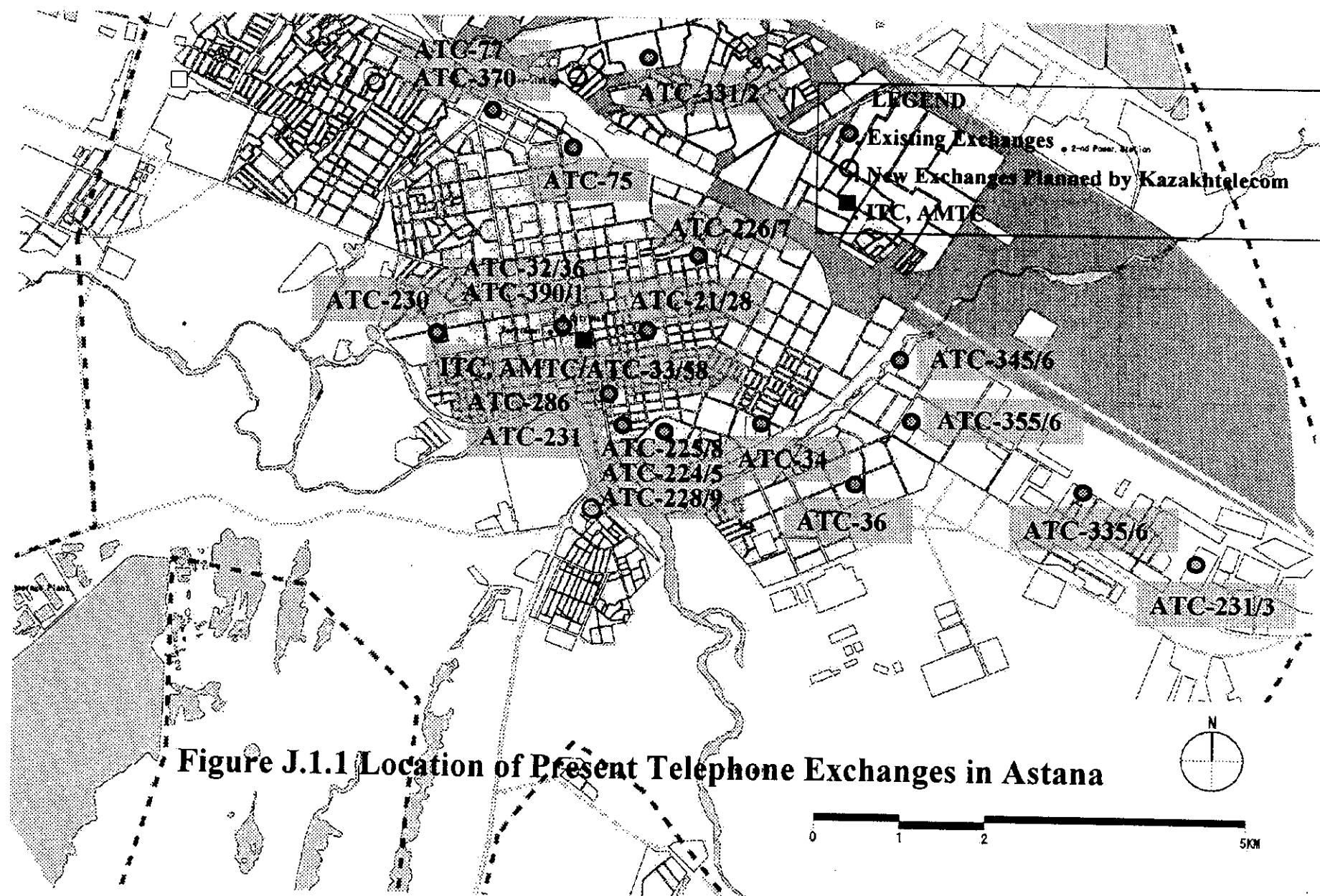


FIGURE



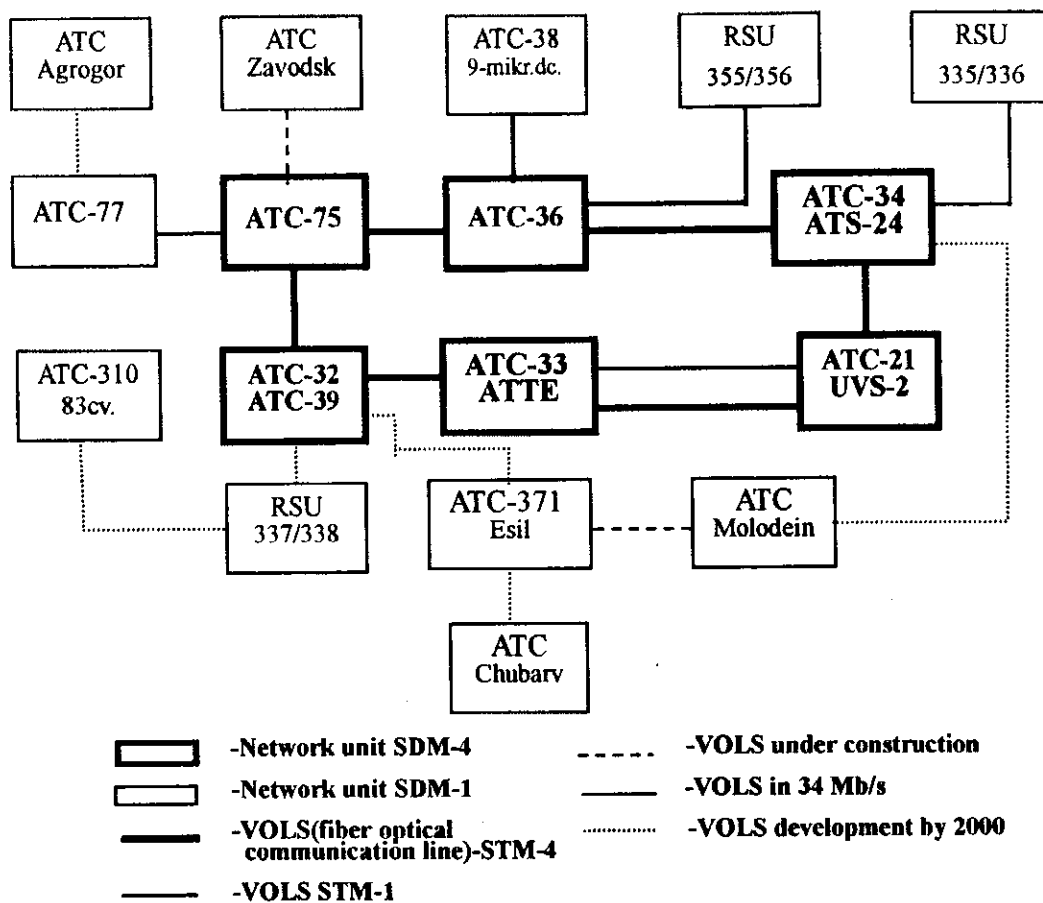


Figure J.1.2 Optical Fiber Cable Transmission Network in Astana

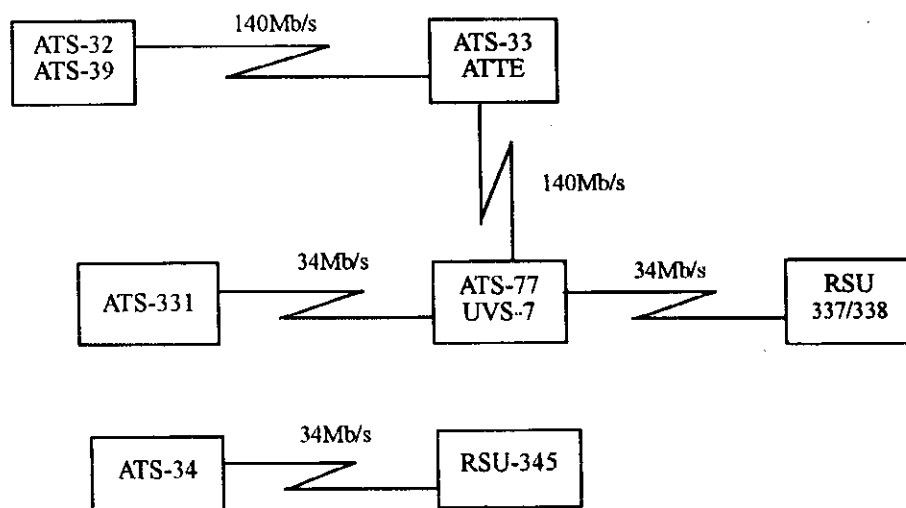
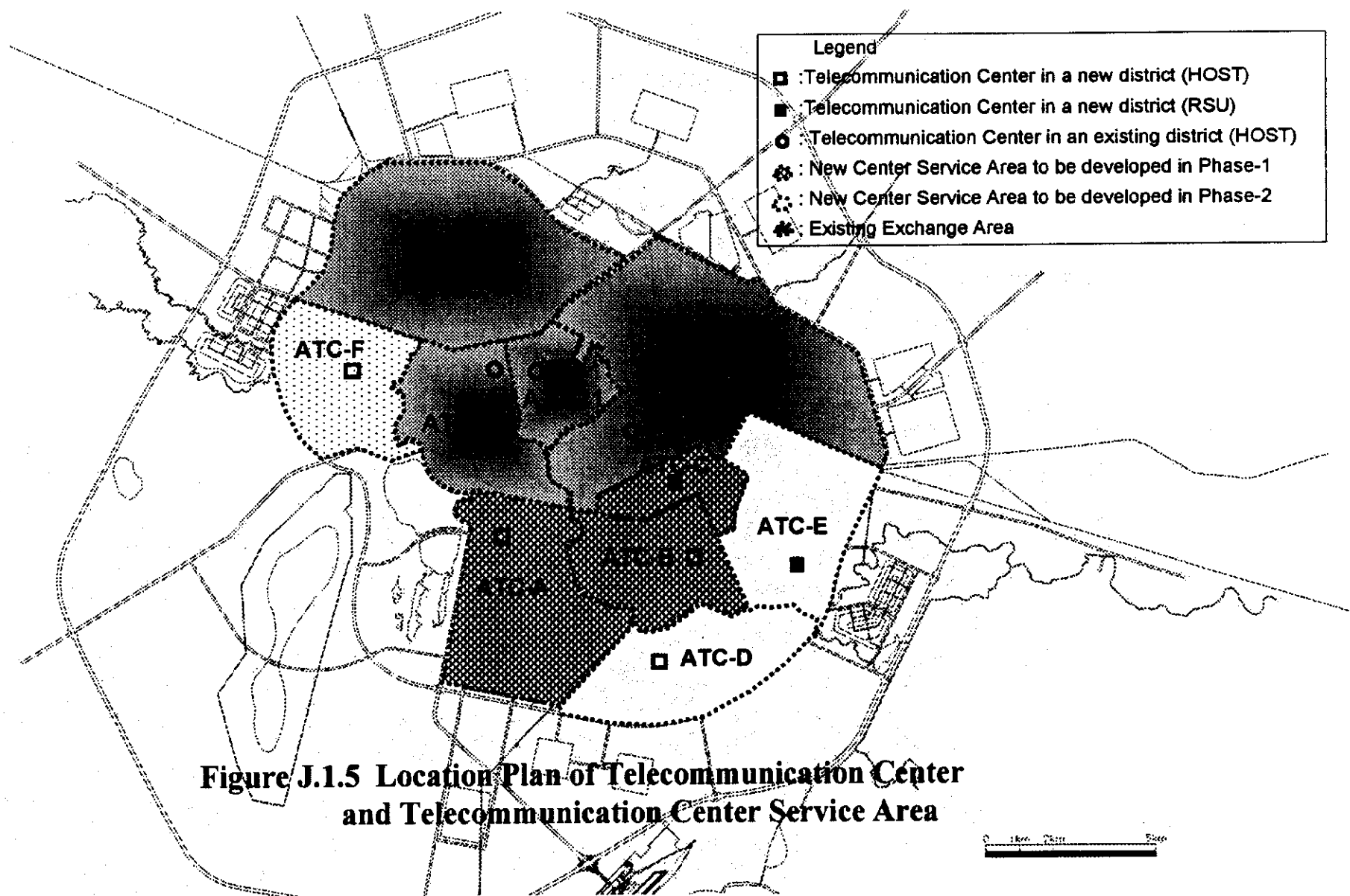
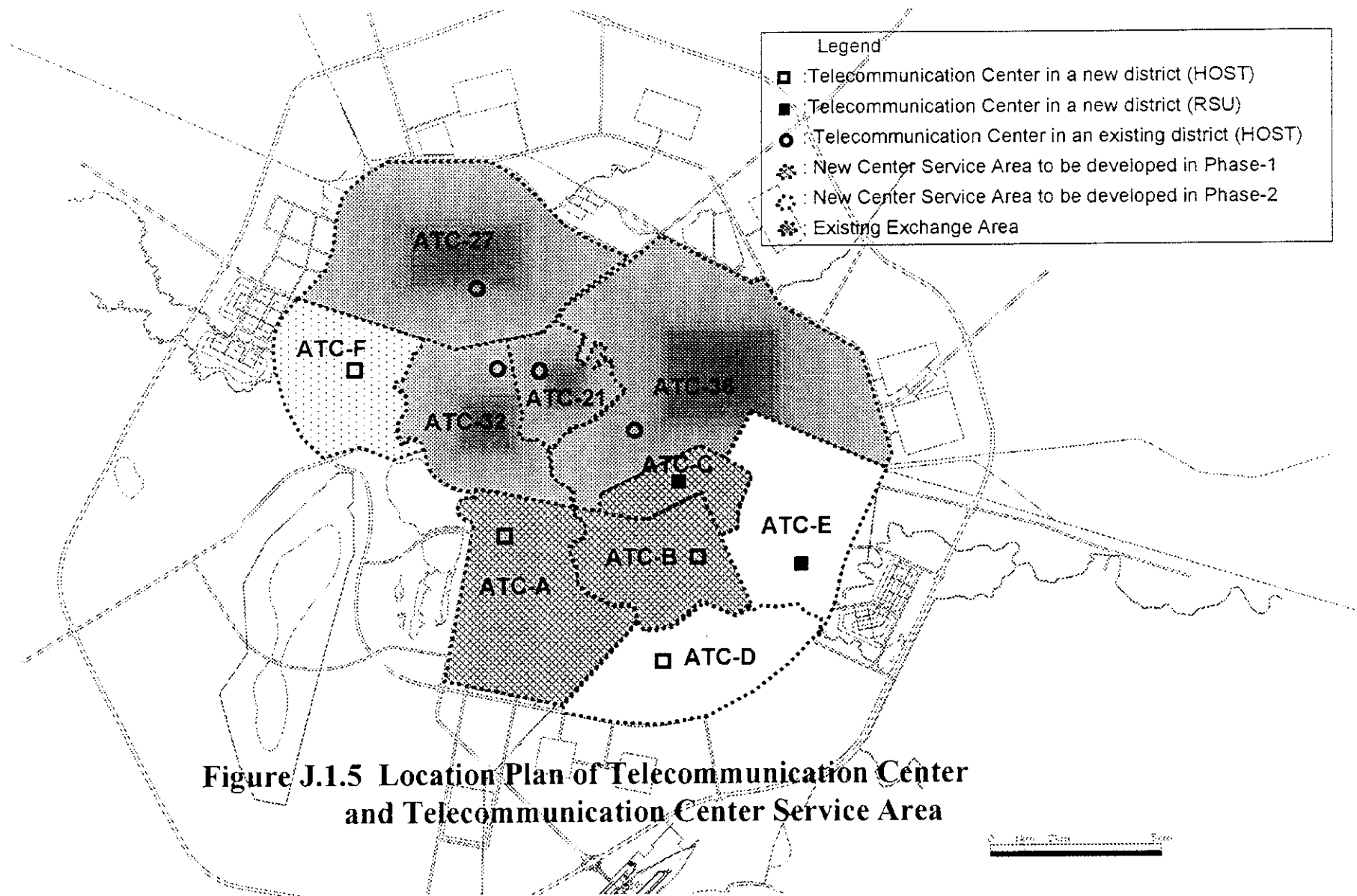


Figure J.1.3 Radio Links in Astana



Figure J.1.4 Planned Districts and Sub-Zoning in Astana





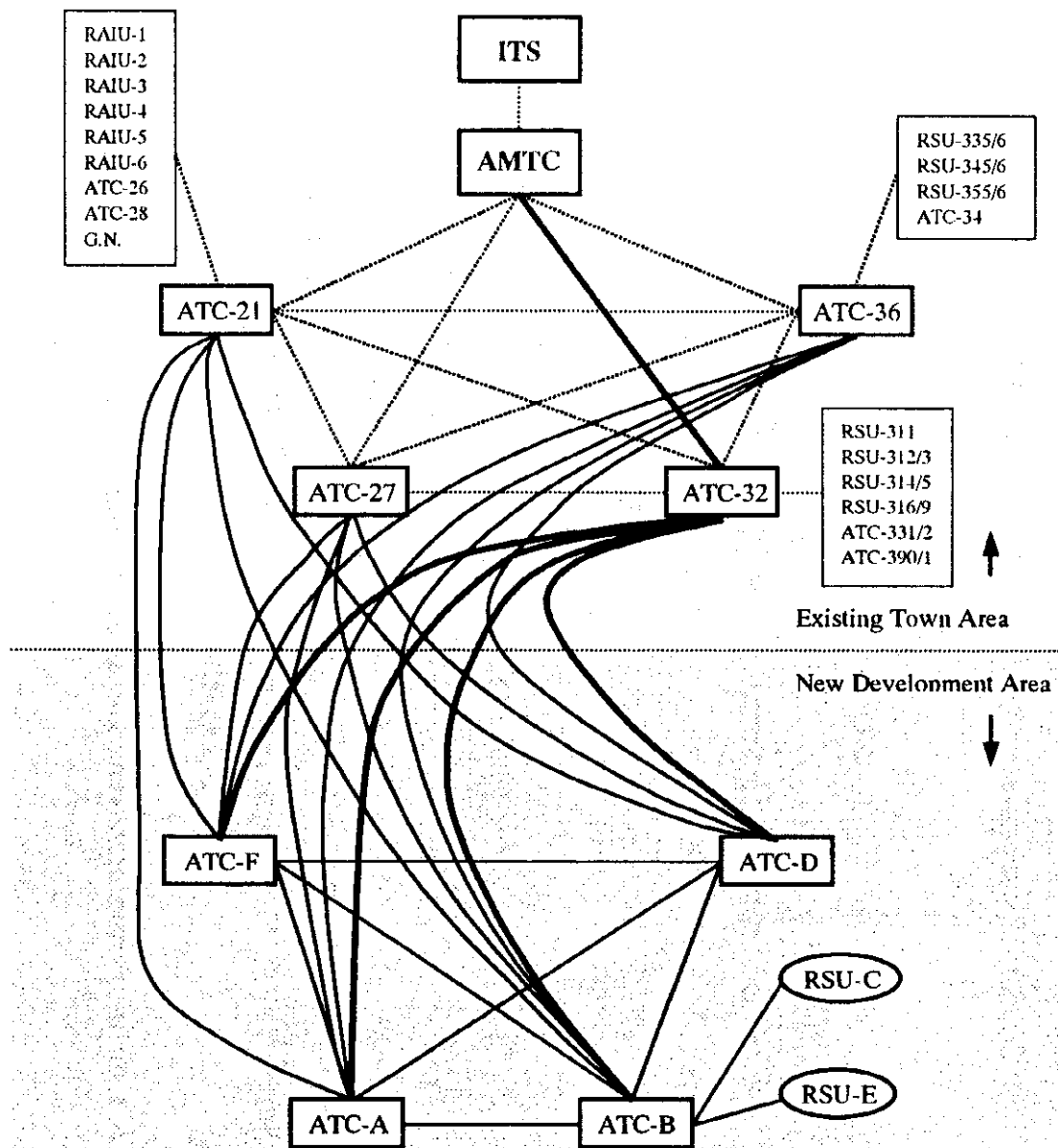


Figure J.2.1 Circuit Diagram Plan of Astana Local Network

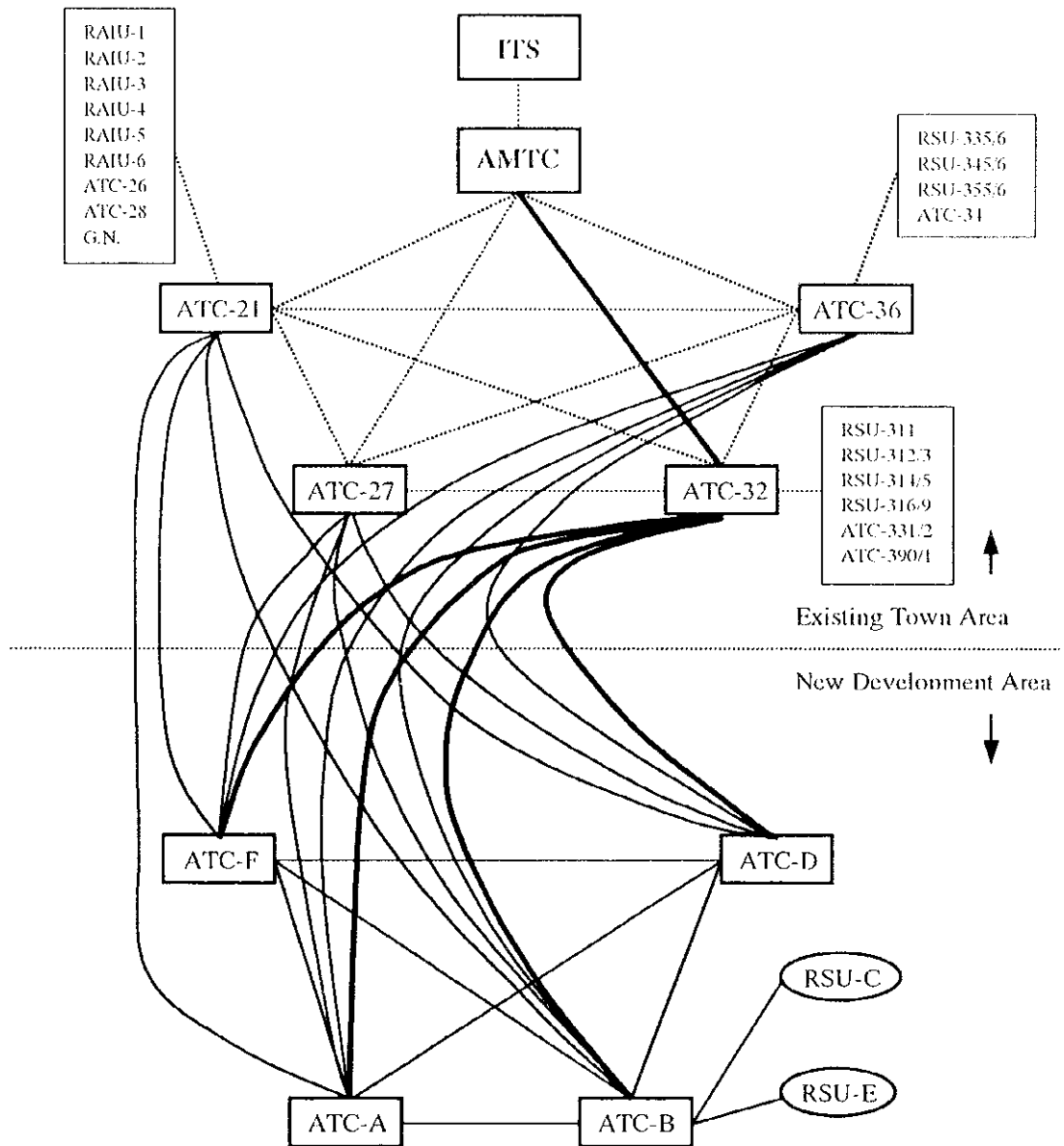


Figure J.2.1 Circuit Diagram Plan of Astana Local Network

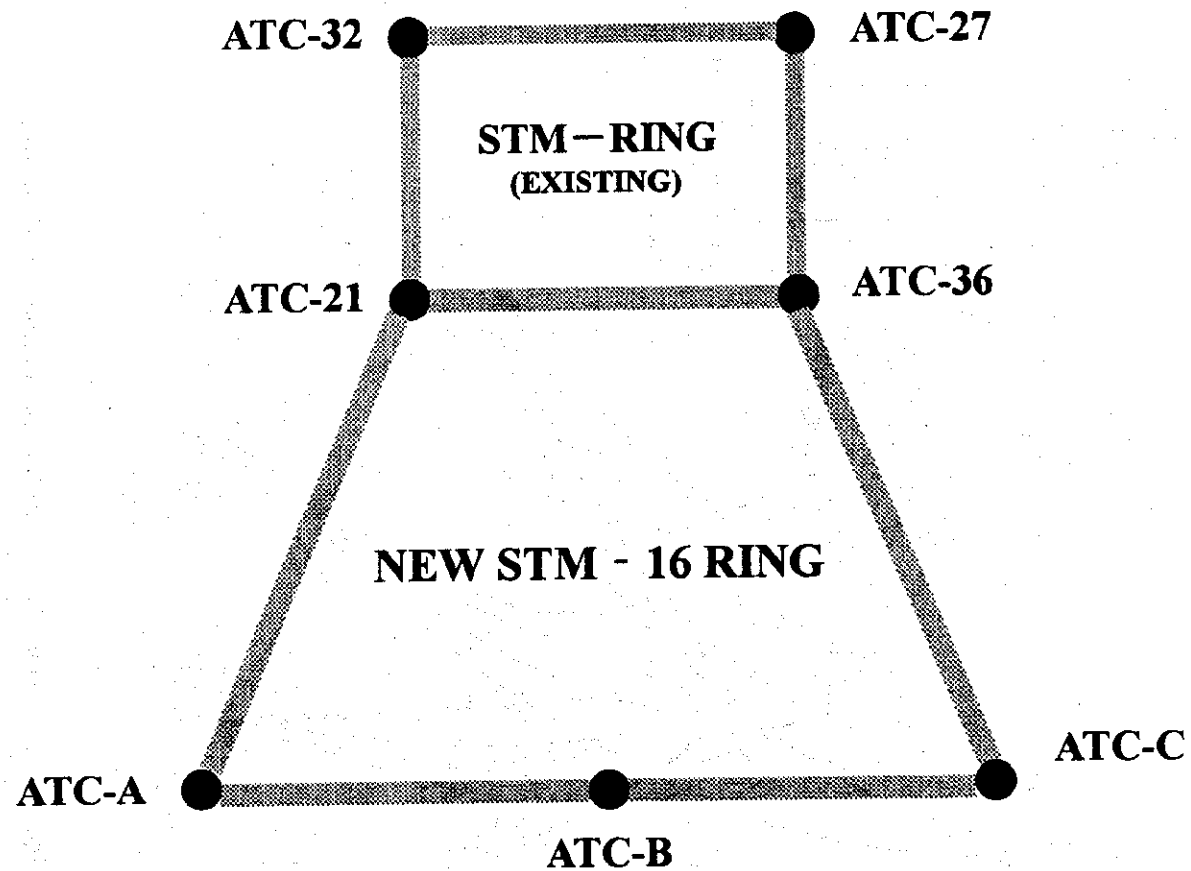


Figure J.3.1 Future Configuration of Astana Local SDH Ring Transmission System(Phase-1)

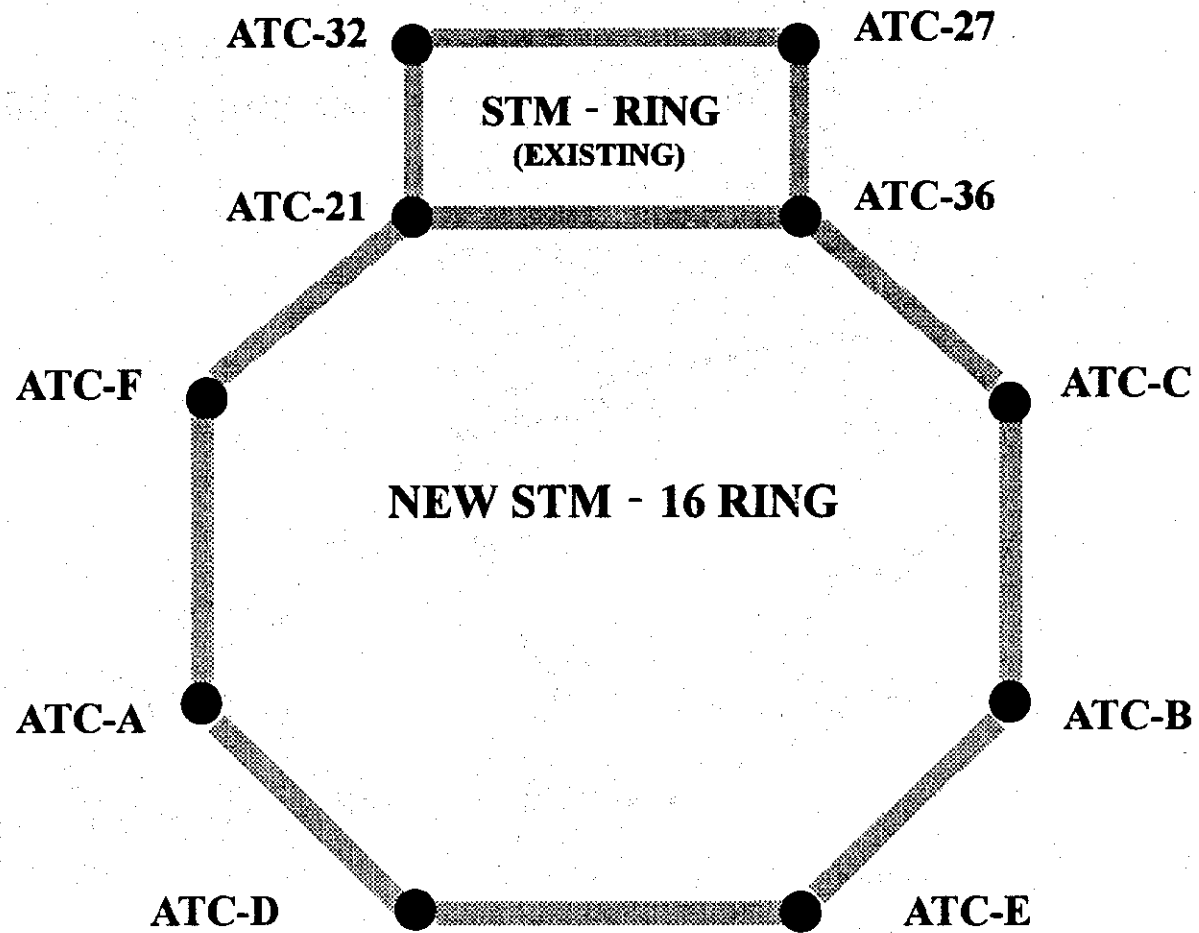
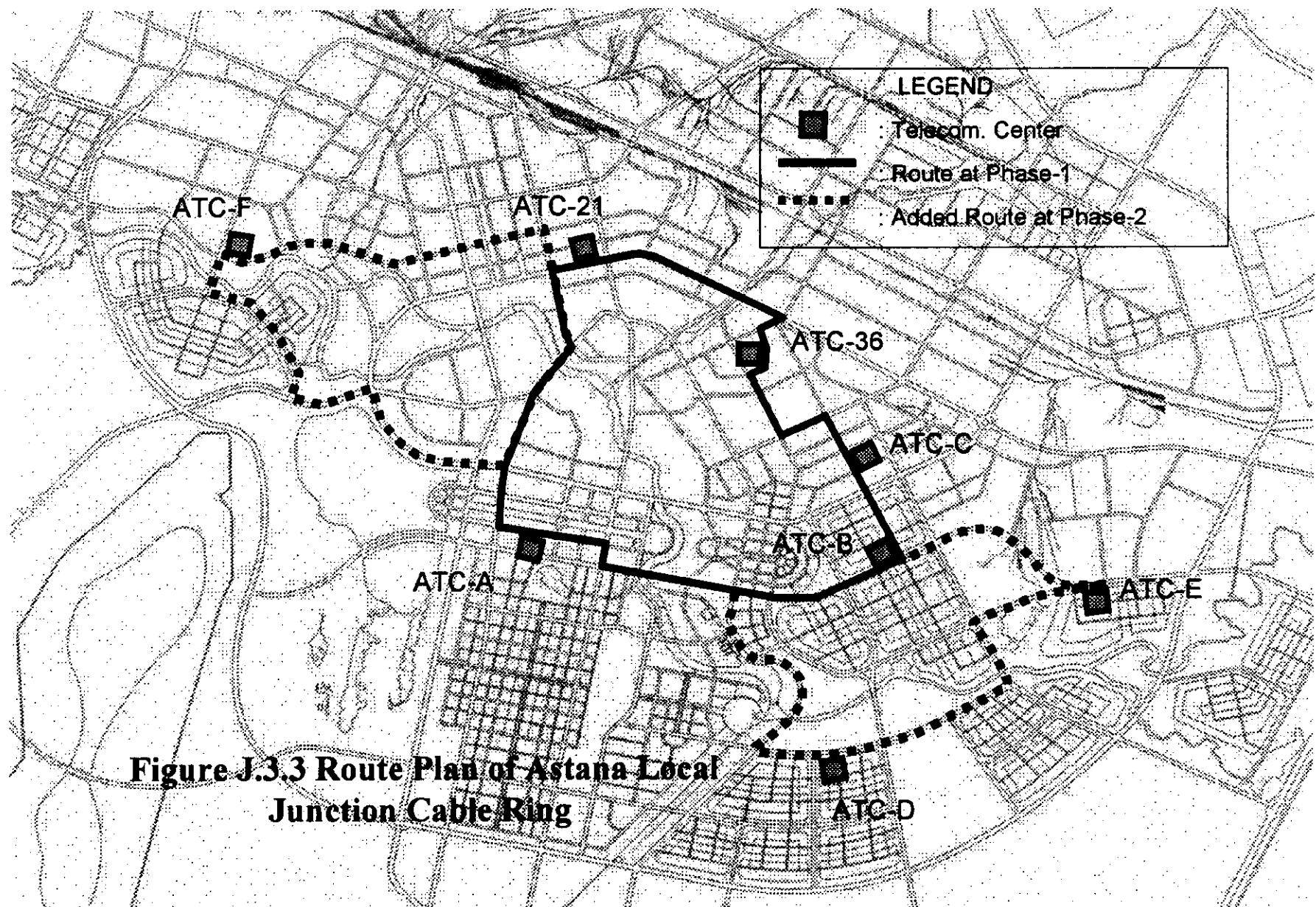
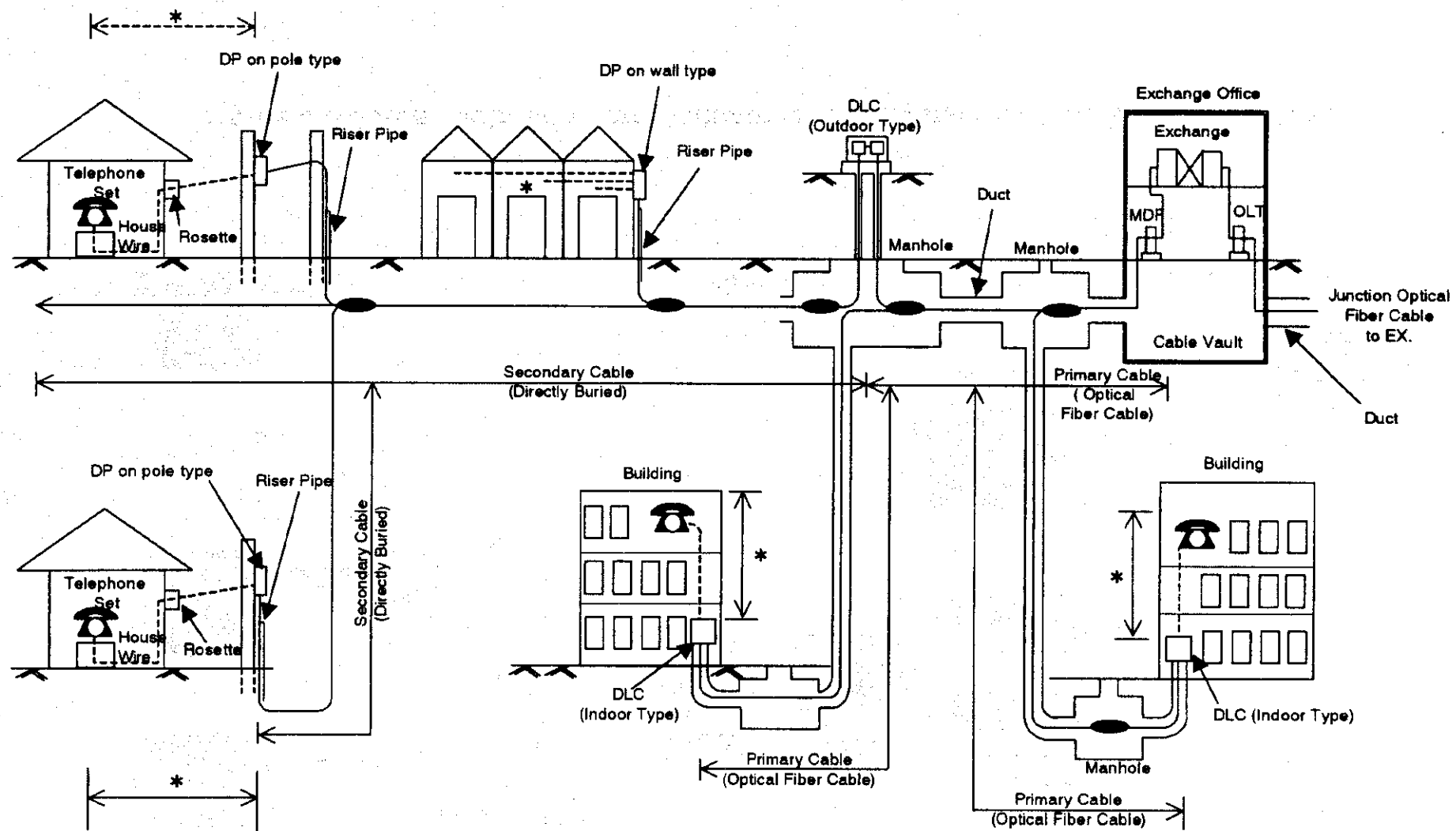


Figure J.3.2 Future Configuration of Astana Local SDH Ring Transmission System(Phase-2)



**Figure J.3.3 Route Plan of Astana Local
Junction Cable Ring**



* ----- : Works under the Responsibility of Kazakhstan Side

Figure J.3.4 Configuration of Subscriber Cable Network

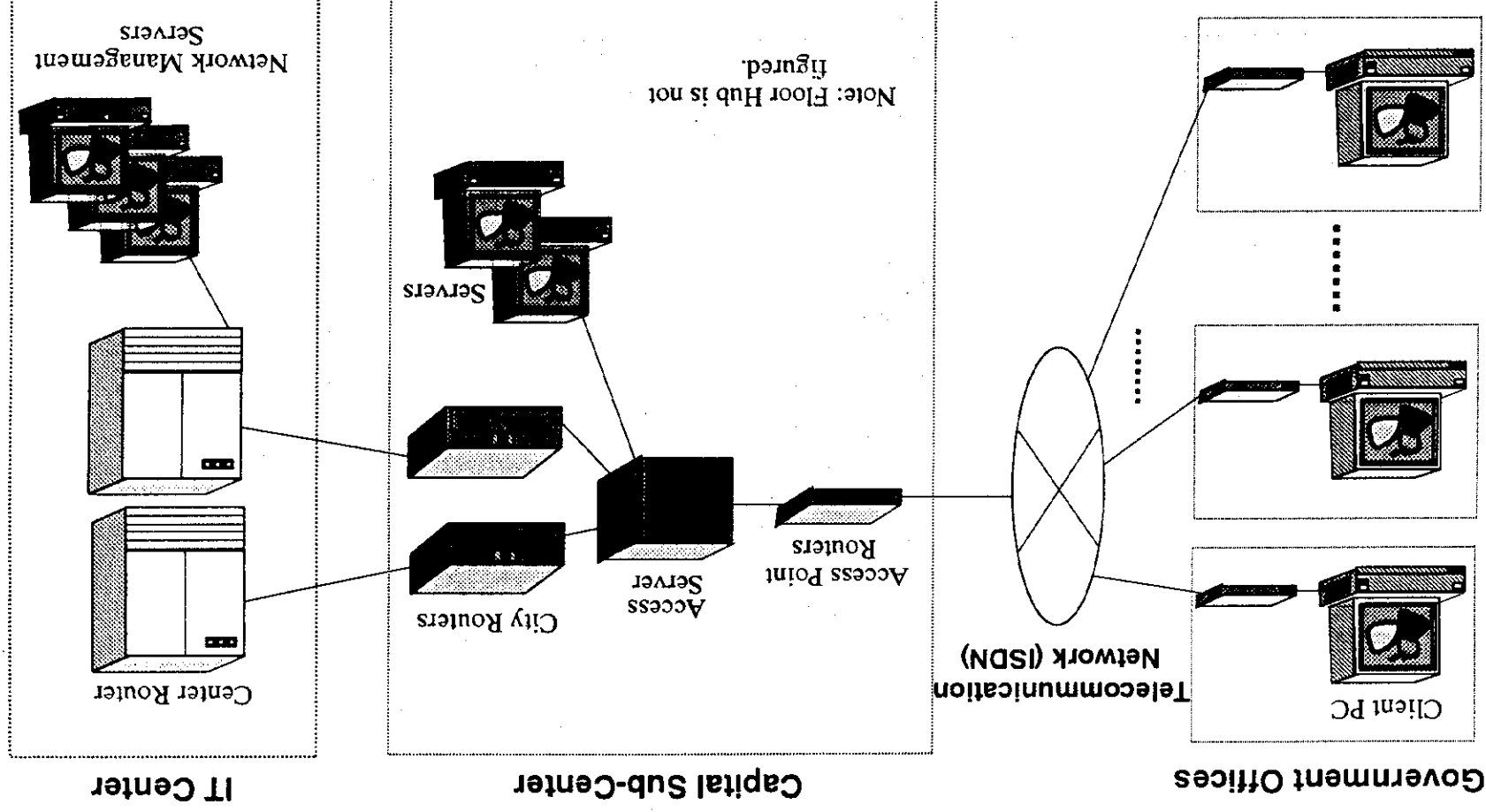
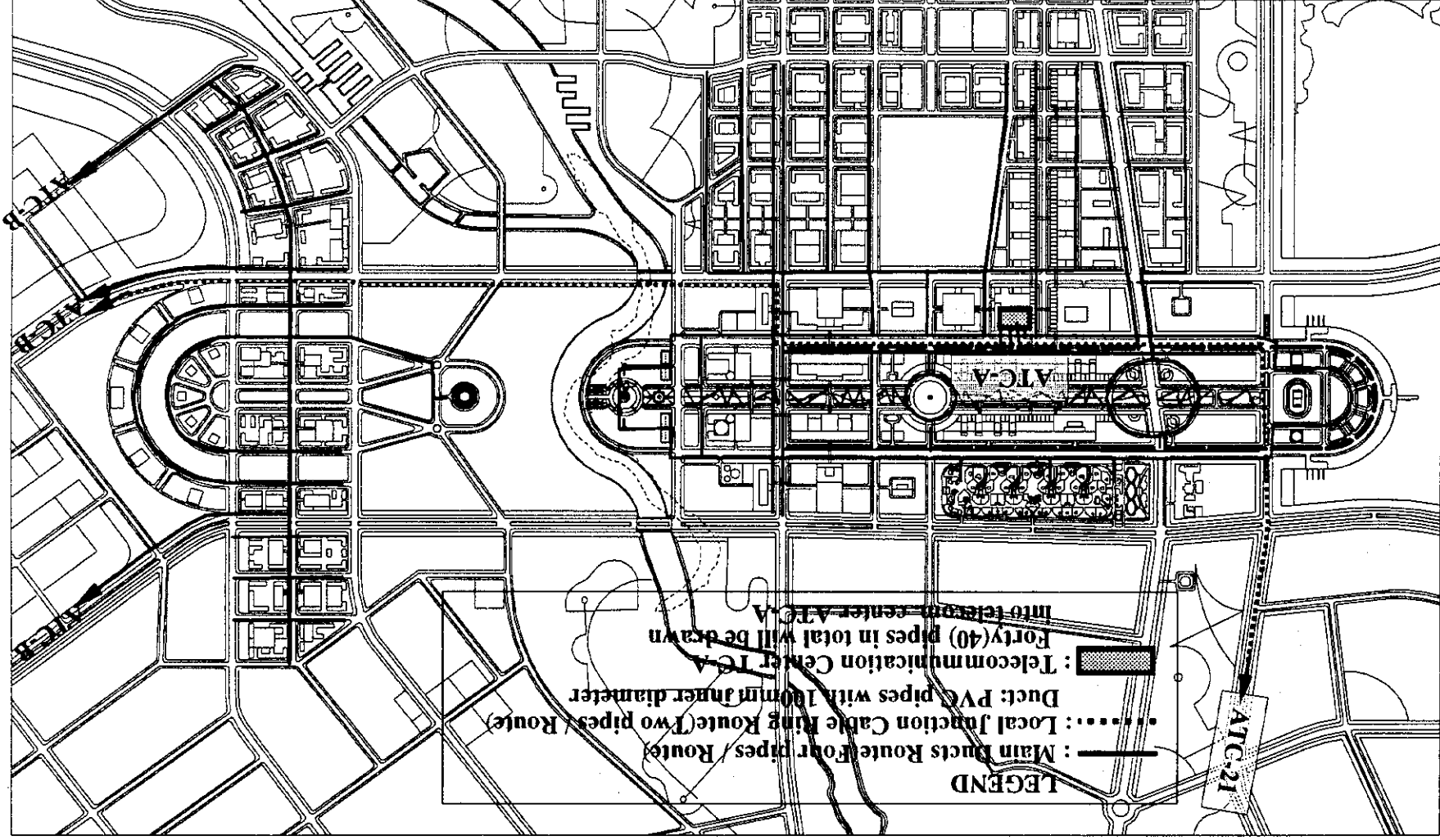


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CHAPTER K

SOLID WASTE

SUPPORTING REPORT K: SOLID WASTE

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K.1 Present Condition of Solid Waste Disposal

K.1.1 Present Condition of Institutional and Legal Structure

(1) Related Laws and Regulations

In the ROK, no specific laws regarding the waste management like “Waste Disposal and Public Cleansing Law” in Japan has been in effect which define and classify wastes and stipulate the roles and responsibilities of each concerned organization such as national government, municipal government, private businesses and individuals.

Instead of such waste management law, there are many laws in the country pertaining to environmental protection. Especially the following two laws include articles related to waste management.

- Law No.160 of July 15th, 1997 on the Environmental Protection
- Law No.162 of July 15th, 1997 on the Specially-Protected Natural Territories

Also the following law is concerned with waste management from the view of the public health.

- Law of May 19th, 1997 on the Health Protection of the Population.

Besides above-mentioned laws, the following law is also related for collecting and removing the waste from the residential buildings or houses.

- Law of April 16th, 1997 on Housing Relations

In 1997, the Ministry of Health's Department and Sanitary Monitoring approved “Sanitary Rules #3.01.007.97 – Maintenance of Populated Areas Territories” prepared by various health organizations. Under this regulation, the following rules are stipulated:

- Responsibility of municipalities for waste collection and transportation
- Specification of waste collection and transportation equipment
- Specification of the location of waste storage containers
- Frequency of waste removal
- Operation hours for waste collection

There are also many SNiP regarding waste management. The following two SNiP are particularly important for the implementation of the Master Plan for the Waste Management in this study.

- SNiP 2.07.01-89 on "Urban Planning. Planning and Building up of Cities and Rural settlements"
- SNiP on "Landfill of Municipal Solid Waste and Industrial Waste"

(2) Current Waste Classification

Despite the lack of legal definition, the following classifications are presently in common use throughout the country.

- *Municipal solid waste (MSW, or Domestic solid waste)*

Solid waste which is generated from households, all buildings including residential, governmental and commercial, institutions such as hospitals and schools, public spaces such as parks and streets, administrative offices at industries.

- *Industrial solid waste (ISW)*

Solid waste which is generated from industries, especially useless by-products from manufacturing processes or other industrial activities. Some of those industrial solid wastes have hazardous character and this type of waste is classified into 4 classes according to a certain toxicity factor by the "temporary classifier of toxic industrial waste and methodological recommendation on assessment of class of toxicity of industrial waste" (Moscow, 1987). However, this hazardous waste classification is not refer to the international standards such as waste classified lists under the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal.

- *Hospital Solid Waste (HSW)*

There is no definition for the waste generated from hospitals, clinics and other medical institutions by the Law in this country. Such wastes are divided into two types, one is the waste with hazardous character that needs proper treatment for disposal and the other is non-hazardous waste, which is similar to municipal solid waste (MSW). The former is also often called as medical waste including infectious waste, infective waste, biohazardous waste, medical hazardous waste, microbiological waste and pathological waste. The latter waste is managed as MSW in Astana.

(3) Responsible Organizations

City Communal Management (*Gorcommunkhoz*) is a state enterprise under the Office of *Akim* is responsible for the solid waste management. Especially

the Department of Waste Transportation and Utilization under *Gorcommunkhoz* that founded in 1999 is practically responsible for the implementation of solid waste management activities including collecting, transporting and disposing of MSW at the Landfill site.

As city area is presently divided into three collection areas, *Gorcommunkhoz* is collecting from one of those areas where is mainly south part in Astana and also collecting MSW from small settlements such as Promyshlenny, Internatsionalnoye, Michurino, Kuygenzhar, Telman, Prigorodnoye, Kirovo or Zhelenznodoezhnwhere where used to be out of old city boundary.

Besides *Gorcommunkhoz*, three other private enterprises, namely Special Auto Transport of Almaty area (*Almaatinsky*), Special Auto Transport of Saryarka area (*Saryarkinsky*) and *TURMYS*, are collecting MSW from residential, governmental and commercial buildings, institutions, and offices at the industries as well as *Gorcommunkhoz*.

From the public spaces such as streets and parks, the Department of City Care and Development under *Gorcommunkhoz* is in charge of sweeping, cleaning and removing the waste. This organization also has responsibility for supply and maintenance of equipment such as public trash bins set up throughout the city and plastic containers with wheel and brooms and others used by street sweepers.

Ecological Police maintains the city cleanliness by watching illegal activities. Sanitary and Epidemiological Center, Environmental Protection Department and other organizations complement MSW management from the environmental view.

All collected MSW in Astana are transported and disposed of at the landfill site where is located approximately 6 km northeast from the center of the city. *Gorcommunkhoz* has the responsibility of operation of this existing landfill site.

K.1.2 Municipal Solid Waste (MSW)

(1) MSW Quantity

The quantity of MSW is only officially measured at the landfill site based on volume by counting the number of trucks that transport MSW to the landfill.

It is reported that the total waste volume that has been disposed of at the landfill site since 1972 when is started its operation is approximately 10.43 million m³ at the time of 9th of November in 1999. This volume is

including not only MSW but also some of industrial waste, especially construction waste.

The existing master plan by Saudi Bin Ladin Group adopted the unit generation rate of 1.4 m^3 per capita per year, which is in a range indicated in SNiP 2.07.01-89 annex 11 for norms of domestic waste accumulation, though it is unclear if this value is based on the practical waste generation survey in Astana. Based on this the generation quantity of MSW could be estimated at about $463,000 \text{ m}^3/\text{year}$ in 2000 with population in Astana as 330,748.

There are yet a few other estimations by pertinent agencies. The City Environmental Department estimates that approximately $364,500 \text{ m}^3/\text{year}$ of MSW is generated in Astana City. According to an interview with the landfill manager, daily MSW volume accepted at the landfill is approximately 800 m^3 per day, which corresponds to $292,000 \text{ m}^3$ per year. These quantity gaps may be caused by the following reason.

- Unit generation rate of MSW in Astana is actually lower than 1.4 m^3 per day per capita.
- Current MSW collection service does not cover the whole area of the city.
- Some of MSW is burned or disposed of near the house by residents themselves illegally.
- Some of MSW is dumped to the unknown place illegally.

In this M/P study, it is summarized that the generation quantity is $463,000 \text{ m}^3/\text{year}$ and the collection coverage rate is 80% of them that means approximately $370,000 \text{ m}^3/\text{year}$ of MSW is transported to the landfill. The rest of about $97,000 \text{ m}^3/\text{year}$ of MSW may be disposed of somewhere else by individuals.

It is recommended for more detail waste management plan to carry out further surveys such as waste quantity survey at both generation source and landfill site and time and motion study.

(2) MSW Composition

Physical composition of MSW based on wet base and measured by volume is indicated in the following table. Though it is unknown when and where it was analyzed, it can be a typical composition of MSW presently. There are four major components, paper waste, food waste, screen residues (ash, slag),

and plastic waste. Waste volume of these four categories accounts for more than 80% of all MSW. According to *Gorcommunkhoz*, the composition rate of plastic waste increased significantly in recent years.

Composition of MSW

No.	Waste Types	Percentage by volume
1	Paper waste	25.85
2	Food waste	24.60
3	Plastic waste	14.75
4	Waste wood	4.35
5	Textile	3.85
6	Glass	3.30
7	Metal	4.35
8	Bones	-
9	Screen residue (ash, slag)	20.35
10	Leather rubber	-
11	Stones, bricks	-
12	Others	-
	Total	100

The moisture content of MSW fluctuates between 30 and 58% and bulk density of MSW is in the range of 0.18 and 0.3 ton/m³. Considering the difference of bulk density of each waste character, composition rate of food waste will be larger by weight because moisture content of food waste is bigger than others.

The reason why the composition of glass is very low is by recycling it. In Astana, there is the deposit refund system for glass bottles. For example, a redemption shop at the central open market is accepting various kind of glass bottles of beer, vodka and soft beverages that can re-used as returnable bottles. Refund price is from Tenge 3 to 10 depend on the type of bottle. On the other hand, since there is no such deposit refund system for plastic bottles like PET bottles that has been significantly popular for beverages, these empty bottles easily become the waste.

(3) MSW Storage, Collection and Transportation System

1) Storage of MSW at the source

MSW from the buildings

For temporary storage of MSW, storage containers are used according to size and population density of the buildings, methods and frequency of collection and removal of the waste. There are two types of storage containers used, one with capacity of 0.75 m³ (or 0.785 m³) made by steel and the other is with the capacity of approximately 8 m³ and 6 of

charging windows for low-rise dwelling area. Location of these storage containers are specified by the guideline as follows:

- They should be no less than 20 meters away from windows of dwelling or public administration buildings and playgrounds;
- They should be no more than 100 meters away from the furthest dwelling;
- There should be convenient pathway laid out to each container; and
- There should not exceed five containers at one place.

They are positioned behind buildings or at common areas in settlements so that people can throw their garbage anytime they want. As there is no lid for these containers or keeping them open even though they have lid, it might result in emission of bad smell or growth of flies and rats. This also means that small animals or stray dogs may scavenge for food from the container.

It is observed that some people bring their garbage by small bucket or some people throw them packed in plastic bags. Other plastic materials such as PET bottles of beverages or plastic films for packaging are also well observed in the containers. Food waste (or kitchen waste) used to be separated at generation source for recycling to feed stuff, but it has been prohibited by the decision of the City Sanitary-Epidemic Station because of increased rats and mice around the waste storage area.

Storage containers may be washed and cleaned regularly by the same organizations that collect MSW. Its frequency during warm season is much more, maybe double, than it during cold season.

Large residential building with 5 stories or more, garbage-discharging chute is used to annex to the building. Residents can throw their trash into the chute anytime and building manager is taking care of those wastes at the bottom. But some apartment building stopped to use chute because of littering at the bottom.

MSW from Streets and Public Places

In Astana, there are many public trash containers set out along the street, in the public area like parks, bus stops or stadiums, around buildings such as governmental offices, markets or hotels. The Department of City Care and Development is taking care of planning, purchasing, setting up and maintaining such containers. There are two types of

small public container, one is square type which is bigger than other, and rectangular type with white triangular open lid. Both are colored in green so that people can easily distinguish what it is.

It is observed that the cigarette ends, cigarette case, or PET beverage bottles are often discharged into the containers. In summer season, a lot of plastics packaging films of ice cream are disposed of into the garbage bin near the street ice-cream shops.

2) Collection and Transportation of MSW

MSW from the buildings

As previously mentioned, there are four main organizations that collect and transport MSW from various buildings to the disposal site, *Gorcommunkhoz*, *Almaatinsky*, *Saryakinsky* and *TURMYS*. *TURMYS* only collects MSW from particular large residential dwellings newly constructed such as "Samal" and "Twin Towers" by contract with the administration office of these houses. *Gorcommunkhoz*, *Almaatinsky* and *Saryakinsky* share the responsibility of collection area in the city.

Waste collection and disposal fee is Tenge 48 per person per month for *Gorcommunkhoz* and Tenge 50 per person per month for both Special Auto Transport Company. Within these fees, about Tenge 3 to 4 is the fee for disposal of at the landfill site.

Gorcommunkhoz has 30 vehicles with the design capacity load of 10 m³ for waste transportation, 15 of them are special equipped trucks with auto loading/unloading system and others are just dump trucks.

Almaatinsky and *Saryakinsky* have also their waste transportation vehicles as well as *Gorcommunkhoz*.

MSW storage containers are emptied at regular intervals or upon request by private enterprises or building administration offices when it becomes full. Collection and transportation is generally carried out during daytime.

In the central open market, the market administration office is in charge of collecting the waste once from garbage container located all over the market to the waste storage area in the market and orders the contracted waste hauler to transported to the landfill.

Plastic bags, low grade LDPE, imported from China or other countries have been used for packaging the goods recently. Large size bag is

Tenge 7 each and small size is Tenge 5 each. Such change of consumer's lifestyle is also reason why the plastic waste composition rate has been increased.

MSW from Streets and Public Places

MSW collection activity is performed by street sweeping workers of the Department of City Care and Development, from 8 A.M. to 8 P.M. Usually two to four workers work together with brooms, shovels, and a plastic mobile container equipped with wheel. They are not only sweeping the street but also collecting the waste from the public garbage containers. There is no particular transfer point where the waste is loaded into the transportation vehicle. When the truck passes the place sweepers work, collected waste is immediately transferred into the truck. According to the Master Plan Report by Saudi Bin Ladin Group, 15 trucks are used to collect and remove MSW from the public area to the landfill.

(4) MSW Disposal System

Astana City operates one approved landfill site, which is the only way of final disposal. The landfill site is located near the coal ash disposal pond along Astana-Pavlodar Highway, approximately 10 km northeast of the city center.

The landfill site was commission in 1972 using an abandoned sand quarry with 65.6 hectares of total area, length of up to 1,050m and width of up to 750m, according to Act No. 234, dated 12 July 1995, of local municipal governor. There are surrounding ditches with the depth of 1.5m and the breadth of 2m along the boundary of the landfill site and only one entrance gate is equipped facing the highway to control the waste acceptance.

In the center of landfill area there is one large quarry (generally called "Polygon") with total area of 5.2 hectares, the depth of 12-20m (it used to be 12-35m), the length of 200-300m and the width of 175-200m. Not only this polygons but also some neighboring others have been used for disposing of MSW and it is reported approximately 10.43 million m³ of MSW are buried from 1972 to 9th of November, 1999. There are three unloading platforms facing to the central polygon from different directions so that the waste can be unloaded from the truck from windward depending on the prevailing wind condition each day. One polygon used to be for liquid waste but it is not used for anymore because no liquid waste has been transported to the landfill site recently. City is planning to dispose of MSW at such polygons

after the current polygon will be filled full. Astana City planned to dispose MSW at this landfill site until 2010. Due to the rapid increase of waste generation volume in recent year. However, the site will have to be closed earlier than 2010. This early closure may also be related to apprehended groundwater pollution caused by the landfill.

As the facilities of the existing landfill site, an entrance gate with signs and guiding-board, a truck checking office, an administration office and wheel washing pool are equipped. Two bulldozers are used in the landfill site to move and compact unloaded waste.

An operation hour of the landfill is twenty-four hours and it opens everyday, but most of the waste is transported during daytime and until midnight. Since there is no weighbridge, the operator at the truck checking office checks and records the type and number of each waste transportation vehicle to calculate the total volume of the waste accepted into the site.

It is observed that uncontrolled open burning is occurred so often even in winter season because of contamination of firing charcoal ash from households that uses charcoal or firewood for cooking or heating. Daily cover soil to isolate the waste layer is not carried out efficiently, therefore such firing or littering of light waste such as plastic films is happened. A lot of birds are flying and picking food waste from the landfill. 20 to 30 scavengers come to the site and pick up the valuable materials from the waste for their currency income. However, this scavenging activity is illegal and they are taken away from the site by force.

In conclusion, present landfill is categorized as open dump landfill, which doesn't have any seepage control facilities like liner facility in order to prevent groundwater contamination and doesn't operate daily cover soil to avoid littering, odor, or breeding of rats. Such open dumping landfill must be improved to a sanitary landfill from the environmental view.

K.1.3 Industrial Solid Waste (ISW)

(1) Current Status of Industries in Astana

According to the Master Plan Report by Saudi Bin Ladin Group, the total number of all enterprises in Astana was estimated at 3,658, with 3,130 in the private sector, 473 State companies, and 55 foreign companies

In 1997, there were 75 major industrial establishment in Astana as follows:

- Mechanical engineering/metal working: 36
- Power engineering: 4

• Food industry:	22
• Flour milling/cereal processing:	4
• Construction industry:	9

Major sectors include equipment manufacture, especially for the agricultural sector, metalworking sector and food industries. The larger industries concerned in energy, construction materials. It is reported that 60% of industries in Astana are not working due to the crisis in the sector. For example, a building structure of the machinery manufacturing company for agriculture industry is now used for a large public market after its shutdown. Most industries are old and need radical overhaul in terms of infrastructure, equipment, and new methods of production and environmental control.

In Astana, there are not so many and large companies except a medicine company in the field of chemical industry that is the one of the large generator of the hazardous industrial waste.

(2) Present Situation of ISW Management

There are several data or information regarding industrial solid waste generation. According to Saudi Bin Ladin report, the quantity of industrial solid waste accepted at the landfill site is approximately 12.7% of municipal solid waste, which means 44,005 m³ per year at the assumption that MSW quantity is 364,000 m³ per year and it is divided into the following three classes by its hazardous risk.

- 11.7% (40,644 m³/year): Hazardous risk Class V (non-hazardous)
- 0.92% (3,188 m³/year): Hazardous risk Class IV
- 0.05% (173 m³/year): Hazardous risk Class III

On the other hand according to *Gorcommunkhoz*, approximately 20% of total waste disposed of at the landfill may be industrial waste, which means about to 73,000 m³ per year at the assumption that they accept solid waste about 1,000 m³ per day.

Hazardous industrial solid waste is categorized into 4 classes from Class I to Class IV depending on its hazardous risk and non-hazardous industrial solid waste is categorized as Class V. Most of non-hazardous industrial solid waste is construction and demolition waste such as demolition debris, concrete, ceramics, saw dust and glasses. According to the SNiP of the landfill site, it is prohibited to accept the hazardous waste categorized in Class I and Class II. Also it is determined the maximum quantity of the

hazardous waste categorized in Class III and Class IV together with another non hazardous solid waste to the landfill site.

There is another table, which indicates the quantity of industrial waste generated at each enterprise in Table K.1.1. This result says that the quantity of Class V industrial waste was drastically increased from 1998 to 1999, which was about 2.2 million tons per year to 5.6 million tons. On the other hand, the quantity of Class III and Class IV hazardous industrial waste are much less than Class V and not so increased. From 1998 to 1999, Class III of industrial waste changed from 18 thousands tons to 19 thousands, and Class IV was decreased from 1.7 million tons per year to 1.4 million tons.

The following table shows the result of industrial waste composition analysis excluding the coal ash from power and heat generation companies and sludge from wastewater Treatment Company.

Composition of industrial solid waste

No.	Industrial Waste Types	Percentage by volume
1	Construction waste	42.8
2	Ferrous metal	23.0
3	Non ferrous metal	0.5
4	Slag	12.8
5	Ferro-concrete waste	12.8
6	Rubber	5.5
7	Wooden waste	2.5
8	Ceramics and clay	3.0
9	Glass	0.5
10	Others	2.5

In the existing landfill site, there is a specified area for the construction wastes. The existing landfill also prepares the disposal area for scrap metals and for used tires individually. The area for used tires is also keeping wooden waste together, but the area is almost empty recently because they has been took away by free to sell by the private organization as a kind of economic recycling activity. Scrap metals are also took away by the metal recycling company regular. *Gorcommunkhoz* can get the profits from this metal sale.

In principle, responsibility for the collection, transport, treatment and disposal of ISW lies with each individual industry enterprise. Therefore, the waste generators tend to intentionally denote hazardous waste as non-hazardous, which may inflict a public risk.

The disposal fee is Tenge 100 for 1 m³ of construction waste and it is managed by the "Talon system". "Talon" is the permission ticket for

dumping waste into the landfill and there are 2 types of talon: talon for 3 m³ and talon for 5 m³. Truck drivers buy these tickets at the disposal site and then they can dump their waste.

The coal ash from power and heat generation companies and the dehydrated sludge from wastewater Treatment Company must be in the category of industrial waste, but it seems not to be handled as industrial waste.

K.1.4 Hospital Solid Waste (HSW)

(1) Current Status of Hospitals and Clinics in Astana

Health facilities such as hospitals and medical clinics available to the public in Astana are provided at four levels, which are:

- State Medical Institutions
- Oblast Medical Institutions
- City Medical Institutions
- Private Medical Institutions

All the public sector institutions provided both residential and out patient facilities offering a variety of general practice and dental facilities. At present, the capacity of these medical institutions is suitable for the population in Astana, and additional capacity should be prepared as the city is developing.

Table K.1.2 shows the list of hospitals and medical institutions in Astana.

(2) Present Situation of HSW Management

The waste generated from medical institutions is collected by same organizations that manages municipal solid waste and handled as non-hazardous waste like MSW.

The following waste generated in hospitals should be classified and managed as infectious waste. It is very common that such infectious wastes should be safely treated in hospital by themselves by incinerating, steam sterilizing or strictly packaged in special containers and then discharged.

- Human blood and blood products
- Culture and stocks of infectious agents
- Pathological waste
- Contaminated sharps
- Contaminated laboratory waste
- Contaminated waste from patient care
- Discarded biological waste

- Contaminated animals carcasses and body parts
- Miscellaneous infectious waste

Though more than fifty health care facilities are in operation in Astana City, no comprehensive statistical data clarify the waste generated at these health facilities. In reference to a recent JICA study for waste management in Almaty, HSW generation volume in Astana City is estimated to be 7,800 m³ annually in 2000, or 2,000 tons per year. On the same token, HSW presumably includes 600 tons of hazardous HSW annually, such as human blood and blood products, culture and stocks of infectious agents, pathological waste or contaminated sharps.

According to *Gorcommunkhoz*, all the waste collected from the health facilities is nominally considered as non-hazardous waste and is thereby disposed of together with other MSW at the city landfill.

K.1.5 Problems to be solved of Waste Management in Astana

The present solid waste flow including MSW, ISW and HSW is shown in Figure K.1.1, which summarizes the current waste management system in Astana City.

The following waste issues raised need to be solved at present and in future.

- Remedial actions of the existing landfill site to mitigate the apprehended environmental pollution,
- Selection and securing of a future landfill site to be in use after closure of the existing one,
- Maintenance and repairing of the existing waste collection vehicles in operation and additional purchase to cater for increasing demand for collection,
- Improvement of garbage storage and rationalization of collection system for clean and sanitary urban environment and avoidance of scavenging,
- Control of illegal dumping, and
- Establishment of a hazardous waste management system for both industrial waste and hospital waste.

One of most urgent issue pertains to the existing landfill condition. City Environmental Department reports that groundwater contamination from the landfill is in progress. If this contamination is a serious one, appropriate remedial actions such as construction of cutting off, re-excavation of buried waste,

equipping appropriate seepage control facility, or at most closure of the site, may be immediately necessitated.

Uncontrolled open burning or outbreak of pathogenic bacteria and vector at the landfill site may also be causing air pollution. This problem can be solved by daily soil covering on top of disposed waste layer. The existing landfill site is not a "sanitary landfill" with the lack of such a covering soil system and leachate control system.

In addition, it was pointed out at the seminar on Waste Management conducted by JICA M/P Study Team, that another important issue related to waste management is garbage littering at storage containers in streets by stray dogs, numbering approximately seven thousand in the city.

K.2 Demand Forecast

K.2.1 Future Estimation of MSW Quantity and Quality

(1) Related Framework Plan and Assumption for Estimation

There are two factors to estimate MSW quantity, one is population projection and the other is unit generation ratio of MSW.

Total population in Astana is estimated in the Master Plan as follow.

- In 2000, 330,748
- In 2010, 490,036
- In 2020, 687,432
- In 2030, 796,024

Figure K.2.1 shows summary of population projection in this Master Plan by each regional district. Comparing that the population in central region is growing slightly, the one in southeastern region will increase more and become larger than central region in 2010. The growth rate of southern region will be high from 2010 and it will become closer to the population in central region.

The current unit generation rate is assumed to be 1.4 m³ referring to SNiP. This unit generation rate has a tendency to increase because future improvement of lifestyles of citizens and in the use of processed and packaged foods. Three cases of an annual growth rate of unit generation rate are considered 1%, 2% and 3% with the assumption that the bulk density is

stable as 0.2 tons/m^3 . As the result of three case calculations that is shown in Table K.2.1, unit generation rate in 2030 is estimated as below.

- 1% growth: $1.90 \text{ m}^3/\text{capita-year}$, (= $5.21 \text{ l/capita-day}$, $1.04 \text{ kg/capita-day}$)
- 2% growth: $2.93 \text{ m}^3/\text{capita-year}$, (= $6.93 \text{ l/capita-day}$, $1.39 \text{ kg/capita-day}$)
- 3% growth: $3.40 \text{ m}^3/\text{capita-year}$, (= $9.32 \text{ l/capita-day}$, $1.86 \text{ kg/capita-day}$)

It is considered that the case of 1% growth is more realistic because the unit generation rate in 2030 reaches near the level of European countries or Japan that is around 1.0 kg per capita per day including commercial MSW. Only some countries such as USA, Canada or South Korea generate MSW per person approximately double than others. Considering the recent trend of promotion for avoidance of waste generation or recycling in the world from the environmental view, assumption of 1% growth is feasible.

(2) MSW Quantity Estimation

Using previous mentioned unit generation rates in conjunction with the population projection, the volume of MSW is estimated and shown in Figure K.2.2. The result says that approximately 463 thousands tons of MSW will be generate in 2000 and it will be increased to 1,512 thousands tons in 2030. In 2030, about 536 thousands tons of MSW will be generate from southeastern region, 415 thousands tons from central region, 355 thousands tons from southern region, and 189 thousands tons from Northwest region. Only 17 thousands tons of MSW will be generated from northern region because of industrial zone.

There is another crucial factor for waste management plan, which is the collection rate. Collection rate is the rate of the number of citizens covered by the municipal or private waste collection service. According to the assumption of this collection rate, waste transportation plan or treatment including landfill plan can be designed. Using the following assumption, MSW volume collection volume can be estimated as Fig. 2.15.4 in the Interim Report shows.

- Current collection rate is assumed to be 80%
- Collection rate will be increased to 95% in 2010
- Collection rate will be stable 100% after 2010

(3) MSW Quality Prediction

Composition of MSW is closely related to lifestyle particularly consumption practices in the current society. Generally, paper waste may increase, because Astana City will become chiefly an administrative city with a number office generating predominantly paper waste. Plastic waste may also increase in accordance with increasing consumption of plastic goods and readily packed foodstuff. Screen residue such as ash from dwelling houses will significantly decrease in conjunction with increased connection to the central heating system and electric or gas system.

Prediction of MSW composition change

No.	Waste Types	Expecting change
1	Paper waste	Increase
2	Food waste	Slightly decrease
3	Plastic waste	Increase
4	Waste wood	Almost no change
5	Textile	Almost no change
6	Glass	Almost no change
7	Metal	Almost no change
8	Bones	Almost no change
9	Screen residue (ash, slag)	Decrease
10	Leather rubber	Almost no change
11	Stones, bricks	Almost no change

In the course of such composition changes, bulk density and lower calorific value will also change. The bulk density has a tendency to slightly decrease and the lower calorific value is estimated to rise above 4,500 kJ/kg.

For predicting more detail MSW composition, the following waste composition surveys are necessary.

- Physical composition analysis on wet base and estimation of bulk density
- Physical composition analysis on dry base
- Chemical composition analysis of the 3 components, i.e., water content, ash content and combustible content
- Chemical composition analysis of the 6 elements, i.e., C, H, O, N, Cl, and sulfa
- Lower calorific value

K.2.2 Future Estimation of Industrial Waste Quantity and Quality

The industrial wastes tend to differ greatly by the type of industries. The future generation quantity of industrial waste therefore is subject to uncertainties

pertinent mainly to future expansion and restructuring plans of industrial activities, as well as changes in working population.

The working population of industries is projected in this Master Plan as 15,901 in 2000; 25,123 in 2010; and 35,118 in 2020; and 37,091 in 2030. If the generation quantity of industrial waste is assumed to grow in proportion to the working population, the volume of industrial waste will increase to 158% in 2010; 221% in 2020; and 233% in 2030 compared with the volume in 2000.

The present M/P estimated the area of demolished houses and buildings for urban redevelopment mostly in the existing urban areas to be, 349 ha by 2010; additional 350 ha by 2020; and 108 ha by 2030. In due course, construction wastes will increase accordingly even though some of them are reused.

According to the power and heat supply development plans in this Master Plan, 154,400 tons of coal ash consisting of 88% of fly ash and 12% of bottom ash will be discharged annually from the new boiler at TETs-2 commissioned in 2006. In the on-going Feasibility Study for Water Supply and Sewerage Development, approximately 4,000 to 5,000 tons of dried sludge cake by solar evaporation will be generated annually from the water purification and wastewater treatment facility.

K.2.3 Future Estimation of Hospital Waste Quantity and Quality

Future quantity of hospital waste is estimated according to the following planning condition.

- Generation quantity of hospital waste is related to the number of beds in medical institutions.
- The number of beds is in proportion to the population increase.
- Unit generation rate of total hospital waste is assumed to be 1.61 kg per bed per day referring to the JICA report "The study on Solid Waste Management for Almaty City in the Republic of Kazakhstan (January 2000)".
- Composition of hospital waste is assumed to be 20% of food waste, 50% of general waste, and 30% of infectious waste also referring to the same JICA report.

The following table indicates such design condition for the projection of the quantity of hospital waste.

Design condition for hospital waste quantity projection

	Composition ratio		Unit generation ratio	Bulk density	Unit annual generation ratio
	*1	*2	*1	*2	
	%	%	kg/bed-day	kg/m ³	m ³ /bed-year
Unit Generation Ratio of Hospital Waste	100%	100%	1.61	-	2.29
Food waste	15-25%	20%	0.32	500	0.23
General waste	40-60%	50%	0.81	200	1.48
Infectious waste	25-35%	30%	0.48	300	0.58

*1) refer to JICA report for waste management master plan in Almaty (Jan., 2000)

*2) design assumption for this study

In the hospital list shown in Table K.1.2, some data for the bed number are missing. Therefore, at first total number of beds is estimated with the assumption that the number of junior medical staff has stronger correlation with the number of beds than the one of doctors, nurses, or total staff. As the result of this calculation, total present number of beds is estimated to be 3,416 in Astana.

The following table is the result of the estimation. The number of beds will be increased in excess of 8,000 and total hospital waste will be increased to approximately 19 thousands m³ per year, or about 4.8 thousand tons per year in 2030. The quantity of infectious waste within the hospital waste is estimated to be 1.5 thousand tons per year in 2030.

Projection of hospital waste generation quantity

	2000	2010	2020	2030
Total population	330,748	490,036	687,432	796,024
Estimated bed number	3,416	5,061	7,100	8,221
Hospital waste in volume [m ³ /y]	7,823	11,590	16,259	18,826
Hospital waste in weight [t/y]	2,007	2,974	4,172	4,831
Infectious waste in weight [t/y]	598	887	1,244	1,440
ditto [t/day]	1.6	2.4	3.4	3.9

K.3 Basic Concept and Target for Waste Disposal Plan

The basic approach for formulating Waste Management System in Astana will be a balance of proper disposal system, optimal recycling activity and affordable cost. The following describes concepts and targets in detail.

- Waste collection rate will be raised to 95% by 2010; 100% in and after 2020.
- Waste reduction activity will commence from 2010 and waste reduction

target rate is 20% in 2030.

- Appropriate sanitary landfill management system will be established to meet the environmental standards pertinent to solid waste disposal.
- Suitable location for a new landfill site will be studied and secured in the northern part of Eco-forest along the Astana-Pavlodar Highway in consideration of the geological, environmental and economic view points.
- An economical and sanitary system of MSW collection and transportation will be established in an in-depth study on the necessity of a transfer station.
- Appropriate waste treatment systems will be considered after 2010. Analysis needs to be conducted on the necessity of intermediate treatment methods such as incineration, composting, or introduction of RDF (Refuse Derived Fuel) system. Although costly, RDF is a measure to reduce the volume of waste and recover the reusable materials or energy from MSW.
- Waste disposal fee will be collected to cover whole waste disposal cost from all waste generators according to the discharged waste quantity.
- Material recycling activity on a market basis will be promoted to reduce the waste generation quantity and accelerate utilize the reusable materials.
- Industrial waste generator will have to bear the responsibility on their waste disposal.
- Hazardous waste management policy shall be established as soon as possible.
- World trend of the latest waste management principles, such as PPP (Polluter Pay Principle), EPR (Extended Producer Responsibility) or Zero Emission policy, will be considered in the waste disposal system.

K.4 MSW Disposal Plan

K.4.1 Strategic Reduction Target of MSW Generation

Reducing the waste generation quantity at the source is now the main stream of waste management in the world. As mentioned earlier the waste reduction target rate is set at 20% in 2030 starting from 2010. The following four scenarios are compared to determine the waste reduction target rate.

- Without reduction
- Scenario 1: 10% of MSW quantity will be decreased in 2030
- Scenario 2: 20% of MSW quantity will be decreased in 2030

- Scenario 3: 30% of MSW quantity will be decreased in 2030

The result is shown in Figure K.4.1 and Scenario 2 is the most appropriate target because the unit generation volume will be almost stable since 2015 as about 1.5 m³ per capita per year that may be less than or equal to the volume of some European countries such as German, Sweden, Denmark, or Japan at present. As well as these other countries also trying to reduce the waste generation, 1.52 m³ per capita per year (833 gram per capita per day when bulk density is 0.2 ton/m³) is the number that can be achieved in Astana.

If this target is readily met, the annual waste generation quantity of 1,512 thousand m³ in 2030 without any waste reduction policy will be reduced to 1,200 thousand m³ in the same year indicated below and Figure K.4.2.

Future Estimation of MSW Collection Volume (m³/year)

	2000	2010	2020	2030
Unit Generatin Rate (Volume Base; m3/y)	1.40	1.50	1.70	1.90
Unit Generatin Rate* (Weight Base; g/d)	767	822	932	1,041
Collection rate	80%	95%	100%	100%
Waste reduction rate	0.0%	1.0%	10.5%	20.0%
Target Unit Generatin Rate (m3/y)	1.40	1.49	1.52	1.52
Target Unit Generatin Rate* (t/y)	767	814	834	833

* Bulk Densiy of MSW at generation source is stable as 0.2kg/m3

	2000	2010	2020	2030
1 Central Planning Region	196,560	269,301	323,253	331,968
2 Northern Planning Region	18,267	12,751	13,749	13,732
3 Southeastan Planning Region	103,304	307,343	429,790	429,253
4 Southern Planning Region	17,933	30,351	112,622	176,802
5 Northwest Planning Region	34,373	71,905	166,792	258,202
Grand Total	370,437	691,651	1,046,206	1,209,957

The capacity of waste disposal facilities and machineries shall be planned on the reduced quantity hereafter.

K.4.2 Introduction of Ongoing Project

Recently a Spanish company has conducted a feasibility study on "Modernization of domestic waste disposal and improvement of ecological situation in Astana City". This study consists of the proposal on the improvement of the existing landfill site, construction of a new landfill site, preparation of the machinery for city cleaning, collection and landfill operation, and establishment of a Dendrological center, including preliminary surveys and design works.

According to this Spanish study, new landfill area will have 15 ha of land area, with the depth of 30 m. The new site will store 4.32 million m³ of waste including construction waste, estimated to be 12% of MSW, and its operation period is for 10 years from 2002 to 2012. This Study also proposed to introduce 100 waste collection vehicles with the loading capacity of 16 m³.

K.4.3 MSW Collection and Transportation

There are two types of waste collection and transportation system currently existing in Astana. One is called "Direct Collection System" that is the waste collection vehicle directly comes to the place where the waste is stored by residents or building manager for picking up and transporting them to the final disposal site.

The other is called "Two-Step Collection System" that wastes from street or waste bins located in the city is once collected by street sweepers and then the waste is transferred to the transportation vehicle when it passes their sweeping area.

Since the waste quantity collected by two-step collection system is much smaller than direct collection, required number of waste collection vehicles is estimated using the following assumptions.

- The capacity of collection vehicle is 16 m³ and averaged load of the vehicle is 80%. It says each vehicle can carry 12.8 m³ of the waste at one time.
- The waste is collected 6 days a week, which means 312 days a year, and collection hour is 8 hours a day.
- The averaged trip number of each vehicle from collection point in the city to the final disposal site is twice a day. This is because 0.5 hours for vehicle preparation, 1 hour for moving from the garage to the city, 1.5 hours for first collection in the city, 0.5 hours for transporting to the landfill site, 0.5 hours for unloading at the site, 0.5 hours for moving to the city, 1.5 hours for second collection, 0.5 hours for transporting, 0.5 hours for unloading, 0.5 hours for moving to the garage, and 1 hour for lunch and rest.
- The life of vehicle usage is 10 years. In 2000, Astana City has enough number of collection vehicles and all are 5 years of usage life remained. And the vehicles purchased every five years.
- Waste collection rate is 80% in 2000, 95% in 2010 and 100% after 2020.

As the result of this rough calculation, required number of waste collection vehicles is estimated as follows.

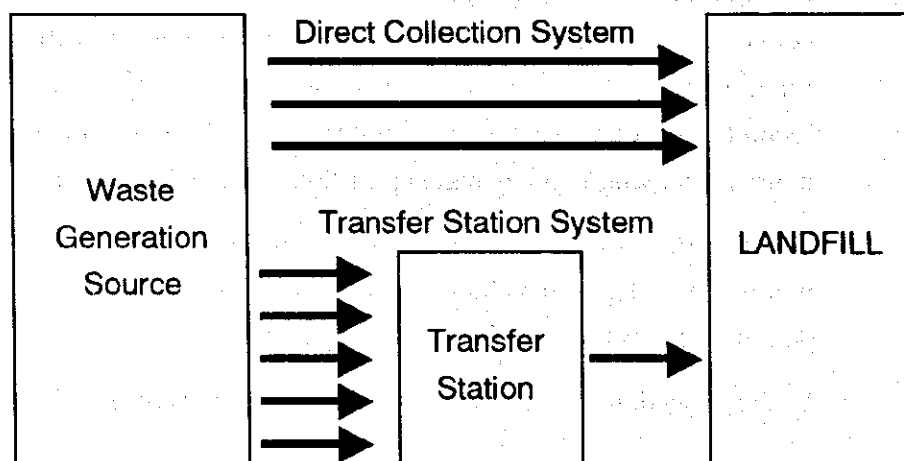
Required number of waste collection vehicles

YEAR	Waste Volume	Required no. of vehicle	Purchase no. of vehicle
2000	370,437	47	0
2005	531,044	67	67
2010	691,651	87	20
2015	868,929	109	89
2020	1,046,206	131	42
2025	1,128,082	142	100
2030	1,209,957	152	52

This result shows that approximately 370 vehicles will have to be purchased totally for operating the waste collection and transportation system in Astana until 2030. According to the feasibility study report study on “Modernization of domestic waste disposal and improvement of ecological situation in Astana City” by Spanish company, the unite price of the waste collection vehicle with the capacity of 16 m³, compact coefficient of 6 times and equipped with the loading scoop is estimated to be US\$ 53,000. It means that Astana City will have to prepare about US\$ 20 million for purchasing the waste collection vehicle.

There is another option can be considered for waste collection instead of direct collection system. It is called “Transfer Station System” that the waste collected from the city is once transported to the transfer station located at some area in the city and there it is transferred to another larger transportation vehicles for transporting to the landfill site.

The image of the transfer station is shown below.



Waste transfer system flow

The advantages of this transfer station system is to optimize the cost for waste collection and transportation when the final disposal site is constructed far from the city or to reduce the number of trip of the vehicles to the landfill to avoid the traffic jam. Also at the transfer station, recyclable materials from MSW can be sorted out with appropriate separating facilities. On the other hand, the disadvantage of the system is the construction cost of the transfer station equipped with the proper environmental control facilities such as wastewater treatment and deodorizer because it is constructed more closed to the residential area.

It is recommended that collection service area can be divided into two areas on a large scale, one is North-Astana Waste Collection Area and the South-Astana Waste Collection Area. The reason for this division is to adjust the waste collection volumes evenly in 2030, and to avoid large amount of waste transportation particularly from Residential District 11 and 12 thorough New City Center. Collection Service area is shown in Figure K.4.3.

Main route from the city to the landfill is the road that cross the railway near the east side of Astana Station and connect to the Astana-Pavlodar Highway, which has been presently used and expected to be in use until 2020 when another route will be developed. After 2020, the waste from South-Astana Waste Collection Area will be separated from North-Astana Waste Collection Area and transported though another road from the east side of the city. Since the distance from South-Astana Waste Collection Area is little further than North Area. A transfer station may be necessary for reducing the trip number of waste transportation trucks to the landfill. Figure K.4.4 shows the waste volume collected and transported from each collection area, and the waste volume of each proposed collection system. The number of vehicles used for waste collection and transportation is recalculated as below in case a transfer station is constructed with an assumption that the capacity of secondary vehicle is 40 m³ and its loading efficiency is 80%. The result says 87 of primary collection vehicles will be purchased till 2010, 131 of them will be newly added or replaced with overage vehicles till 2020, and 114 of them will be required in the last decade till 2030. 18 of secondary vehicles will be also required from 2020 to 2030.

Required number of waste collection vehicles with transfer station

Year	North Collection Area (Direct Collection)			South Collection Area (T/S Collection)			Secondary vehicle	
	MSW volume	Required No. of Vehicle	Purchase No. of Vehicle	MSW volume	Required No. of Vehicle	Purchase No. of Vehicle	Required No. of Vehicle	Purchase No. of Vehicle
2000	370,437	47	0	0	0	0	0	0
2005	531,044	67	67	0	0	0	0	0
2010	691,651	87	20	0	0	0	0	0
2015	868,929	109	89	0	0	0	0	0
2020	1,046,206	131	42	0	0	0	0	0
2025	825,054	104	62	303,028	19	19	9	9
2030	603,902	76	14	606,055	38	19	18	9

K.4.4 Direct Disposal to the Sanitary Landfill without Intermediate Treatment

Article 60 which is "Ecological Requirements When Handling Protection and Consumption Waste" in Law of the Republic of Kazakhstan on Environmental Protection indicates that waste is stored, destroyed and buried in areas allocated by decision of local executive bodies as agreed with special authorized agencies in charge of environmental protection and other executives of the Republic of Kazakhstan, which are in charge of environmental protection.

The landfill is the indispensable facility for satisfying this article regarding the waste management because the waste is generated inevitably by human activity and will never disappear even though the waste avoidance activity is promoted in future through environmental awareness. Therefore, the landfill site shall be provided as the final disposal site meeting with the environmental standards in Kazakhstan with appropriate design, construction and operation.

Required capacity and area of landfill site is estimated with the following assumption.

- Municipal solid waste (MSW) will be compacted and stabilized as about 4 times smaller than generation source. It means the bulk density of MSW increases from 0.2 tons per m^3 to 0.8 tons per m^3 at the landfill.
- Required volume of cover soil is 20 % of settled MSW.
- The volume of non-hazardous industrial solid waste (ISW) is 12% of initial MSW volume before its settlement and it will be never compacted.
- Cover soil is not necessary for ISW.
- Averaged depth of Landfill-1 that is planned by a Spanish company with the capacity of 4,320,000 m^3 is 30 m.
- The height of Landfill-2 that will be constructed after Landfill-1 is 15 m because there is no appropriate deep quarries for the landfill.

As the following table and Figure K.4.5 shows, the required capacity for sanitary landfill is estimated to be approximately 11.1 million m³ including non-hazardous ISW from 2000 to 2030.

Landfill Plan

MSW Accumulation volume		Cover Soil 20% of MSW	ISW 12% of MSW	Total Accumulation Volume (m ³)	Landfill Plan (Capacity; m ³)			Landfill Depth/Height (m)	Required landfill area (ha)
YEAR	(m ³) *1				Landfill-1 (Spanish Plan)	Landfill-2 (phase 1)	Landfill-2 (phase 2)		
2000 - 2010	1,473,049	294,610	707,063	2,474,721	4,320,000			30	15
2011 - 2020	2,243,941	448,788	1,077,091	3,769,820		1,924,542		15	18.3
2021 - 2030	2,872,038	574,408	1,378,578	4,825,023			4,825,023	15	46.0
2000 - 2030	6,589,027	1,317,805	3,162,733	11,069,565					79.3

*1: Compacted and stabilised as 4 times smaller than generation source

*2: No Compaction and No Necessary of Cover Soil for Demolition Waste

As the Spanish plan (Landfill-1) covers about 4.3 million of this, an additional capacity required for landfill-2 after 2012 will be about 6.8 million m³. Landfill-2 will be divided into two phases, which the phase 1 covers until 2020 and the phase 2 covers after 2021. As the height of landfill-2 that piles up the waste on the ground differing from landfill-1 that dumps the waste into the polygon should not exceed 15 m above the ground from the landscaping viewpoint, approximately 64.3 ha of new land will be required for the landfill in the long run. This landfill type is called "Excavated cell/trench method" or "Area Method" shown in Figure K.4.6.

Spanish plan estimates that total project cost of its plan is about US\$ 20.5 million (US\$ 18.9 million except insurance and contingency) including improvement cost of the existing landfill, procurement cost of waste collection vehicle and street cleaning vehicle, and construction cost of a Dendrological Center. Construction cost of Landfill-1 of 15 ha and improvement cost of the existing landfill of 8 ha with heavy machineries for landfill operation is estimated to be about US\$ 9.5 million. Using similar cost estimation methods, construction cost of Landfill-2 phase 1 of 18.3 ha and phase 2 of 46 ha is estimated to be US\$ 6.5 million and 16.3 million each.

Though Kazakhstan has already had SNiP for "Landfill for Municipal Solid Waste", the important functions of "Sanitary Landfill" are introduced as follows.

(1) Waste Acceptance

The wastes disposed of into the Astana landfill site should be non-hazardous municipal solid waste, in principle. It will be also able to accept the waste permitted in SNiP like low hazardous risk industrial waste categorized in

Class IV such as dried wastewater sludge from sewerage treatment facility with understanding by related local authorities.

(2) Incoming Waste Quantity Control

Incoming waste quantity should be controlled through measuring the quantity with the electric weighbridge.

The administration office will have to control not only quantity of incoming wastes but also types of wastes and particular dumping place for each waste for the disposal history recording.

(3) Liner Facilities

The bottom and walls of landfill site should have good impermeable layer, which is either natural or artificial, to prevent leachate leaking into soil layer and underground water source under the bottom, and leaking through the walls, which may cause pollution for surface water.

(4) Leachate Control

Leachate control system that consists of leachate collection facilities and leachate treatment facilities should be provided to control the leachate quality below the environmental standard.

Leachate collection facility is the effective system for semi-aerobic sanitary landfill since it can not only remove the leachate from waste layer, but also collect and exhaust the gas from waste layer, and supply the air into waste layer.

The leachate generated from a landfill site will vary in volume and composition depending on the age of the site and stages of biodegradation reached. Because of the changes in leachate composition with time, the leachate control systems should adapt to these changes. Leachate treatment is required to remove any contaminating components of the leachate and bring it to a standard whereby it can be discharged to the natural environment. Generally ranges of potentially polluting components are, for example, pH, concentration of organic material, ammonium and nitrate, suspended solids and metal content.

The leachate treatment facility will be operated for 10 – 30 years even after closing the landfill site because leachate is generated after the closure.

(5) Gas Control

Gas controlling system shall be equipped to prevent fire, explosion, and to protect the environment in the landfill ground and the surrounding areas.

Gas ventilation mechanism is very effective for not only collecting and exhausting the landfill gas such as CH₄, CO₂, and NH₃, but also natural air circulation within waste layer for keeping the landfill in semi-aerobic condition effectively.

(6) Environmental Monitoring

Environmental monitoring should be carried out during landfill operation period and post-closure period. Monitoring parameters include landfill gas, underground water and surface water, odor, and settlement.

Monitoring of underground water is useful to evaluate possible pollution risks. Monitoring of landfill gas is necessary to know the gas density and explosion risks, especially for site workers safety. Settlement monitoring is useful to watch the level of stability of waste in order to plan post-closure land use.

(7) Operation Method

The solid waste must be sufficiently compacted so as to stabilize the landfill foundation and prolong use period of landfill

The cell method and fill-up method using heavy equipment are recommended for isolating, bedding and compaction of dumped waste. A layer of cover soil should be systematically placed on waste dumped every day. However it might be very hard to carry out the daily soil cover in extremely cold season as the soil itself is frozen. At such days, alternative-covering methods with plastic films, foams or others can be considered.

(8) Site Work Environment

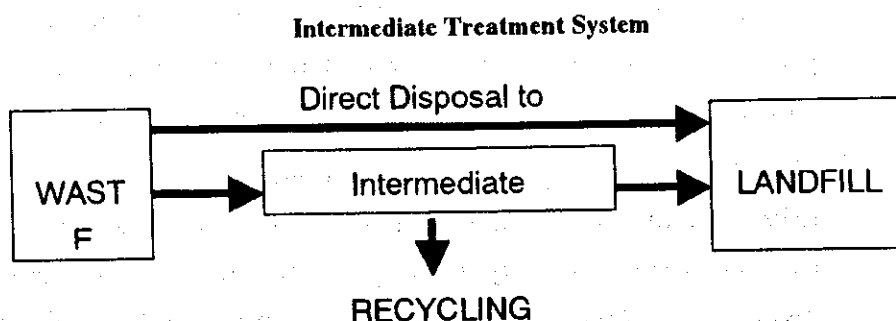
Sanitary and good working conditions, which are necessary for modern landfill site, have been taken into consideration in designing site facilities. Sanitary facilities and amenities such as toilets, showers, lockers, rest rooms will be provided. Daily cover soil will help to keep the site sanitary. Administration building will have office room and meeting room with air conditioning and telephone line. Cars will be provided for site inspection.

(9) Ultimate Land Use

The landfill site will be used for some other purposes such as green park or sports field to increase real estate values in future after closure of the landfill according to Astana City urban plan.

K.4.5 Disposal to the Sanitary Landfill with Intermediate Treatment

Intermediate waste treatment is to treat the waste before disposing of at the landfill for several purposes such as sanitizing the waste, stabilizing the toxic waste, reducing the waste volume, or recovering the reusable material or energy from the waste.



There is some intermediate treatment technologies in the world shown below.

- Incineration
- Incineration with heat recovery (including power generation)
- Incineration with residual ash melting
- Gasification with waste melting
- RDF (Refuse Derived Fuel)
- Composting
- Shredding & sorting

Countries in the world can be divided into several group of waste management policy depend on each regional, climatic, geological, economic and political condition.

For example in Japan, more than 70% of MSW is incinerated by municipalities. Also in Switzerland, Denmark, Luxembourg, around 70% is incinerated. These countries have small land with high population density and higher GDP.

On the other hand in the US, Canada, Spain, Norway, Great Britain, Germany, Italy, Portugal and Finland, 60 to 90% of MSW is directly disposed of at the Landfill. In Spain, Portugal and Finland, about 10 to 20% of MSW goes to the composting plant and in the US, Canada and Germany more than 10% of MSW is sorted out at the intermediate facility for material recycling.

In France, Belgium and Netherlands, about half of MSW goes to the Landfill, 25 to 40% is incinerated and remains are treated for composting or material recycling.

The turning point for the MSW management policy to introduce such above mentioned intermediate treatment facilities is that expecting benefit from intermediate treatment such as energy recovery or recyclable material sales exceed total waste management cost including construction and operation cost of such facilities. The following conditions are important incentives for the intermediate treatment.

- Difficulty to find enough place for the landfill site
- Increasing the cost of operating the landfill and transporting the waste
- Waste generation quantity will increase to meet the cost efficient capacity of the treatment facility
- Waste composition become suitable for energy recovery or material recycling
- Enough demand for recovered energy or recycled materials including compost
- Affordability of Astana City for operating the intermediate treatment facilities
- Establishment of the laws, regulations and guidelines related to the waste management

(1) Incineration

Incineration is to incinerate (burn) the waste using the calorific value the waste itself has in the furnace with high temperature, usually higher than 800°C, to sanitize and reduce the waste volume as residual ash.

The advantage of incineration system is to reduce the waste volume to 10 – 20% in volume base as incinerated ash. If the ash-melting furnace is equipped after incinerator, the waste volume can be minimized to 5 to 10% in volume base as slag. The slag may be recycled as low-grade construction materials. Also energy from MSW may be recovered by incinerating when MSW has enough low calorific value at least 6,000 kJ/kg and when generally the treatment capacity is over 100 ton/day for heat recovery or over 300 ton/day for power generating. High temperature incinerating can sanitize and stabilize MSW and some recyclable materials can be recovered from the pre-treatment stage of incineration.

On the other hand, incineration system cost too much for construction and operation. Unit initial cost of incineration plant is in range between US\$ 200 to 500 thousand per ton of MSW incinerating per day. Unit operation cost is usually US\$ 50 to 150 per ton of MSW incinerating. For example if it is

assumed that the all MSW will be incinerated at one incineration plant in 2020, the treatment capacity of the plant is calculated as follows.

$$\begin{aligned} \text{(Incineration capacity)} &= \text{(daily MSW generation quantity)} \\ &\quad \times \text{(Operation time efficiency)} \\ &\quad \times \text{(Operation conditioning efficiency)} \end{aligned}$$

- Daily MSW generation quantity: 640 tons in 2020 with assumption that bulk density of MSW is 0.2 ton/m³ at generation source.
- Operation time efficiency: 0.77 that is calculated with assumption that operation day is 280 days a year because generally 85 days of non-operating day are necessary for maintenance, inspection, start-up and shut-down.
- Operation conditioning efficiency: Usually 0.96 when incinerator is operated 24 hours a day.

Thus, the incinerator capacity in 2020 is estimated to be about 870 tons per day. It means that the initial construction cost of incinerator is multiplied to be US\$ 174 to 435 million and annual operation and maintenance cost without labor cost will be US\$ 11.6 to 35 million. More initial cost is required if ash melting or power generation equipment is added to the incinerator, though it is expected to reduce the operation and maintenance cost by using electric power generated in the incinerator or revenue from energy sales.

Gasification and waste melting system has been recently introduced in Japan, which at first the waste is converted into synthetic gas at 500 to 600 °C and then the solid residual is melted into the slag at high temperature of at least 1,200 °C using the calorific value that synthetic gas itself has. The initial and operation cost of this system is almost same or little less than the incineration with ash-melting system.

(2) RDF (Refuse Derived Fuel)

RDF can be made to recover the energy from combustible MSW and it is utilized for power generation or energy supply such as heating and cooling. The calorific value of RDF is almost equivalent to coal about 15,000 to 20,000 kJ/kg. The process of RDF manufacturing is shredding MSW, sorting out recyclable materials such as metal and unsuitable waste for RDF such as sand, dehydrating in the dryer, and solidifying to required shape that is usually with 15 to 50 mm of diameter and 30 to 150 mm of length.

The advantage of RDF is easy to storage and transport because of pasteurized for sanitation with chemical additives like lime, odorless, strongly solidified to less volume than MSW. Also the quality of RDF is much better than MSW for smooth incinerating because it is very homogenized. Therefore, RDF system is very useful if the demand for RDF, which means demand for energy, exists.

On the other hand, the disadvantage of RDF system is that RDF is still the waste which means that suitable environmental control facilities should be equipped at RDF incineration facilities as well as the waste incinerator. Also construction and operation cost of RDF manufacturing plant is too high. Due to the mechanical difference between RDF plant and incinerator, it is difficult for RDF system to expect the scale merit to initial cost reduction. It means initial cost of RDF plant increases in proportion to increase of treatment capacity. Initial cost of RDF plant is in range between US\$ 200 to 400 thousand per ton of MSW processing to RDF per day. For example if it is assumed that the all MSW will be treated to RDF at one RDF plant in 2020, the treatment capacity of the plant is calculated as well as incinerator is as follows:

$$\begin{aligned} (\text{RDF manufacturing capacity}) &= (\text{daily MSW generation quantity}) \\ &\quad \times (\text{Operation time efficiency}) \\ &\quad \times (\text{monthly variation coefficient}) \end{aligned}$$

- Daily MSW generation quantity: 640 tons in 2020 with assumption that bulk density of MSW is 0.2 ton/m³ at generation source.
- Operation time efficiency: 0.77 that is calculated with assumption that operation day is 282 days a year because of 30 days of non-operating day for maintenance and inspection, and operating 16hours a day and 6 days a week
- Monthly variation coefficient: 1.15, which is usual coefficient in Japan.

Thus, RDF manufacturing capacity in 2020 is estimated to be about 1,000 tons per day. It means that the initial construction cost of RDF Plant is multiplied to be US\$ 200 to 400 million. This initial cost doesn't include the cost of construction of RDF utilizing facility.

However, a potential energy expected to recover from RDF is estimated below:

$$\begin{aligned} (\text{Electric value recovered}) &= (\text{Low calorific value of RDF}) \\ &\quad \times (\text{Annual generation quantity of RDF}) \end{aligned}$$

x (Boiler efficiency) x (turbine efficiency)
x (Electric conversion factor)

Design assumption

- Low calorific value of RDF: 16,800 kJ/kg (=4,000 kcal/kg)
- Annual generation quantity of MSW: 233,600 tons (=1,168,634 m³)
- Annual generation quantity of RDF: 93,440 tons (= 40% of MSW)
- Boiler efficiency: 80%
- Turbine efficiency: 30%
- Electric conversion factor: 3.612 kJ/kW (= 860 kcal/kW)

The calculation result simply says that about 12MWh of electric power may be generated at the RDF incineration plant.

Needless to say, although this calculation is an extreme example, RDF system in small scale for supplying heat energy to a small specified regional area can be a considerable idea in future in Astana City.

(3) Composting

Composting, usually aerobic composting is the most commonly used biological process for the organic portion of MSW to a stable humus-like material known as compost. Composting process generally consists of three steps, first is processing of MSW, second is aerobic decomposition of the organic fraction of the MSW, the third is product preparation and marketing. For planning composting system, there are many factors can be considered such as particle size, carbon-to-nitrogen ratio (C/N ratio), blending and seeding, moisture content, temperature, mixing and others.

Advantage of composting is the revenue from compost sales, which means that most crucial factor is that strong and stable market demand exists near the plant for successful composting. Also by composting, the amount of the MSW goes to the landfill site can be reduced.

Disadvantage of composting is also high cost for constructing the composting facility if mechanical composting method is introduced. Even if non-mechanical (manual) composting method is introduced wider area is required than mechanical method and suitable environmental control facilities are required to keep the work environment for labors in good sanitary condition from odors.

The reducing the treatment load at preprocessing stage, source separation that sorted out organic matters from MSW is highly recommended. However it is very difficult for residents to separate such organic matter when they

discharge the waste. In history, Astana City used to ask residents to separate the kitchen waste from other MSW, but it was stopped because of sanitary trouble by rats.

According to such condition, composting from MSW by municipality is not feasible option for the waste management system in Astana.

K.4.6 Summary of Proposed MSW Disposal Plan

Considering the economy of Astana City and the current waste management system carried out well, it is not desirable to introduce the intermediate treatment system for MSW which covers most of all its generation quantity in early years because of huge cost of the plant construction and operation. Therefore, the highest priority is to improve the waste management system in order to be perfectly controlled by concerned organizations in all waste streams using direct collection system and sanitary landfill at least up to 2010.

The Spanish proposal appears to satisfy this short-term development needs.

Continuously it is proposed to construct the following sanitary landfill (Landfill-2) near the existing one in Eco Forest zone because the surface of closed landfill can be covered by green in accordance with SNiP. Two alternatives are proposed for Landfill-2, one is in same zone as the existing landfill and the other is in the opposite zone over Astana-Pavlodar Highway. The location shall be determined by further study of geological condition and it must keep 500 m of buffer distance from roads. As it is previously mentioned, Landfill-2 will be divided into two phases, which the phase 1 covers until 2020 and the phase 2 covers after 2021.

After establishment of direct disposal system, it is recommend for Astana City to study the possibility of introducing intermediate treatment system from the view of resource utilization. Therefore, the period from 2010 to 2020 will be a trial period for introducing a pilot intermediate treatment facility to assess the possibility for further expansion in view of operation and affordable costs. Proposed intermediate treatment method will be RDF system or incineration with heat recovery because Astana-City is very energy consumed city. Maximum capacity of the pilot plant may be 50 tons per day, or equal to about 7% of total MSW in 2020. The facility will be built in the Central Industrial District northeast from Astana Railway Station and its construction cost is estimated to be US\$ 10.5 million.

Based on the result of this pilot scale trial, an expansion of the intermediate treatment capacity will be considered till 2030.

For collecting and transporting MSW from South-Astana Waste Collection Area, it is proposed to construct a transfer station with the capacity of 2,000 m³ (400 tons) per day and its cost is estimated to be US\$ 2.6 million.

There is no particular solid waste treatment or disposal facility plan proposed for the New City Center. Considering the characteristic of the waste generated from the New City Center with high composition ratio of waste paper or electrical devices such as computers, a recycling center which temporarily stores such marketable and recyclable materials separately, will be provided within the Business Area. Construction cost of a recycling center for New City Center is about US\$ 0.1 million.

This master plan does not positively propose a material recycling facility which separates and recover recyclable material such as glass bottles, metal cans, plastics and so on because in principle such recycling activity must be led by market and private base as a business activity. Municipality should have the responsibility only for promoting such recycling activity.

K.5 ISW Disposal Plan

In principle, industrial solid waste must be handled, treated and disposed by industries themselves with the concept of "Polluter Pay Principle (PPP)" or "Extended Producer Responsibility (EPR)".

Due to the difficulty to construct a private landfill site in Astana, however, the municipal landfill can accept non-hazardous waste such as construction waste and some of hazardous waste permitted by SNiP with appropriate disposal fee collection.

An important role of municipality or state government is to establish the ISW management rules such as manifest system that trace ISW discharge stream and treatment standard for hazardous ISW.

Possibility of municipality participated treatment facility for hazardous ISW will be only studied in case such facility will be a strong incentive to invite industries to set up their plant in Astana City, or in case the present environment pollution caused by hazardous ISW from existing industries is too serious but they have no money and no technology for constructing a treatment facility.

Large amount of coal ash generated from TETs-1 and TETs-2 will be discharged into the ash discharge pond as like now and before, though utilizing such coal ash will be also tried in future.

Wastewater sludge from the wastewater treatment facilities will be dehydrated and recycled as organic fertilizer, or disposed of at the municipal landfill as non-hazardous ISW.

K.6 HSW Disposal Plan

There is no hospital management guideline in Astana City that might cause serious environmental pollution and sanitary problem. As the quantity HSW is small compared with MSW, non-hazardous HSW can be disposed of at the landfill mixed together with MSW. Hazardous HSW, however, must be controlled strictly to prevent any infectious waste problem. There are some disposal methods for hazardous HSW treatment and incineration is the most commonly used in the world.

In principle, the responsibility of such hazardous HSW disposal lies with each medical institution. There are two alternatives can be considered; one is that each institution has its own treatment facility individually in its area and the other is a centralized intensive treatment system. A centralized treatment system may be considered if individual treatment turns out to be too costly.

In case of the centralized treatment system, the capacity of incinerator in 2010 is calculated as follows:

(Incineration capacity)

= (Daily Hazardous HSW generation quantity) x (operation time efficiency)

- Daily HHW generation quantity is 2.4 tons in 2010
- Operation time efficiency: 0.77 that is calculated with assumption that operation days is 282 days a year because of 30 days of non-operating days for maintenance and inspection, and operating 8 hours a day and 6 days a week.

The capacity of Hazardous HSW incinerator is estimated to be about 3 tons per 8 hours, which means capacity per hour is about 375 kg/hr and it will be continue to be in operation by extending operation time for increasing waste.

Construction cost of centralized hazardous HSW incinerator is approximately US\$ 1.6 million.

As the life of such a small scale incinerator is generally 15 years, it will be replaced in the period from 2010 to 2020 so that its capacity will satisfy increased hazardous HSW quantity in 2030. The capacity of new one is estimated to be 5 tons per day and it costs US\$ 2.6 million.

K.7 Future Waste Flow in Astana

In conclusion, proposed waste flow of MSW, ISW and HSW will be formulated as shown in Figure K.7.1 and proposed waste management plan is indicated in Figure K.7.2.

K.8 Implementation Schedule

Implementation Schedule of proposed waste disposal plan is shown below.

Implementation Schedule for Solid Waste Disposal Infrastructure

Proposed Infrastructure Plan	2000	2010	2020	2030	Remarks
1 Improvement of Existing Landfill Feasibility study Basic and detail design Procurement and Improvement Operation					Proposed by Spanish Company
2 Sanitary Landfill-1 Feasibility study Basic and detail design Procurement and construction Operation					Proposed by Spanish Company Next to Existing one Total area: 15 ha Depth: 30 m
3 Sanitary Landfill-2 Feasibility study Basic and detail design Procurement and construction Expanding construction Operation					Total area: 64.3 ha Height: 15 m
4 Waste Collection vehicles procurement					
5 Hazardous HSW Incinerator Feasibility study Basic and detail design Procurement and construction Replacement construction Operation					Incinerator-1: 3t/d Incinerator-2: 5t/d
6 Pilot Scale Intermediate Treatment Plant Detail survey and master plan Feasibility study Basic and detail design Procurement and construction Operation					Incinerator or RDF Capacity: 50 t/d
7 Transfer Station Detail survey and master plan Feasibility study Basic and detail design Procurement and construction Operation					For South-Astana Waste Collection Area
8 Recycling Center Basic and detail design Procurement and construction Operation					Recyclables stock yard for New City Center
9 Large Scale Intermediate Treatment Plant Detail survey and master plan Feasibility study Basic and detail design Procurement and construction					Only in case it is feasible