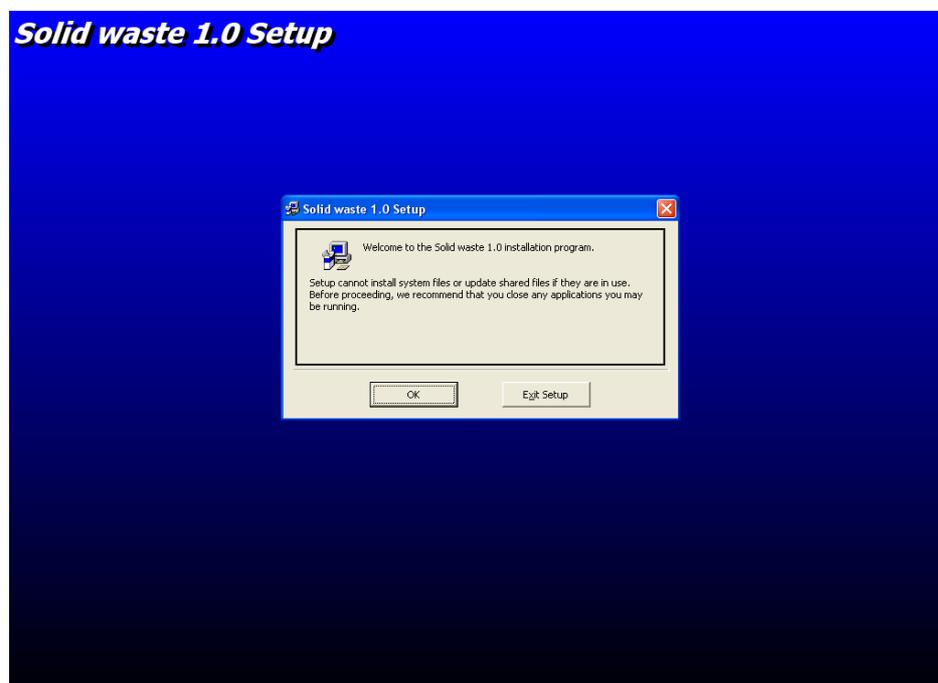
3. ทำการเลือกไดเร็กทอรี่ ที่จะทำการติดตั้งโปรแกรม กรณีที่ท่านไม่ต้องการเปลี่ยนแปลงค่า
เริ่มต้นในการติดตั้งให้ท่าน Click ปุ่ม Setup
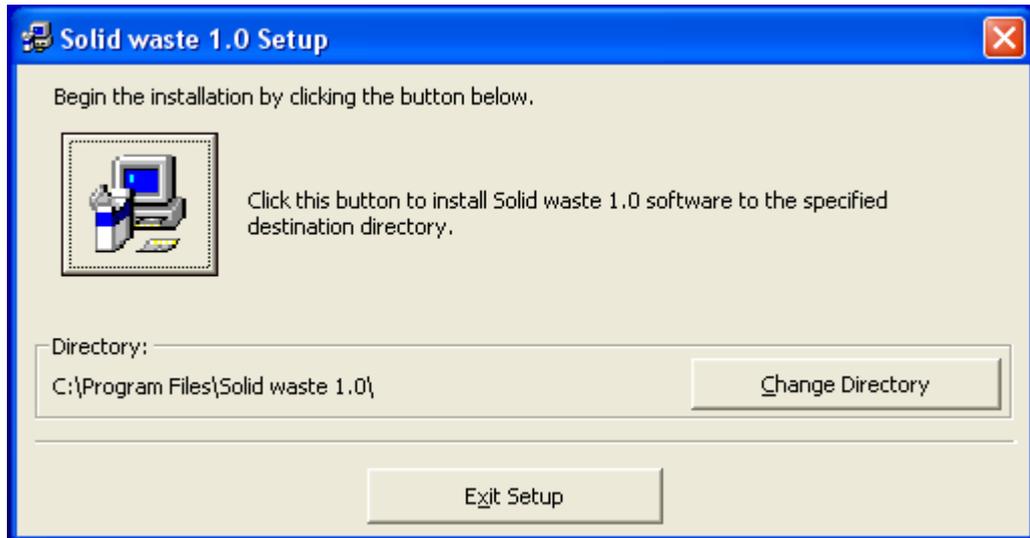
ท่านสามารถระบุตำแหน่ง ที่จะทำการติดตั้งโปรแกรมได้ โดย Click ที่ปุ่ม Change Directory
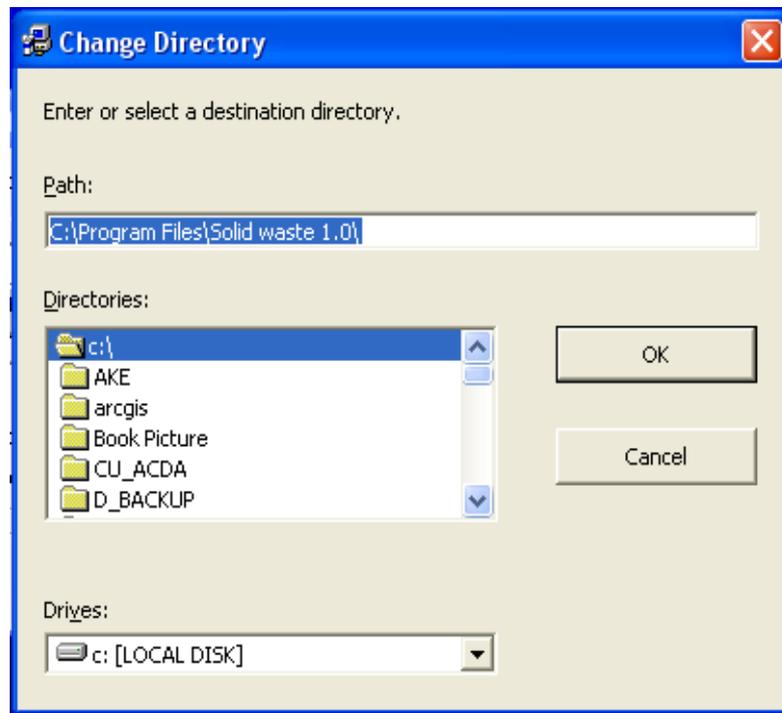
       คอมพิวเตอร์จะทำการติดตั้งโปรแกรมจนเสร็จเรียบร้อย และจะแสดงหน้าต่างสุดท้าย ให้ท่าน
Click OK เป็นอันเสร็จสิ้นการติดตั้งโปรแกรม
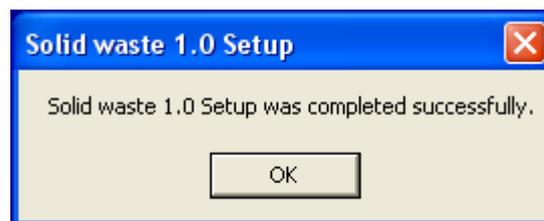
การติดตั้งข้อมูลที่ใช้ในโปรแกรมจัดการระบบขนส่งมูลฝอย

Copy โฟล์เดอร์ที่ชื่อ Data จากแผ่น CD-ROM มาวางลงใน ไดร์ฟ C:\
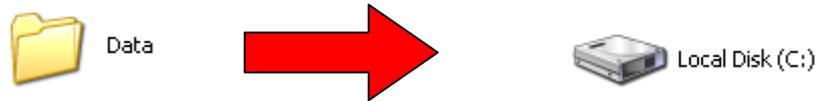
ทำการปลดค่า Read Only จาก โฟล์เดอร์ Data
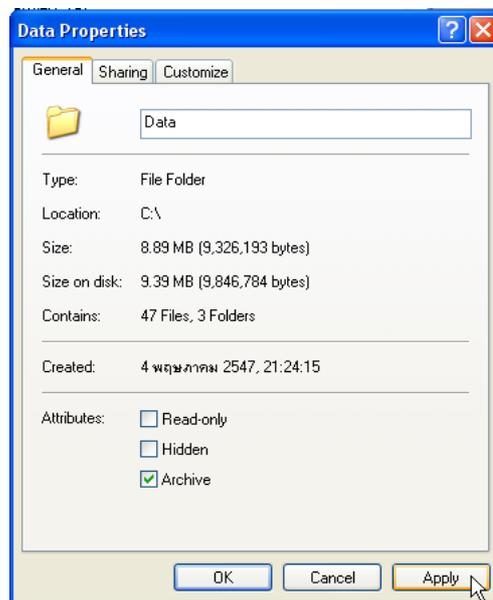
เสร็จสิ้นการติดตั้งฐานข้อมูลของโปรแกรมจัดการระบบขนส่งมูลฝอย

คู่มือการใช้งานโปรแกรมจัดการระบบเก็บขนมูลฝอย

หลังจากการติดตั้งโปรแกรม Solid waste 1.0 เรียบร้อยท่านสามารถเข้า โปรแกรมได้โดยเข้า
ไปที่เมนู Start >> All Programs >> Solid waste 1.0 >> Solid waste 1.0 หรือการ Double Click ไอ
คอนโปรแกรมจากหน้าจอ Desktop เพื่อเข้าโปรแกรม

Icon ของโปรแกรม Solid waste 1.0

เริ่มใช้งานโปรแกรม Solid waste 1.0

หน้าต่างแรกที่ท่านจะพบเมื่อเข้าสู่โปรแกรมคือหน้าจอ   Login   เพื่อกำหนดสิทธิ์การใช้
โปรแกรมของผู้ใช้แต่ละราย

ทำการกรอกชื่อผู้ใช้และรหัสผ่าน ในกรณี User ทั่วไปให้ใช้ UsernameและPassword ดังนี้

      Username : Guest

      Password : 1234
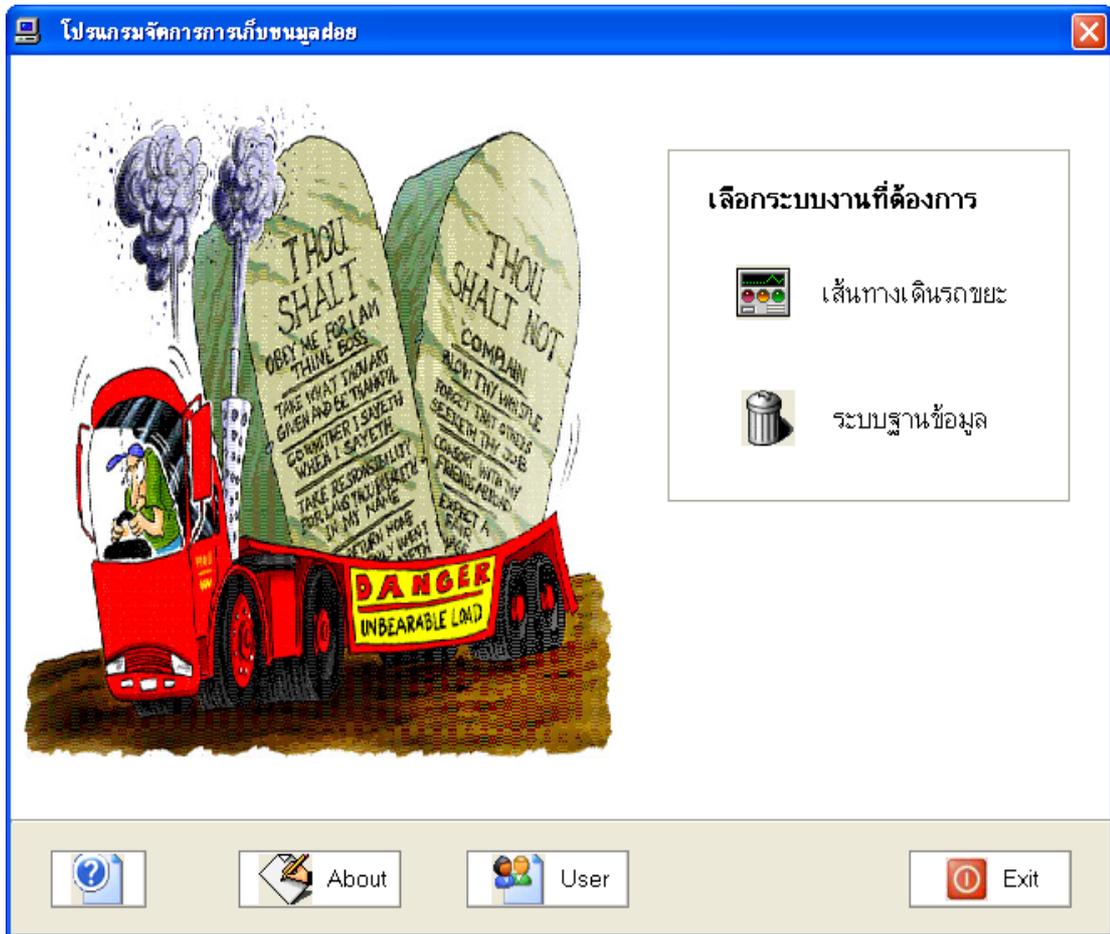
หน้าต่างแรกสำหรับการเลือกระบบงานที่ต้องการทำงาน ให้Click เลือกระบบงานด้านล่าง ประกอบด้วยปุ่มคำสั่งหลัก 3 ปุ่มได้แก่

      ปุ่มคำสั่งความช่วยเหลือในการใช้โปรแกรม

      ปุ่มคำสั่งแสดงรายละเอียดการจัดทำโปรแกรม

      ปุ่มคำสั่งแสดงรายละเอียดผู้ใช้โปรแกรม

ระบบงานวิเคราะห์เส้นทาง

เป็นระบบงานที่ใช้ในการวิเคราะห์เส้นทางเดินรถเก็บขนมูลฝอยที่ดีที่สุด   โดยโปรแกรมจะ
เรียก ฟังก์ชันต่างๆ ที่ทำหน้าที่ในการวิเคราะห์เส้นทางจาก โปรแกรม Arcview 3.1

Click ปุ่มคำสั่งเพื่อเริ่มทำการวิเคราะห์เส้นทาง

เส้นทางเดินรถขยะ
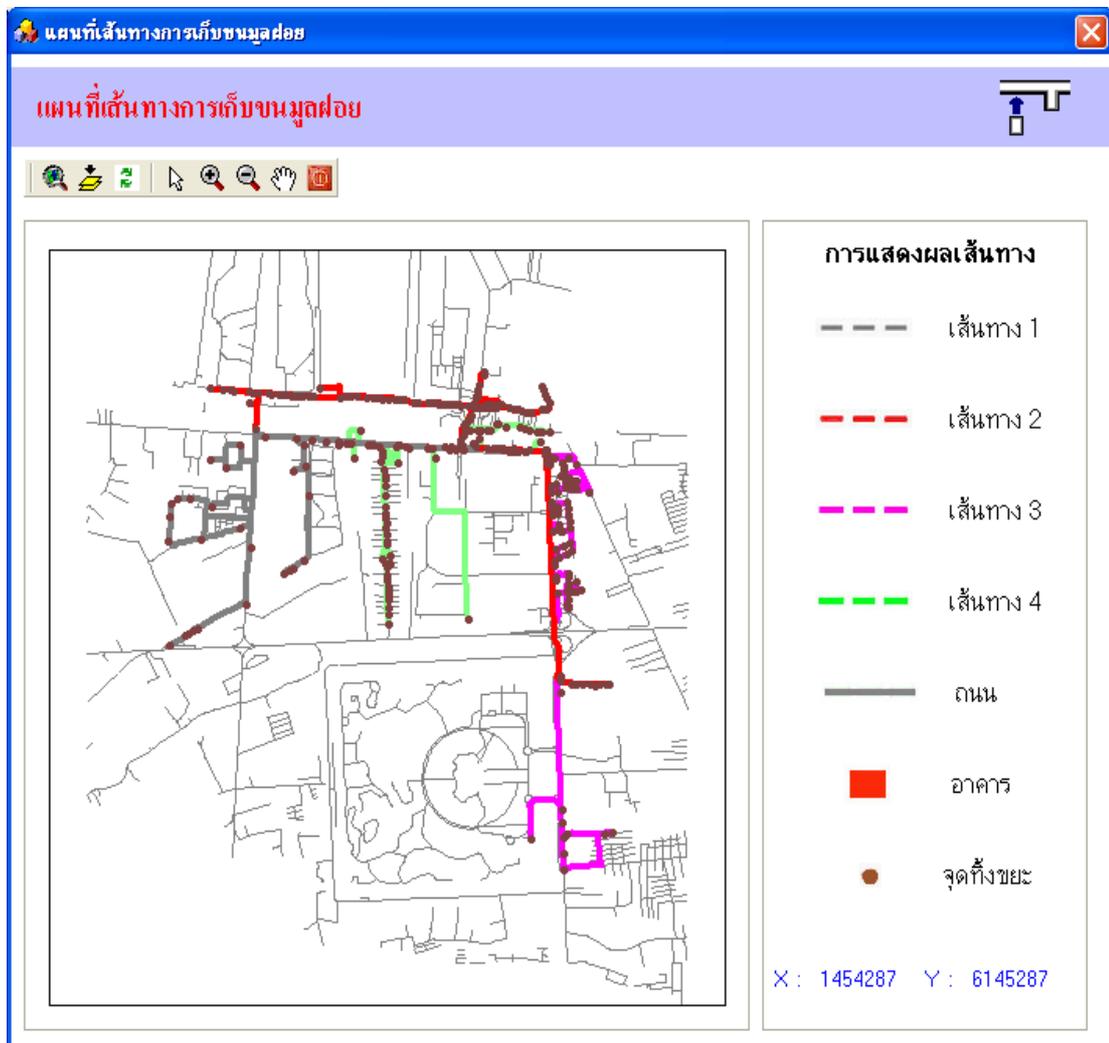
ระบบงานฐานข้อมูล

    ฐานข้อมูลแบ่งออกเป็น 6 ระบบย่อย โดยแต่ละระบบจะมีการแสดงข้อมูลเชิงบรรยายและรูป ภาพ นอกจากนี้ยังสามารถแก้ไขและปรับปรุงข้อมูลต่างๆภายในฐานข้อมูลได้อีกด้วย
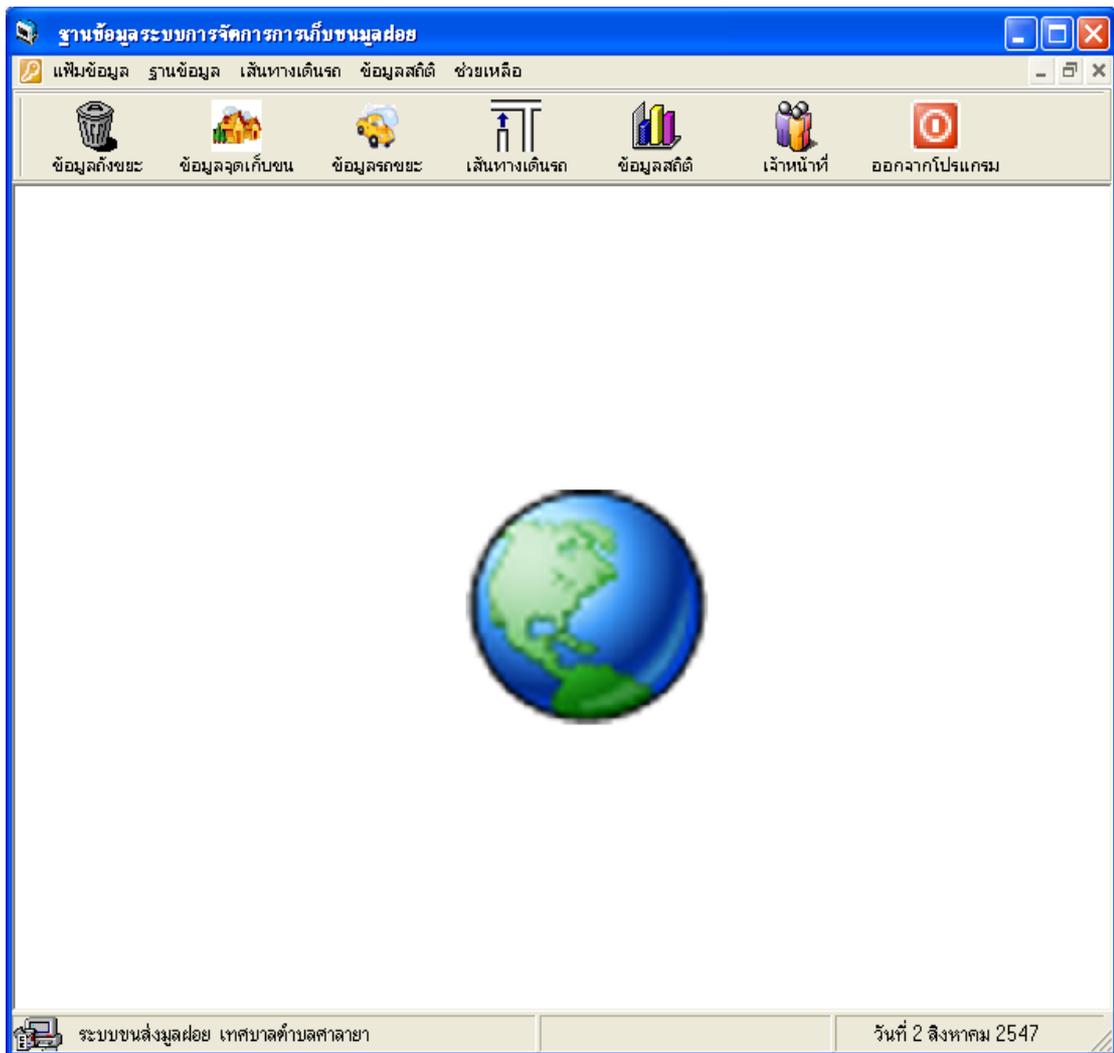
ฐานข้อมูลถังขยะ

หน้าต่างที่แสดงรายละเอียดของข้อมูลตัวอย่างถังขยะ โดยผู้ใช้สามารถ แก้ไขข้อมูลหรือเพิ่ม
เติมข้อมูลถังขยะ รวมถึงสามารถจัดพิมพ์รายงานได้

 ปุ่มคำสั่งเพิ่มข้อมูล   ปุ่มคำสั่งค้นหาข้อมูล
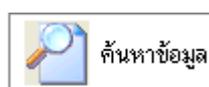
 ปุ่มคำสั่งแก้ไขข้อมูล   ปุ่มคำสั่งรายงานข้อมูลถังขยะ

การเพิ่มหรือแก้ไขข้อมูล จะสามารถทำได้เฉพาะผู้ใช้ระดับ admin เท่านั้น

ฐานข้อมูลจุดเก็บขนมูลฝอย

หน้าต่างแสดงข้อมูลจุดเก็บขนมูลฝอยแต่ละจุดในเขตเทศบาลตำบลศาลายาโดยผู้ใช้สามารถแก้ไขข้อมูล หรือเพิ่มเติมข้อมูลต่างๆรวมถึงจัดทำรายงานได้

การเพิ่มหรือแก้ไขข้อมูล จะสามารถทำได้เฉพาะผู้ใช้ระดับ admin เท่านั้น

ฐานข้อมูลรถเก็บขนมูลฝอย

หน้าต่างแสดงข้อมูลรถเก็บขนมูลฝอยโดยผู้ใช้สามารถ แก้ไขข้อมูล หรือเพิ่มเติมข้อมูลต่างๆ
ได้

 ปุ่มคำสั่งเพิ่มข้อมูล

 ปุ่มคำสั่งแก้ไขข้อมูล

 ปุ่มคำสั่งรายงานข้อมูลรถขนส่งมูลฝอย

การเพิ่มหรือแก้ไขข้อมูล จะสามารถทำได้เฉพาะผู้ใช้ระดับ admin เท่านั้น

ฐานข้อมูลเส้นทางเดินรถเก็บขนมูลฝอย

      หน้าต่างแสดงข้อมูลเส้นทางเดินรถเก็บขนมูลฝอย   แต่ละสายโดยจะแสดงข้อมูลเชิงแผนที่
ที่อ้างอิงระบบพิกัดภูมิศาสตร์โลก ผู้ใช้สามารถโต้ตอบกับข้อมูลแผนที่ได้
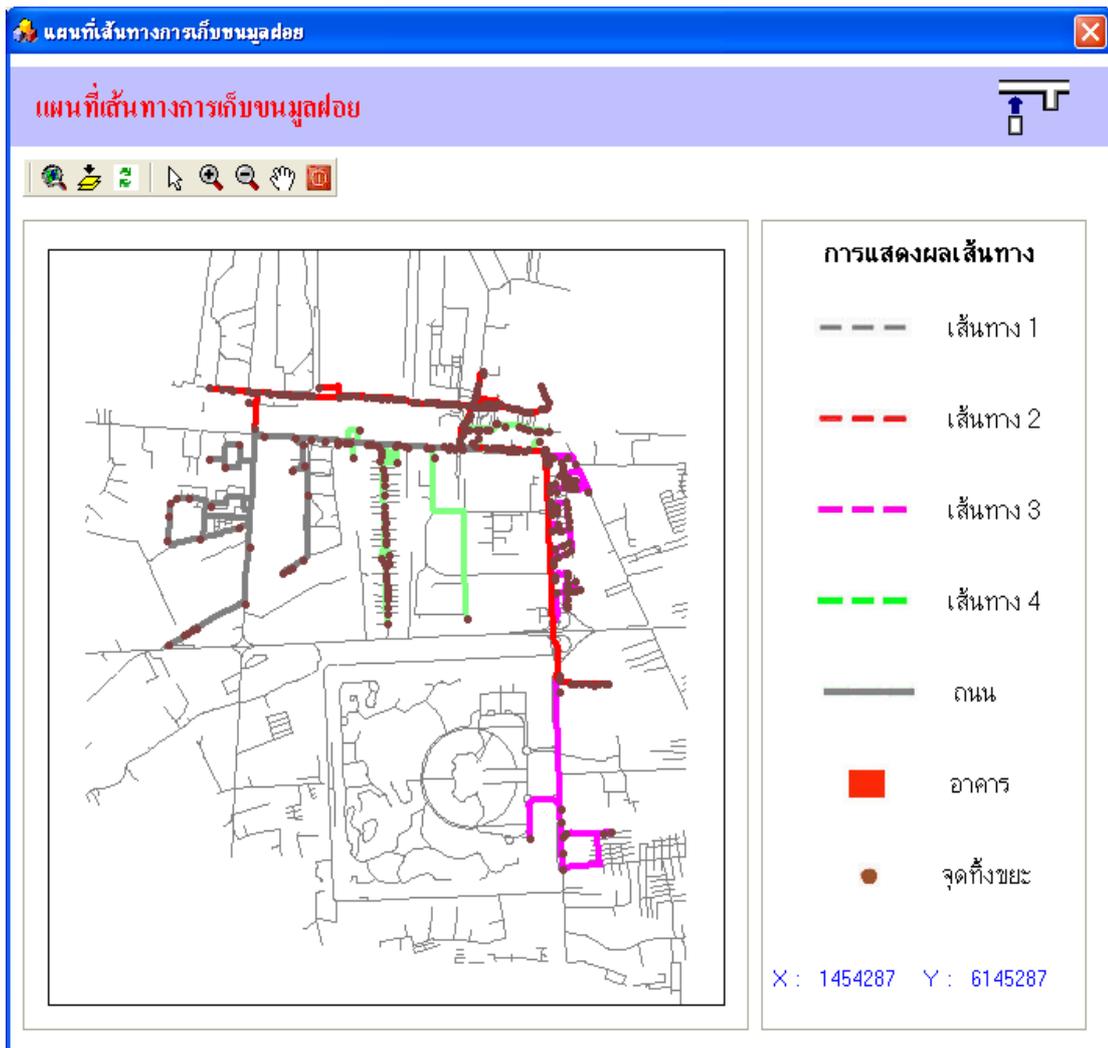
 แถบเครื่องมือควบคุมแผนที่

 ปุ่มเชื่อมโยงระบบวิเคราะห์เส้นทางไปสู่ arcview

 ปุ่มขยายแผนที่เต็มจอ

 ปุ่มรีโหลดแผนที่

 ปุ่มเลือกเส้นทางเก็บขนบนแผนที่

 ปุ่มขยายภาพ

 ปุ่มย่อภาพ

 ปุ่มเลื่อนภาพ

 ปุ่มออกจากหน้าต่างเส้นทางขนส่งมูลฝอย

เครื่องมือควบคุมการแสดงผลแผนที่
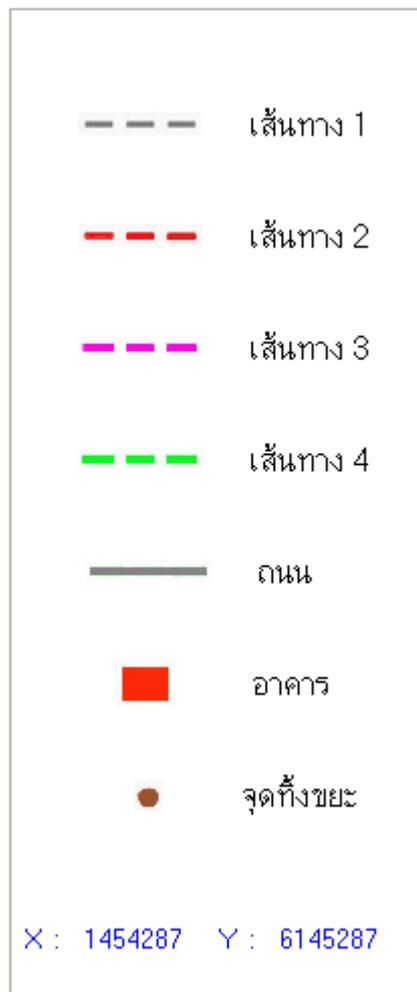
ข้อมูลสถิติ

   ระบบจัดเก็บข้อมูลปริมาณขยะมูลฝอยรายวัน ผู้ใช้สามารถกรอกข้อมูลขยะมูลฝอยต่างๆลง
ในฐานข้อมูลเพื่อนำข้อมูลไปใช้ในการวิเคราะห์จัดการ ต่อไป

 ปุ่มคำสั่งเพิ่มข้อมูล   ปุ่มคำสั่งค้นหาข้อมูล
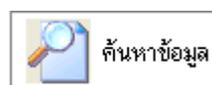
 ปุ่มคำสั่งแก้ไขข้อมูล

 ปุ่มคำสั่งรายงานข้อมูลปริมาณขยะมูลฝอยรายวัน

  การเพิ่มหรือแก้ไขข้อมูล จะสามารถทำได้เฉพาะผู้ใช้ระดับ admin เท่านั้น

กราฟ

การรายงานข้อมูลปริมาณขยะในรอบปี โดยผู้ใช้สามารถกรอกอมูลปริมาณขยะรายเดือนลงใน
ฐานข้อมูล และแสดงผลข้อมูลในรูปกราฟ นอกจากนี้โปรแกรมยังสามารถงออกข้อมูลกราฟในรูป
แบบภาพ เพื่อนำไปใช้จัดทำรายงานต่อไป

ตารางแสดงข้อมูลปริมาณขยะรายเดือน

เดือนที่   เดือน   ปริมาณมูลฝอย
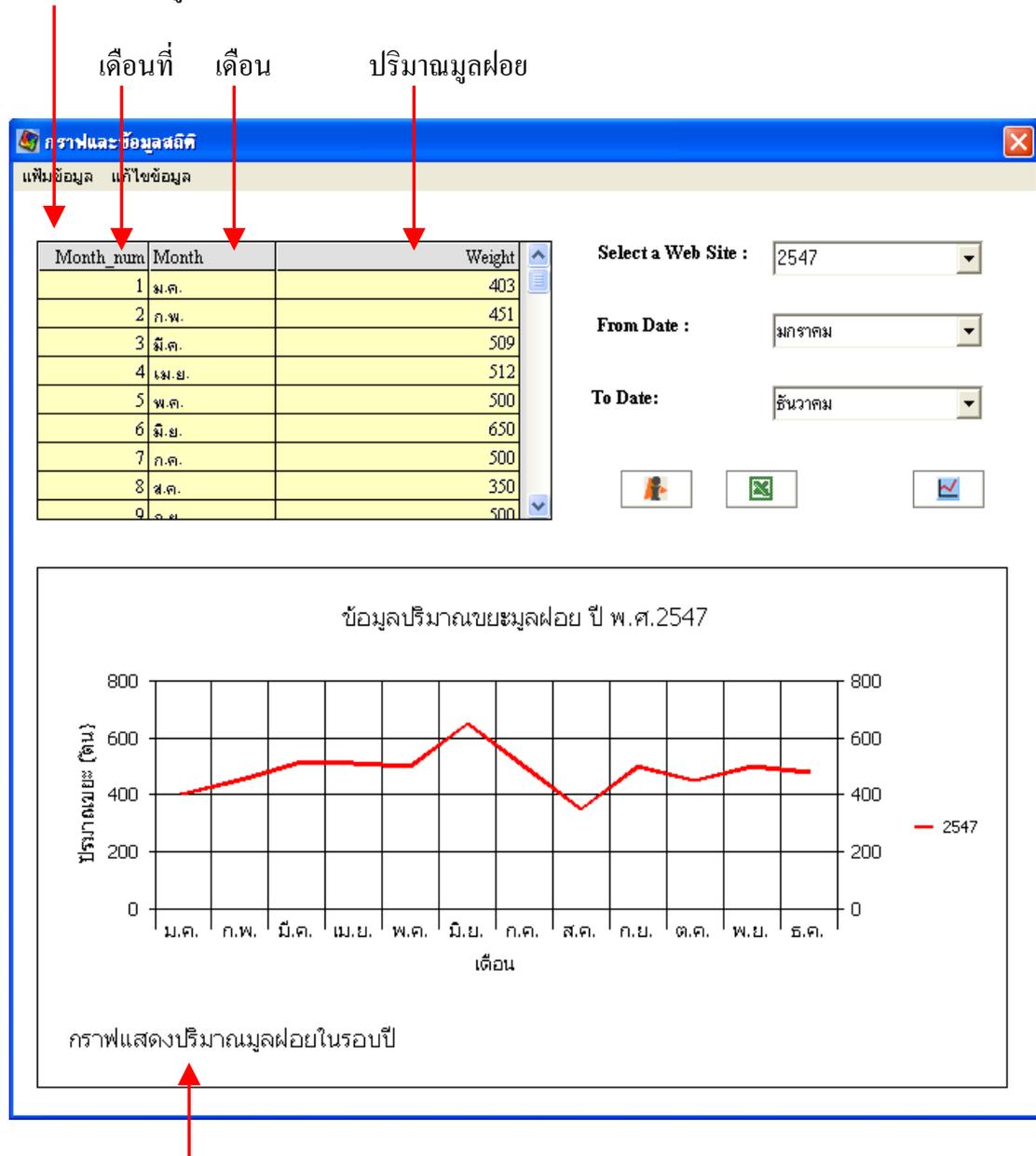
หน้าต่างข้อมูลปริมาณขยะรายปีในรูปกราฟ

การนำเข้าข้อมูลปริมาณขยะรายเดือนเข้าในฐานข้อมูลสามารถทำได้โดย Click [icon] ที่ปุ่มคำสั่งโปรแกรมจะแสดงหน้าต่างสำหรับการกรอกข้อมูลปริมาณขยะ ดังนี้

การวิเคราะห์ข้อมูลทางสถิติ

โปรแกรม Solid waste 1.0 ถูกสร้างให้สามารถวิเคราะห์ข้อมูลปริมาณขยะมูลฝอยในอดีต เพื่อทำนายแนวโน้มปริมาณขยะมูลฝอยในอนาคต

Click [icon] เพื่อเริ่มการวิเคราะห์ค่าแนวโน้มทางสถิติจะได้หน้าต่างรับข้อมูลปริมาณ ขยะที่จะใช้วิเคราะห์ ดังนี้

หน้าต่างแสดงแนวโน้มปริมาณขยะในอนาคตพร้อมค่าประมาณปริมาณขยะในอีก 10 ปีข้างหน้า

ผลการวิเคราะห์ข้อมูลทางสถิติ

กราฟแสดงแนวโน้มปริมาณมูลฝอย

สมการเส้นตรง คือ : $Y = -66 + (284X)$
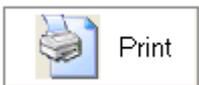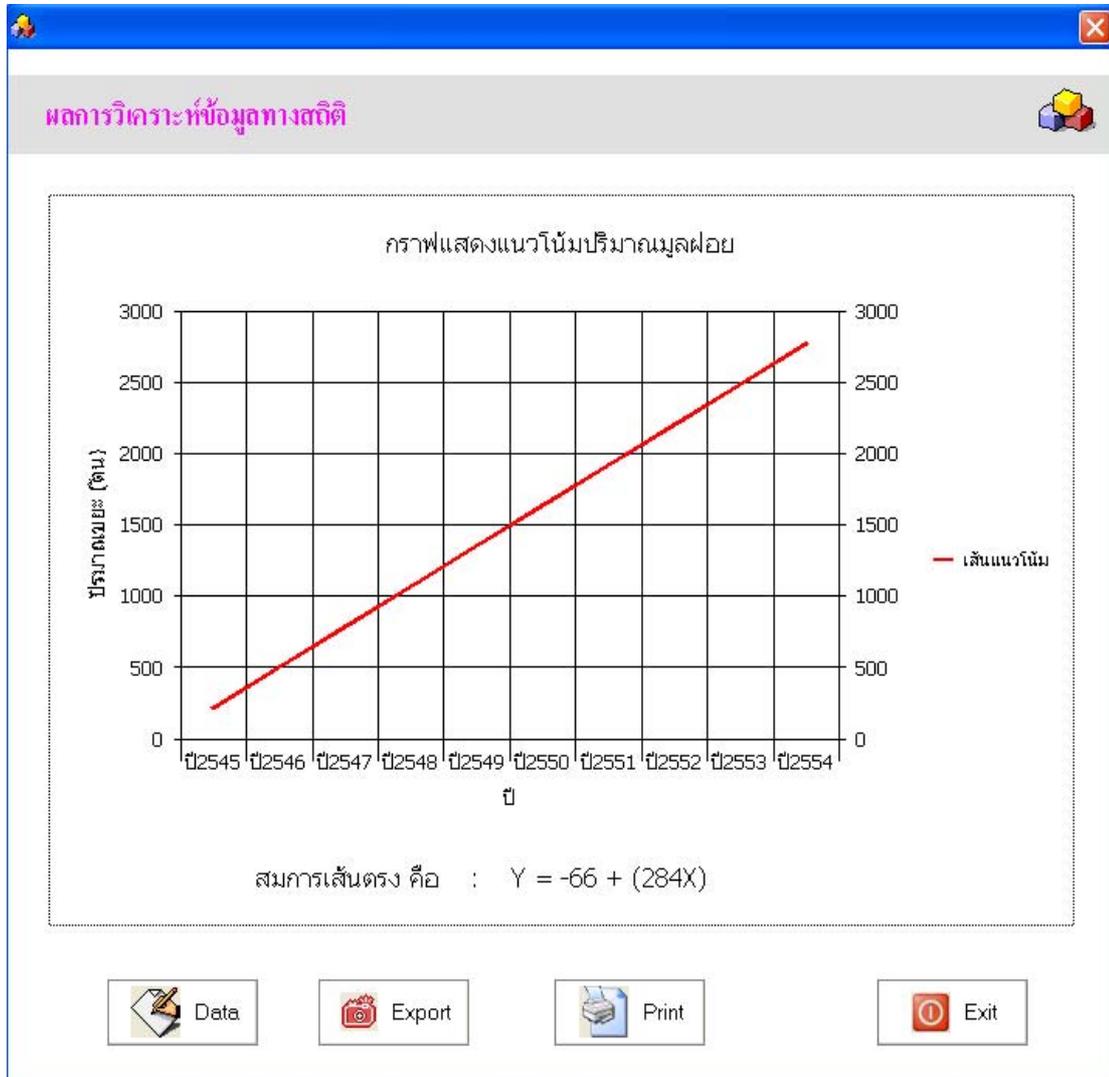
ปุ่มคำสั่งกรอกข้อมูลเพื่อการทำนายใหม่

ปุ่มคำสั่งส่งออกกราฟแนวโน้มปริมาณขยะ

ปุ่มคำสั่งในการพิมพ์งาน

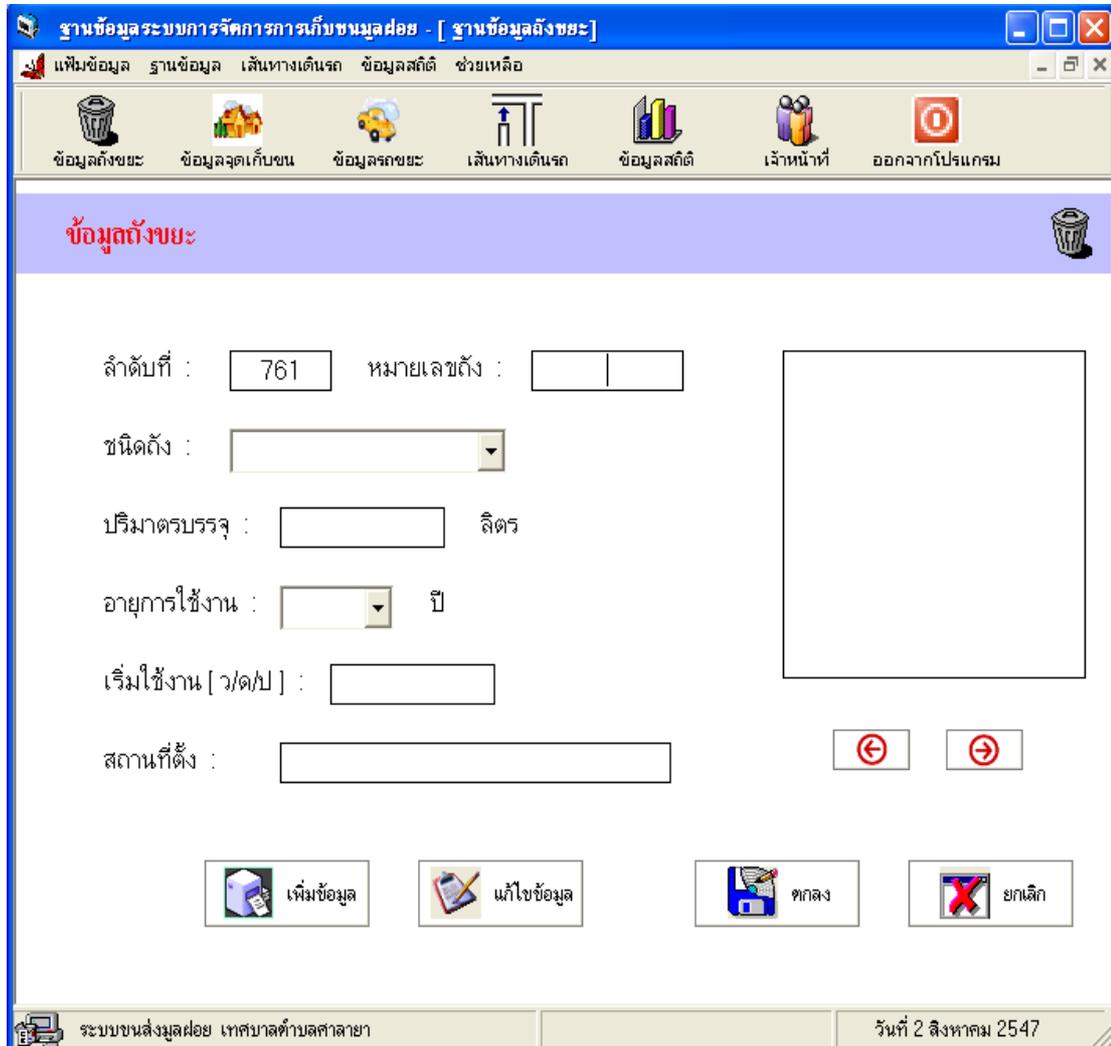ปุ่มคำสั่งออกจากกราฟแนวโน้มปริมาณขยะ

การเพิ่ม และแก้ไขข้อมูล

การเพิ่มข้อมูลลงในฐานข้อมูลของระบบขนส่งมูลฝอย สามารถทำได้โดยผ่านทางหน้าต่างของโปรแกรม ดังนี้

1.เปิดหน้าต่างระบบฐานข้อมูลที่ต้องการ

2. Click ปุ่มเพิ่มข้อมูล

3. ทำการกรอกข้อมูลต่างๆ ลงในฐานข้อมูล

4. Click ที่รูปสัญลักษณ์ด้านขวามือ บนสุด เพื่อนำเข้ารูปภาพ

5. ทำการเลือก ไดเร็กทอรี่ที่เก็บรูป เพื่อเตรียมบันทึกรูปไว้ในฐานข้อมูล
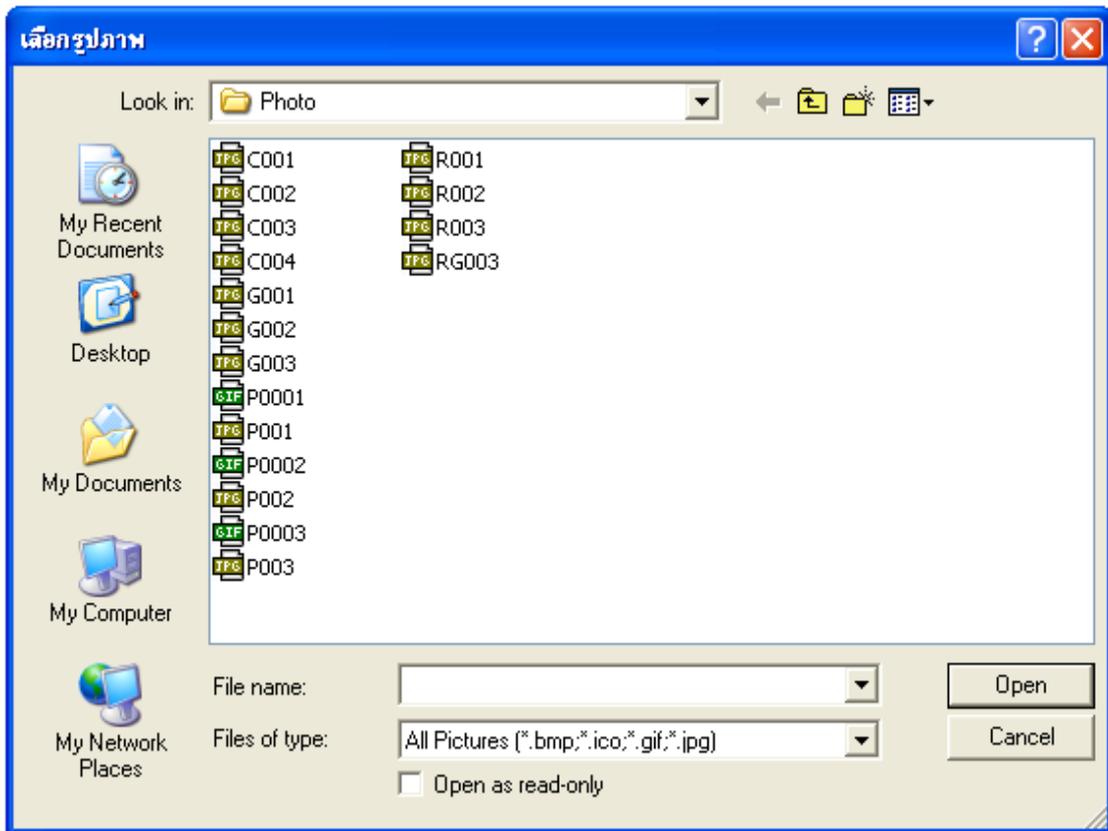
6.   ตรวจสอบความครบถ้วนถูกต้องของข้อมูลจากนั้นทำการบันทึกข้อมูลโดย   Clickที่ปุ่ม
ตกลง

7.   กรณีที่ท่านต้องการปรับปรุงหรือแก้ไขข้อมูลในฐานข้อมูล สามารถทำได้โดยการClickที่
ปุ่ม แก้ไขข้อมูล

BIOGRAPHY

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