The Socialist Republic of Vietnam (SNV)

The Preparatory Survey on Wastewater Management and Solid Waste Management for Da Nang City The Socialist Republic of Viet Nam

Final Report

November 2014

Japan International Cooperation Agency (JICA)

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OS
CR(10)
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Abbreviations

AMPDC	Adjustment of Master Plan of Da Nang City to 2030 and Vision 2050
BOT	Build Operate and Transfer
CAPEX	Capital expenditures
DONRE	Department of Natural Resources and Environment
DPI	Department of Planning and Investment (of Da Nang)
DPC	Da Nang People's Committee
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EPC	Engineering, Procurement, Construction
EVN	Electricity of Vietnam
FIRR	Financial Internal Rate of Return
JCM	Joint Crediting Mechanism
JPY	Japanese Yen
MBT	Mechanical Biological Treatment
MOE	Ministry of the Environment (of Japan)
MONRE	Ministry of Natural Resources and Environment (of Vietnam)
MPI	Ministry of Planning and Investment (of Vietnam)
O&M	Operation and Maintenance
OPEX	Operating Expense
PPP	Public-Private Partnership
GRDP	Gross Regional Domestic Product
SPC	Special Purpose Company
URENCO	Urban Environment Company (of Da Nang)
USD	United States Dollars
VND	Vietnamese Dong

Note on exchange rate

In this report, the exchange rate applied is: 100 JPY = 1 USD = 20,000 VND

Preface

This survey was initiated based on the contract signed between JICA and the Survey Team on 15 June 2012 with the objective to prepare for a PPP project on waste and wastewater treatment in Da Nang City. This objective was based on the Minutes of meetings on the mission for the preparatory survey on wastewater management and solid waste management for Da Nang city in the Socialist Republic of Vietnam which was signed between JICA and the People's Committee of Da Nang City on 28 December 2011.

However, as JICA and the People's Committee of Da Nang City agreed to exclude the wastewater treatment from the scope of the survey on 19 December 2012, the report on wastewater that were compiled before December 2012 could not be officially approved by the Da Nang City and thus was annexed to this report.

1 Da Nang City Profile

1.1 Natural Conditions

1.1.1 Geography

Da Nang is one of the major port cities in Vietnam (in addition to Ho Chi Minh city and Hai Phong), and the biggest one on the South Central Coast of Vietnam, on the coast of the South China Sea at the mouth of the Hàn River. It is the 4th biggest economic centre in Viet Nam after Hanoi, Ho Chi Minh, and Hai Phong. The city is 759 km south of Hanoi, and 960 km north of Ho Chi Minh City.

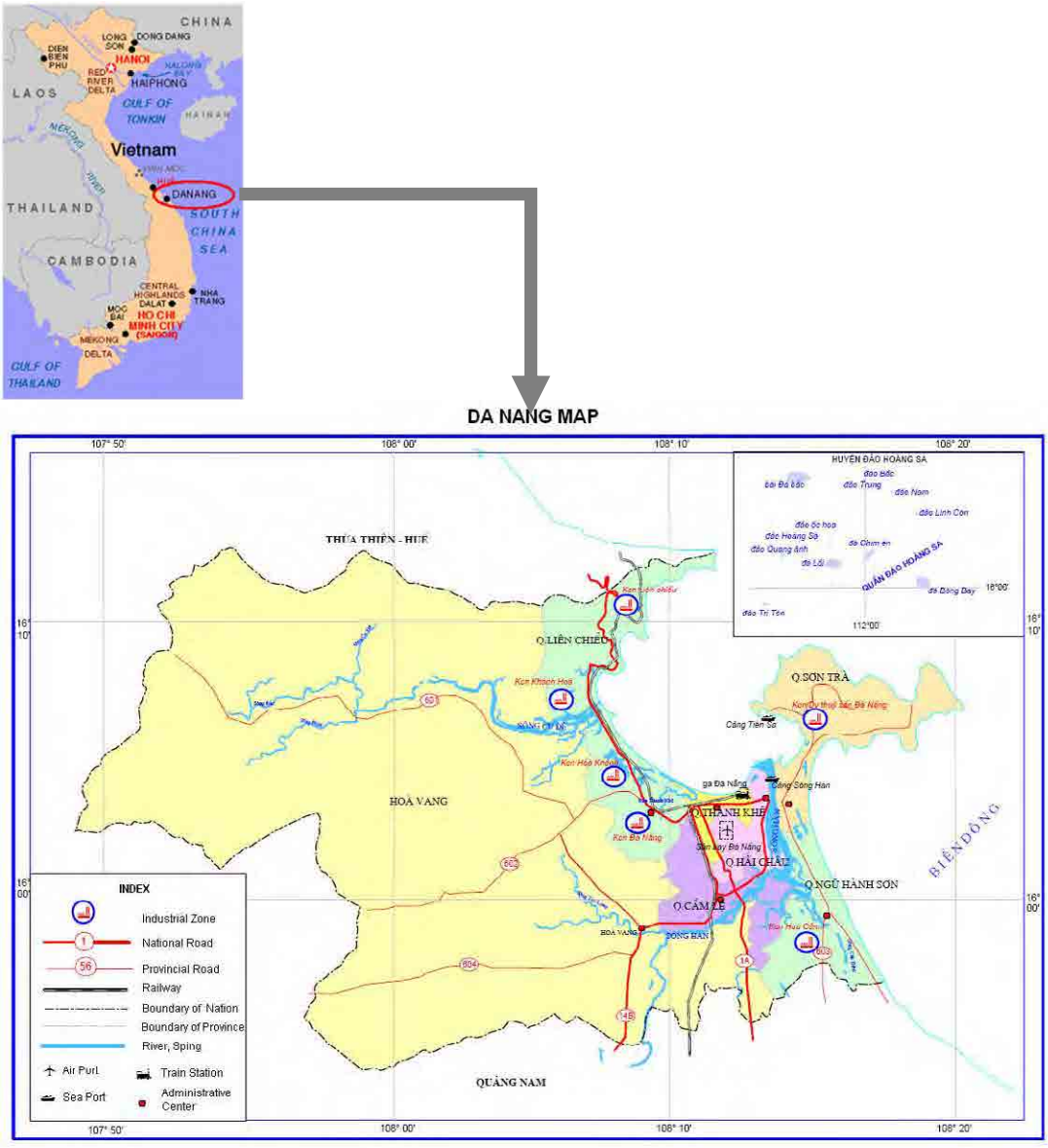


Figure 1-1: Geographical Location of Da Nang

Source: Made by the Study Team from the base map of Da Nang City

1.1.2 Geology and Topography

Geologically, Da Nang is situated at the edge of a Paleozoic fold belt known as the Truong Son Orogenic Zone, whose main deformation occurred during the early Carboniferous period. Da Nang's topography is dominated by the steep Annamite mountain range to the north and northwest, featuring

peaks ranging from 700 to 1,500 meters in height, and low-lying coastal plains with some salting to the south and east, with several white sand beaches along the coast.

1.1.3 Climate

Da Nang has a tropical monsoon climate with two seasons: a typhoon & wet season lasting from September through March and a dry season lasting from April through August. Temperatures are typically high, with an annual average of 25.2 °C in 2011. Temperatures are highest between June and August, and lowest between December and February. The annual average for humidity is 82.3% in 2011, with highs between October and February and lows between May and July.

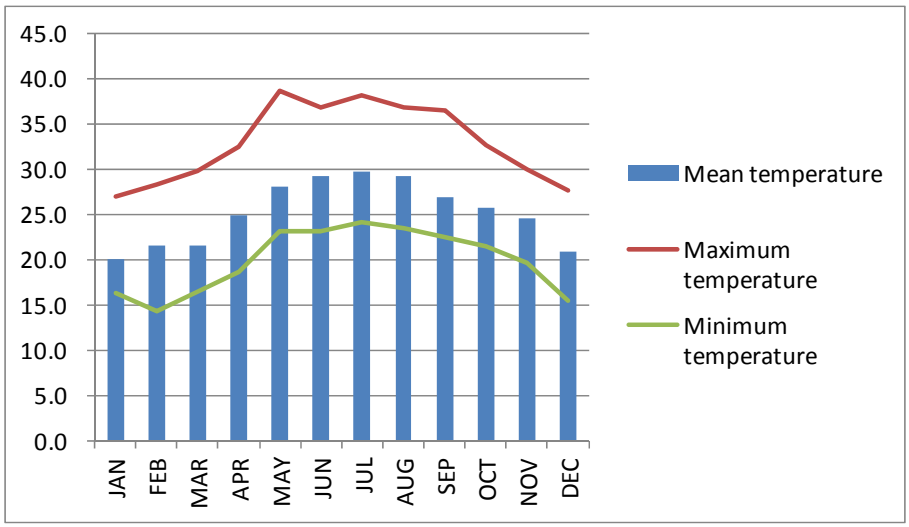


Figure 1-2: Monthly Temperature in Da Nang (2011)

Source: Da Nang Statistical Yearbook (2012)

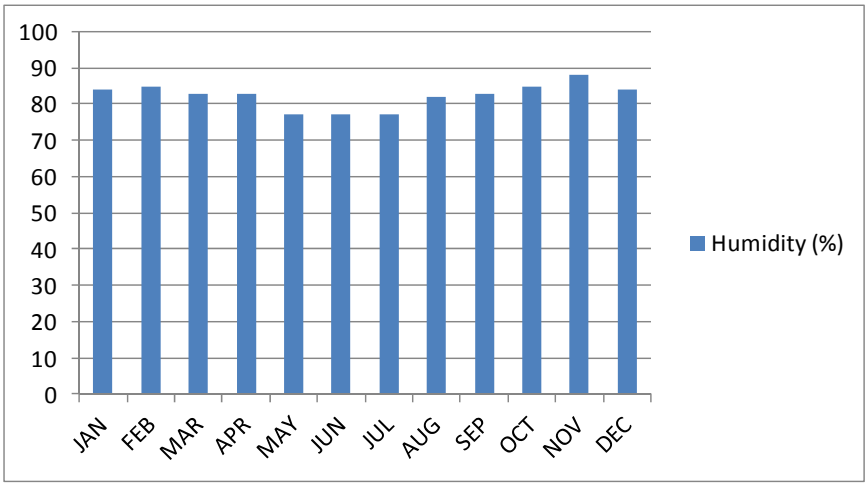


Figure 1-3: Monthly Humidity in Da Nang (2010)

Source: Da Nang Statistical Yearbook (2011)

Da Nang totally receives 3,716 mm of rainfall in 2012. Rainfall is typically highest between September and November (ranging from 810 to 1,241mm) and lowest between February and May (ranging from 0 to 36 mm). Da Nang receives an average sunshine hours of 2,013 annually during 2002-2011, with highs between 240 and 250 hours per month in May and July and lows between 80 and 100 hours per month in November and December.

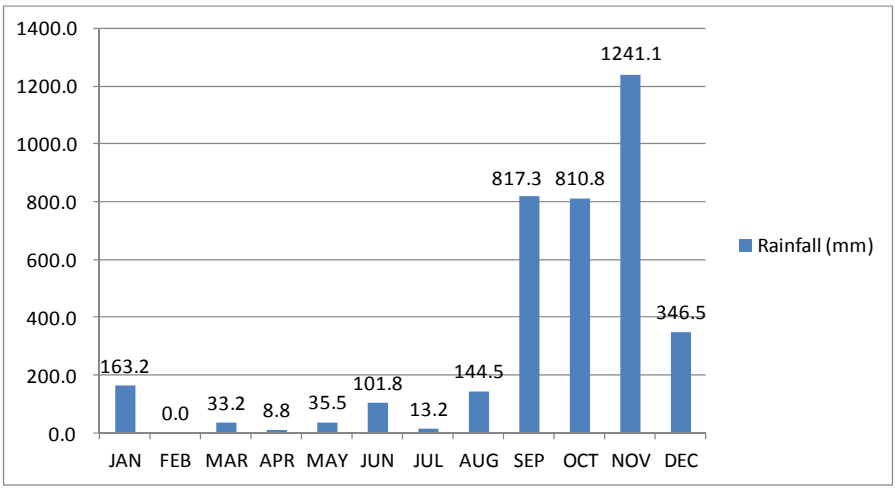


Figure 1-4: Monthly Rainfall in Da Nang (2011)

Source: Da Nang Statistical Yearbook (2012)

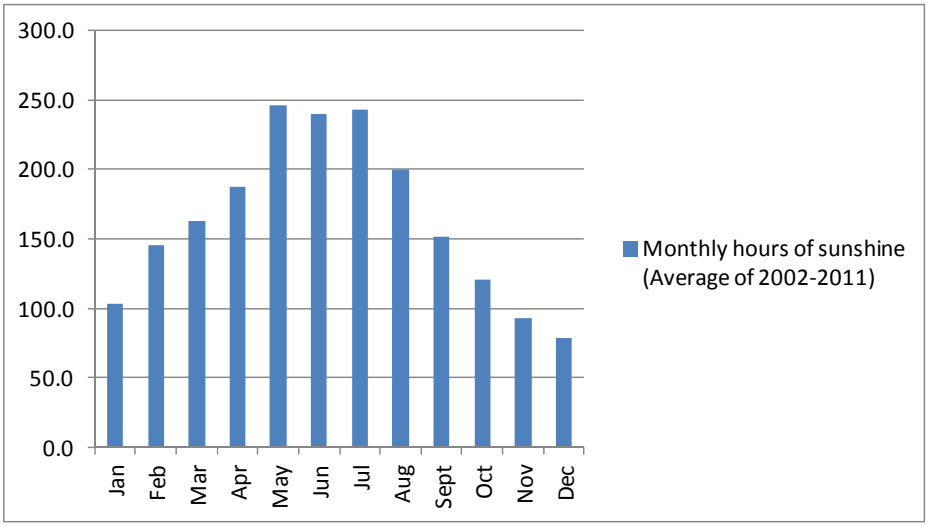


Figure 1-5: Monthly Hours of Sunshine in Da Nang (Average of 2002-2011)

Source: Da Nang Statistical Yearbook (2012)

1.2 Socio-Economic Conditions

1.2.1 Demography

According to the 2009 census, Da Nang is the fifth most populated city in Vietnam with a population of 887.4 thousand. The average annual population growth between the census of 1999 and 2009 is 2.6%, which is the 6th highest in the country behind Bình Dương (with 7.3%), Hồ Chí Minh City (3.5%), Kon Tum (3.1%), Bình Phước (2.9%), and Gia Lai (2.7%). The city has the highest urbanization ratio among provinces and municipalities in Vietnam, containing only 11 rural communes, the fewest of any province-level unit in Vietnam. As of 2009, 86.9% of Da Nang's population lived

in urban areas; average annual urban population growth was 3.5%.

Da Nang's crude birth rate was recorded at 18.6 live births per 1000 persons; the crude death rate was measured at 6.7 per 1000 persons. Life expectancy at birth was estimated at 77.4 years for women and 72.4 years for men, or 74.8 years overall. The infant mortality rate was measured at 11.0 infant deaths per 1000 live births, less than two points above the nation's average for urban areas. In the same census, the city's immigration and emigration rates were measured at 10.06% and 2.4%, respectively, for a net migration rate of 7.7%. Da Nang's population is estimated to reach one million inhabitants by 2014. The figure below compares the population pyramids between the whole country of Viet Nam and Da Nang City.

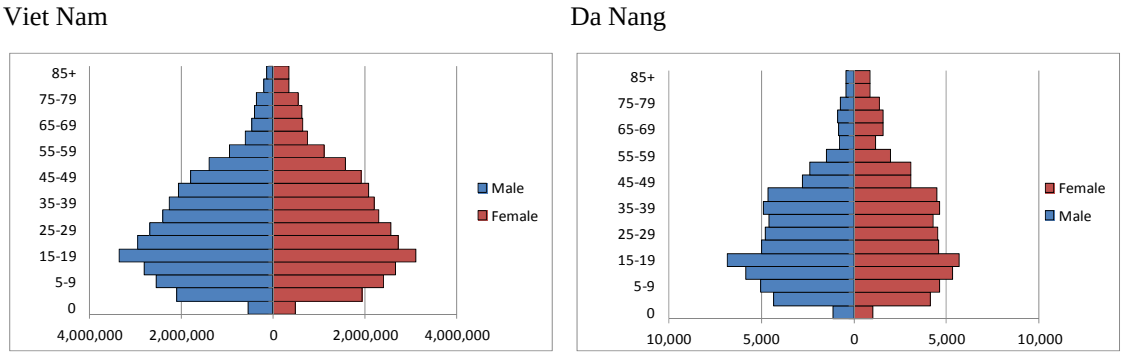


Figure 1-6: Population Pyramid (Viet Nam and Da Nang) in 2009

Source: Da Nang Statistical Yearbook (2011)

The city has the highest urbanization ratio among provinces and municipalities in Vietnam, containing only 11 rural communes, the fewest of any province-level unit in Vietnam. As of 2009, 86.9% of Da Nang's population lived in urban areas; average annual urban population growth was 3.5%.

1.2.2 Labor Force and Employment

Da Nang City currently holds approximately 463 thousand labor force in 2010, of which around 440 thousand are under stable employment. Unemployment rate is 4.86% in 2010. The figure below shows the composition of labor force by education level.

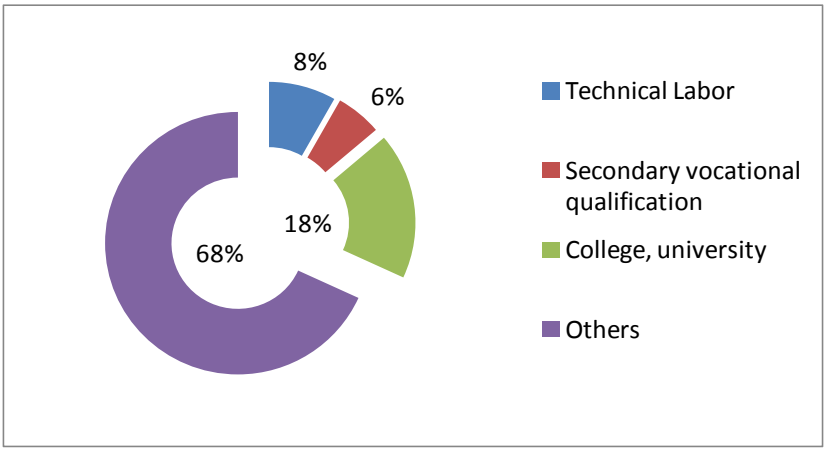


Figure 1-7: Labor Force by Education Level (2010)

Source: Da Nang Statistical Yearbook (2011)

In terms of the types of economic activities, approximately 20% of the total employment in Da Nang is absorbed by manufacturing and retail/wholesale service industries respectively.

Table 1-1: Employment by type of economic activities (2010)

Type of Economic Activities	2010	
	Number (thousand)	%
Agriculture, forestry, fishing	38.50	8.91%
Mining	0.70	0.16%
Manufacturing	89.20	20.65%
Electricity and gas supply	9.20	2.13%
Water supply, waste and wastewater treatment	1.55	0.36%
Construction	47.40	10.97%
Retail and wholesale (inc. vehicles repair)	83.50	19.33%
Transport	27.50	6.37%
Hotel and restaurant	42.00	9.72%
Communication	8.20	1.90%
Financial, banking and insurance services	5.80	1.34%
Real estate and lease/rental services	3.80	0.88%
Scientific/technical services	2.10	0.49%
Public administration,defence,and social security	5.00	1.16%
Party activities and membership organizations	14.70	3.40%
Education and training	23.55	5.45%
Health and social works	7.50	1.74%
Recreational, culture and sporting activities	5.80	1.34%
Other services	16.00	3.70%
Total	432.00	-

Source: Da Nang Statistical Yearbook (2011)

1.2.3 Regional Gross Domestic Product (RGDP)

RGDP in Da Nang is 28,902 billion VND (Vietnamese dongs) at current prices (approx. 60.2 billion US dollars) in 2010. Per capita RGDP in 2010 is 35.87 million VND or about 1,700 US dollars. About 54% of RGDP in Da Nang comes from service industry, followed by manufacturing and construction (42%). The primary industry (Agriculture, forestry and fishing) only occupies about 4% of RGDP in Da Nang.

Table 1-2: RGDP by types of economic activities in Da Nang (2011)

Type of Economic Activities	**Million dongs**	**%**
Agriculture, forestry and fishery	**1,084,748**	**3.75**
Agriculture	383,128	1.33
Forestry	46,902	0.16
Fishery	654,718	2.27
Industry and Construction	**12,142,769**	**42.01**
Mining and Quarrying	123,015	0.43
Manufacturing	6,338,404	21.93
Electricity, Gas Supply	2,159,210	7.47
Construction	3,522,140	12.19
Services	**15,674,463**	**54.21**
Wholesale, retail and vehicles repair	3,467,463	12.00
Hotels and restaurants	1,220,702	4.22
Transport, storage and communication	4,622,118	15.99
Financial service	2,060,535	7.13
Scientific and technical services	34,499	0.12
Real estate, leasing and rental services	1,149,906	3.98

Type of Economic Activities	Million dongs	%
Public administration, defense and social security	466,250	1.61
Education and training	987,345	3.40
Health and social works	414,669	1.43
Culture and sporting activities	205,845	0.71
Party and membership organizations	41,895	0.14
Social and personal services	215,217	0.74
Private households with employed persons	25,569	0.09
Import duty	761,131	2.00
Total	**28,901,980**	**-**

Source: Da Nang Statistical Yearbook (2012)

1.2.4 Investment

As the national economic center of the central regional and the Western Highlands in Viet Nam, the investment in Da Nang has been steadily increasing with the average annual growth of 10% during 2007-2010. The sectors the investment has been made the most include manufacturing, hotels/restaurants, and transport/warehouse/communications.

Table 1-3: Investment in Da Nang by Sector at constant 1994 prices (2007-2010)

Unit: million VND

Sectors	2007	2008	2009	2010
Agriculture, forestry and fishery	136,861	36,470	22,368	20,328
Agriculture and forestry	132,994	29,519	22,079	19,941
Fishery	3,867	6,951	289	387
Industry and construction	**2,551,222**	**2,511,778**	**2,861,598**	**2,924,883**
Mining and Quarrying	19,807	12,332	22,858	30,567
Manufacturing	1,262,529	1,168,562	1,567,461	1,680,373
Electricity, water supply	505,627	603,822	620,264	690,126
Construction	763,260	727,062	651,014	523,816
Services	**3,770,834**	**5,139,287**	**5,338,588**	**5,521,219**
Wholesale and retail trade, motor cycles	539,671	591,476	766,238	525,902
Hotels and restaurants	307,480	802,779	1,227,006	1,412,077
Transport, warehouse and communications	627,080	1,183,374	1,179,779	1,189,390
Financial credit	70,871	249,012	189,050	948,901
Scientific activities and technology	37,901	291,135	74,851	47,937
Real estate, renting business activities	312,597	1,420,207	1,273,413	546,397
Public adminsitration and defense; compulsory social security	188,765	72,775	216,944	336,201
Education and training	153,296	113,263	191,430	250,833
Health and social work	234,452	66,286	55,488	53,527
Recreational, culture and sporting activities	166,488	57,452	35,585	155,120
Association, unions, cooperatives	45,929	37,303	34,729	43,884
Social and personal service activities	1,086,303	254,228	94,075	11,050
Total	**6,458,918**	**7,687,535**	**8,222,556**	**8,466,430**

Source: Da Nang Statistical Yearbook (2011)

1.2.5 Agriculture, Forestry and Fishery

In the primary industry, sea fishery is the biggest producer of gross output, followed by agriculture (crop production and animal husbandry) in Da Nang. The planted area of annual crops is mainly occupied by paddy while the starchy plants, food and industrial crops are planted for the remaining area.

Table 1-4: Gross output of agriculture, forestry and fishery at constant 1994 prices

Unit: million VND

Types	2005	2008	2009	2010
Agriculture	**204,975**	**183,508**	**192,522**	**194,363**
Cultivation	123,153	120,644	118,792	115,776
Animal husbandry	79,157	60,151	71,105	75,940
Services	2,665	2,713	2,625	2,647
Forestry	**24,934**	**21,258**	**21,745**	**22,126**
Afforestation and forest feeding	3,988	2,716	2,895	3,104
Exploitation of forest products	19,346	17,577	17,760	17,917
Services	1,600	965	1,090	1,105
Fishery	**438,278**	**400,974**	**351,558**	**359,025**
Aquaculture	42,478	26,744	25,186	19,137
Marine caught	381,825	363,834	322,886	336,808
Inland water fishery caught	701	628	854	640
Services	13,274	9,768	2,632	2,440
Total	**668,187**	**605,740**	**565,825**	**575,514**

Source: Da Nang Statistical Yearbook (2011)

1.2.6 Industry

Industry sector in Da Nang earned around 12.2 trillion VND of gross output in 2010 at constant 1994 prices. About 42% comes from the state economic sector while 37% from non-state economic activities. The remaining 31% is earned by foreign investment activities. The table below shows the gross output by types of industry during 2005-2010 in Da Nang at constant 1994 prices.

Table 1-5: Gross output of industry by types at constant 1994 prices

Unit: million VND

Type of Industry	2005	2008	2009	2010
Mining	**132,141**	**82,331**	**93,210**	**96,961**
Manufacturing	**7,672,838**	**9,294,616**	**9,745,742**	**11,037,840**
Food & beverage	1,519,685	1,786,685	1,859,889	2,410,626
Cigarettes	206,799	57,940	69,640	88,340
Textile products	334,066	277,006	398,137	458,164
Sewing products	583,360	1,183,986	920,124	1,152,192
Leather products, shoes and sandal	277,027	178,792	118,522	167,080
Wood products	188,026	164,521	157,111	235,264
Paper, paper products	139,756	171,792	232,152	185,871
Publishing, printing	51,314	86,464	73,981	87,392
Chemical products	227,032	184,408	147,284	275,690
Rubber	750,097	984,036	1,005,771	1,115,311
Non-metallic mineral products	994,239	1,768,147	2,051,843	1,939,182
Iron and steel	301,246	367,480	785,302	732,810
Metallic products	487,685	719,659	796,084	721,622
Electric, computer	1,411	2,958	116,837	170,664
Electric equipment	341,429	282,641	227,682	330,759
Machinery, equipment	145,049	138,054	30,682	84,228
Motor vehicles	63,801	30,396	87,990	220,459
Other means of transport	550,884	171,404	75,454	47,972
Beds, wardrobes, tables, chairs, etc.	509,797	738,247	591,257	614,134
Electricity supply	**214,981**	**860,765**	**981,702**	**1,053,216**
Water supply	**30,454**	**55,683**	**50,819**	**66,217**
Total	**8,050,414**	**10,293,359**	**10,871,473**	**12,254,234**

Source: Da Nang Statistical Yearbook (2011)

The types of industry that produces more than 1 trillion VND of gross output are food & beverage, sewing products (garments), rubber products, and non-metallic mineral products.

1.2.7 Trade (Export and Import)

Da Nang recorded its export turnover of 634,534 thousand USD while its import turnover was 751,318 thousand USD in 2010. 40 to 50% of export and import turnovers accounted for foreign invested economic activities.

Table 1-6: Export and Import Turnover in Da Nang (2008-2010)

Unit: USD1000

Export and Import	2008	2009	2010
Export turnover in area	**575,287**	**509,125**	**634,454**
Central	204,687	134,839	143,860
Local	200,656	178,087	152,024
Foreign invested	169,944	196,199	338,570
Import turnover	**638,253**	**651,758**	**751,318**
Central	282,164	212,289	229,729
Local	184,653	277,641	223,372
Foreign invested	171,436	161,828	298,217

Source: Da Nang Statistical Yearbook (2011)

The major export items are fishing and sewing products while the major import items are machinery/equipment, textile materials and iron/steel.

Table 1-7: Major Export Items in Da Nang (2008-2010)

Unit: USD1000

Export goods	2008	2009	2010
Coffee	56,128	22,818	317
Fishery products	83,728	81,737	100,048
Rice	1,020	16,012	8,997
Agricultural products	2,290	11,427	531
Sewing products	145,644	125,662	193,767
Footwear	16,563	8,023	9,138
Artisanal goods	51,038	46,860	55,161
Other goods	218,876	196,586	190,942

Source: Da Nang Statistical Yearbook (2011)

Table 1-8: Major Import Items in Da Nang (2008-2010)

Unit: USD1000

Import goods	2008	2009	2010
Wheat flour	6,457	8,641	12,668
Chemical products	61,750	47,524	40,928
Drug	29,985	48,472	48,497
Chemical fertilizers	62,875	44,032	18,589
Plastic	21,577	54,116	41,185
Textile material	73,537	89,518	114,003
Footwear material	5,955	1,208	2,822
Iron and steel	70,163	158,992	38,140
Electrocnic goods	11,892	8,991	2,718
Motorbike	511	830	2,360
Machinery & equipment	180,468	21,232	403,039

Source: Da Nang Statistical Yearbook (2011)

1.3 City Administration

The People's Committee of Da Nang has the highest authority of city administration on behalf of the People's Council of Da Nang under which there are various departments and agencies in charge of implementing sector-by-sector policies and programs in the city. The key roles of city departments and agencies in Da Nang are summarized in the table below.

Table 1-9: Key Roles and Duties of City Departments and Agencies

Department/ Agency	Roles and Duties
Department of Planning and Investment	▪ Research and prepare short and medium term plans, and submit them to the People's Committee; select preferential programs and/or projects and construction works for socio-economic development, and major balances regarding finance, construction budgets using, and sponsorship and foreign cooperation funds. ▪ Coordinate with the Department of Finance and Pricing to prepare estimated expenditure for the City budget and submit it to the People's Committee for approval. ▪ Oversee business activities of economic sectors in the city to correlate them with the general socio-economic development plans of the City. ▪ Supervise programs and/or projects implemented in the City. ▪ Guide concerned offices in the city to prepare plans, programs and/or projects involving the socio-economic development of the city; instruct in the compliance with State laws regarding foreign investment activities; act as the official authority to receive investment projects prepared and submitted by domestic and foreign investors who want to invest in the city; consult with the People's Committee for the granting of investment license for projects under the authorization of the government. ▪ Supervise and expedite the preparation of the departments and districts in the city regarding plans, development programs and projects; prepare policies and submit appropriate solutions to the People's Committee to fulfill the planned targets of the city successfully; and be responsible for the management of certain plans assigned by the People's Committee. ▪ Study and establish economic management policies, and make proposals to the People's Committee to identify how to apply these policies appropriately in accordance with general regulations and the specific characteristics of the City. ▪ Coordinate with relevant departments, under the assignment of the People's Committee, to consider and approve economic-technical norms, verify domestic and foreign investment projects, and verify bidding documents and enterprise establishment; be responsible for management of the use of ODA and other sponsorship funds. ▪ Manage and grant business registration licenses in the City according to current regulations, consider and submit preferential certificates of investment to the People's Committee for approval. ▪ Prepare and submit quarterly, half-yearly and annual reports to the People's Committee and the Ministry of Investment and Planning regarding the implementation of the City's plans and foreign enterprise activities; submit proposals regarding the professional development of cadres in the city who are in charge of planning and investment. ▪ Verify and consult with the People's Committee or the Ministry of Investment and Planning for the granting of foreign investment licenses, and managing foreign capital enterprises and representative offices or branches. ▪ Carry out State management in the field of foreign affairs (FDI and ODA) in Da Nang City. ▪ Call for investment projects ▪ Grant business registration certificates to private and State enterprises.
Department of Finance	▪ Assist the City People's Committee in organizing the implementation of, and providing guidance to agencies belonging to the city and other sub-level agencies, compliance with the laws and carrying out of policies and regulations of the State regarding finance, budget, accounting and auditing in the locality. ▪ Prepare documents regulating the collection of fees, charges and additional payments; loan and debt repayment; and the mobilization of contributions of individuals and

Department/ Agency	Roles and Duties
	organizations of the locality, and submit these documents to relevant bodies for consideration and promulgation. Subsequently, the Department of Finance will provide guidance and organize the implementation of the documents as specified by the law. ▪ Provide guidance to city State agencies and non-production units, and other sub-level agencies to prepare the annual estimated State budget expenditure according to the regulations of the government and the guidance of the Financial Ministry; evaluate and collect these estimates to prepare the estimated local budget expenditure and the supplementary amounts of district budgets, and stipulate the supplementary amounts of the budgets of communes and wards. When necessary, the Department of Finance will prepare adjusted estimated local budget expenditure and submit it to the City People's Committee for consideration and to the City People's Council for decision. It is also responsible to suggest necessary methods for completing the tasks of budget collection and expenditure, practicing thrift, and preventing speculation and to submit these proposals to the relevant authorities for decision. ▪ Prepare plans for allocating the estimated city budget expenditure and submit them to the City People's Committee for consideration and to the City People's Council for decision, and manage the approved budget of the city. Cooperate with the Department of Investment and Planning in planning basic construction funding and the distribution of the basic construction funding and submit to the City People's Committee for decision. Cooperate with collection agencies to collect taxes, fees and other receivables in the locality; cooperate with the State Treasury to carry out the full and timely distribution of the city budget in compliance with the policies and standards applied for bodies using the budget. ▪ Manage State owned properties belonging to the administration and non-production sector in the locality in accordance with government regulations and the guidance of the Financial Ministry. ▪ Consider and inspect the finance for construction and the formation of projects funded by the local budget and other loan projects of the locality; assist the City People's Committee in the inspection of capital use and the carrying out of the plans for loan repayment; and control and inspect the use of capital and local sponsored properties. ▪ Manage and use the city's financial reserve fund in compliance with the law and the decisions of the City People's Committee. ▪ Manage the funds authorized by the central authorities. ▪ Inspect and consider for approval the finalization of expenditure of funds by State agencies, administration and non-production units and other organizations using the budget. ▪ Provide guidance to lower level financial agencies to collect data concerning State budget collection and expenditure in the locality and the carrying out of budget finalization at their level. The Department of Finance will evaluate the activities of State budget collection and expenditure, prepare the total annual State budget final report of the locality and submit it to relevant authorities for approval as regulated. ▪ Make financial and budget reports as regulated. ▪ Carry out the State management of lottery and business activities, financial consultancy, insurance, accounting, and auditing services in the locality in compliance with the law. ▪ Cooperate with the State capital and property management agency in enterprises concerning their financial management as assigned. ▪ Inspect the financial and budget management of lower level agencies, administration and non-production agencies and enterprises in the locality having direct duties and obligations concerning the local budget and the carrying out of management policies of State finance and properties of the locality as regulated. ▪ Carry out united management regarding planning to foster and use cadres who have the professional skills of finance and accounting in the locality. ▪ Carry out other activities assigned by the City People's Committee, the Financial Ministry and the Government Pricing Board.

Department/ Agency	Roles and Duties
Department of Natural Resources and Environment	▪ Consult and support the People's Committee to implement the State management in natural resources and the environment including land, water resources, mineral resources, geology, environment, meteorology and measurement and maps, general management on the sea and islands (with the city has the sea and island), implement public services in the field under the management scope of the Department. ▪ Submit to the provincial People's Committee: ➢ Decision draft, instructions and other documents issued by the provincial People's Committee in the field of natural resources and environment. ➢ Drafts of plans i.e. 5 year-plan and annual plan of programs, scheme, and projects in the field of natural resources and environment and management and protection solutions in the area. ➢ Draft regulating title standards of chief and deputy of the organization under the Department and Head and Deputy Head of natural resources and environment division of district, towns, and provincial cities. ▪ Submit to the Chairman of the provincial People's Committee: ➢ Draft of documents issued by the Chairman of the provincial People's Committee in the field of natural resources and environment. ➢ Draft of decision on establishment, merging, dissolution, reorganization of division, and department and business units of DONRE. Submit draft of decision on the functions, duties, powers and organizational structure of the department as stipulated by laws. ➢ Draft of documents specified in the working relationship between DONRE with the relevant department and the People's Committee of districts, towns and provincial cities (hereinafter referred to as the district level People's Committee). ▪ Responsibilities related to environment ➢ Assess the current situation of the local environment by regular investigations, to identify areas with contaminated environment, make a list of establishments causing environmental pollution, causing serious environmental pollution in the area and periodically report the provincial People's Committee. MONRE check the implementation of measures to overcome environment pollution from those establishments as stipulated by law. ➢ Chair or coordinate with relevant agencies to build and organize the implementation for resource mobilization plan in order to cope, overcome environmental pollution caused by environment incident under the assignment from the provincial People's Committee. ➢ Grant, renew, revoke licenses for waste generators, collectors, transporters, treatment of hazardous waste in accordance with the legal guidance, inspection, and certification of qualified scrap for import under the authority. ➢ Appraise the strategic environment assessment, EIA report, environment protection scheme, projects to establish nature conservation areas and biodiversity with the approving competent of the provincial People's Committee to guide, inspect the implementation after approval. ➢ Chair and coordinate the intersectional implementation of programs, projects to overcome, improve landscape, conservation and sustainable development of wetlands (if any) assigned by the provincial People's Committee. ➢ Guide in construction, organization and management of environmental monitoring system in accordance with the statistic laws, data storage on the local environment. ➢ Organize the implementation the communication activities for environment protection within the scope and function of DONRE. ➢ Organize the collection for appraisal fees of EIA report, and environmental protection fees for waste as stipulated by law. ➢ Synthesize the operating expenses of the environmental protection agencies, local units and coordinate with Finance Department to report the provincial People's Committee, submitting the same level People's Councils to chair, coordinate with Finance Department for the financial management of environmental protection funds assigned by the provincial People's Committee.

1.4 City Development Policy and Priority

1.4.1 The Master Plan on Da Nang City's Socio-Economic Development through 2020

In October 2010, "the master plan on Da Nang city's socio-economic development through 2010" was approved by the Prime Minister of the Peoples' Committee of Viet Nam. The master plan provides the objectives and quantified targets of socioeconomic development in Da Nang City with the sector-wise orientation of the development, as summarized in the table below.

Table 1-10: Outline of the Master Plan on Da Nang City's Socio-Economic Development through 2020

ITEM	CONTENTS	
Development Objective	▪ To build and develop Da Nang city into a large urban centre of the country, a socio-economic center of the Central region, serving as an important service and seaport center and a hub for international and domestic goods transportation and transshipment; a postal and telecommunications as well as financial and banking center; one of the health, cultural, sports, educational and training, scientific and hi-tech center of the Central region; and a location of strategic importance in terms of defense and security for the Central region and the whole country.	
Specified Development Targets	Economic Development	▪ Annual economic growth rate of 12-13% ▪ Economic structure in 2020 will be as follows: service-55.6%, industry and construction-42.8%, and agriculture-1.4%. ▪ The city's GDP to make up 2.8% of national GDP in 2020. ▪ Export turnover will increase by 19-20% annually during 2011-2020. ▪ Per capita GDP to reach USD 4,000-5,000. ▪ Budget proportion to GDP to reach 35-36%
	Social Development	▪ To keep the natural population growth rate below 1% per annum. ▪ To create 30,000 new jobs annually. ▪ To put an end to the infant malnutrition and poor households by 2020. ▪ To continue expanding education and training scale. ▪ To continue boosting the socialization of healthcare. ▪ To build a civilized and modern municipal culture while preserving and maintaining the national cultural identities. ▪ To conduct economic development in parallel with improvement of the living environment. ▪ To focus on infrastructure development in association with improvement of the quality of urban public services. ▪ To enhance the consolidation of national defense and security, maintain political stability, social order and national security.
	Environmental Protection	<u>During 2011-2015</u> ▪ 90% of wastewater of industrial parks, export processing zones and inner city districts to be collected and treated to comply with the environmental quality standard. ▪ To control sources of hazardous wastes in the city; complete the construction of hazardous waste collection and treatment system; build a consolidated medical hazardous waste disposal facility. ▪ To segregate waste at sources and strive for 90% of municipal solid waste to be collected and treated in a hygiene manner. ▪ To develop recycling industries, striving for 50% of collected wastes to be recycled and around 50% of deceased people to be buried by cremation. ▪ To strive for 90% of the inner city residents and 70% of residents in suburban communes to have access to clean water. ▪ To control air pollution caused by road traffic, industrial exhaust from urban quarters. To keep the air pollution index (API) under 100. ▪ To increase the urban greenery area (parks, gardens, street plants, office and school greeneries), arrange proportionally types of tree. Striving for 3-4m2 of greenery per head. ▪ To undertake measures to preserve the city's forest biodiversity.

ITEM	CONTENTS	
		▪ To continue implementing the policy of "closing down" natural forests, enhancing the management and protection of forests and speeding up the forestation process in order to raise the forest coverage to 50.6% by 2015. <u>During 2016-2020</u> ▪ To build Da Nang city into an "environmental city" by 2020. ▪ To continue realizing the 2016-2020 targets, ensuring that all criteria for an environmental city be attained, specifically: ▪ 100% of industrial and domestic wastewater be treated up to comply with the environment standards; ▪ 70% of solid waste be recycled; ▪ 25% of water volume be reused; ▪ To develop the urban greenery area, reaching 9-10m^2/person by 2020.
Orientations for Development of branches, Sectors and Key products	Services	▪ To strive for the service sector's growth rate higher than the city's general economic growth rate, which will be 13.5%/year during 2011-2015 and 14% during 2016-2020; the service sector will represent 52.2% of the city's economy by 2015, and 55.6% by 2020. ▪ Trade: To strongly develop the trade sector with rather modern infrastructure facilities, which is expected to growth at 12.2% annually in the 2011-2015 period and 14.1% in the 2016-2020 period. ▪ Hotel and restaurant: To strive for a growth rate of 12.3% in the initial period and 13.6% in the subsequent period. The sector's proportion in the city's GDP will reach 26.5% by 2015 and 26% by 2020. ▪ Transport, warehousing, information and communications: To strive for a growth rate of 14% in the initial period and 17.4% in the subsequent period. The sector's proportion in the city's GDP will reach 13% by 2015 and 15% by 2020. ▪ Finance, banking and insurance: To build Da Nang into a large financial, banking and insurance center of the Central region and the whole country. ▪ Tourism: To strive for an annual high growth rate of 15-16%, a tourism revenue of VND 1.2 trillion by 2010, VND 2.42 trillion by 2015 and VND 3.89 trillion by 2020.
	Industry and construction	▪ Development targets by 2020: the industry-construction GDP will increase 12.2% on average during 2011-2015 and 12.3% during 2016-2020, which will make up for 45.4% and 42.8% of the city's total GDP by 2015 and 2020, respectively.
	Agriculture, forestry and fisheries	▪ The agricultural GDP will grow 4-5% annually on average during 2001-2010 and 4.8% during 2011-2020. By the end of 2010, the economic structure of fisheries- agriculture-forestry will be 69.5%, 26.8% and 3.7%, then 73.3%, 23.5% and 3.2%, respectively by 2020.
	Infrastructure	<u>Transport</u> ▪ To build Da Nang-Quang Ngai and Da Nang-Cam Lo (Quang Tri) expressways, upgrade highway 14's section from Tuy Loan to the Da Nang-Quang Nam boundary to reach the grade-I standard with 4 lanes; upgrade Ho Chi Minh highway's 45km section running through Da Nang to the mountainous grade-III standard. To broaden four roads to the city and build traffic hubs from Da Nang to provinces. To build new roads connecting the inner city with the Ho Chi Minh highway and expressway. ▪ To build Lien Chieu port to facilitate the transportation of the region's exports and imports and transit goods in the East-West corridor, which will have a handling capacity of 6-7 million tons/year, and be able to receive vessels of 50,000 DWT in the 2010-2020 period. To build Tho Quang port for vessels of under 50,000DWT, expand and upgrade Tien Sa port to be capable of receiving 60,000 DWT vessels. To invest in expanding, upgrading the Da Nang international airport according to the approved plan to 2020.

ITEM	CONTENTS	
		▪ To build new railway stations for relocation of the railway system out of the inner city. ▪ To build new traffic hubs in the inner city, upgrade urban major streets, build a system of inter-regional bus stations and embellish urban stations and stops, and plan a system of car parks to serve the urban population. ▪ To broaden cross-sections of rural road routes, inter-field routes and consolidate inter-field canals, ensuring agricultural and rural mechanization and modernization. ▪ To strive by 2020 to complete 100% of intra-field traffic routes and canals in service of agricultural production. ▪ To develop mass transit in order to restrict the increase of personal means of transport and to prevent serious traffic jams and environmental pollution. <u>Post and Telecommunication</u> ▪ Post: To apply automation technology through investment in automatic equipment accepting and distributing postal parcels and packages which will be located at public places and operate round-the-clock, thus well meeting the people's demand. ▪ Telecommunications: To ensure high speed of access so as to meet the entertainment and television services' broadband demand. <u>Power Supply</u> ▪ On power sources: To continue using power from the national grid through the Da Nang 500kV station of 500/220/35-450MVA; transformer stations of 220/110kV and independent diesel power generators of different economic sectors. By 2020, based on the forecast of additional charge capacity of the Da Nang 500kV station from 450 MVA to 900 MVA-1,350 MVA, while supplementing transformer stations of 220kV. ▪ On the power grid: from now to 2015, taking 2020 into consideration, the high-voltage power transmission system of 220kV and 110kV continue playing the major role in transmitting power from national sources to the city. The middle-voltage grids will gradually be converted into the 22kV grids; the low-voltage grids will gradually be transformed into urban underground cables and aerial bundle cables for suburban areas. <u>Irrigation and water supply system</u> ▪ To invest in building a new Trung An Reservoir; repair and upgrade reservoirs, irrigation works and consolidate canals to ensure water sources for watering 100% of agricultural land and for aquaculture. ▪ To intensify investment in, speed up the supply of water for daily life in rural areas, striving for 80% of rural population to have access to clean water by 2010, which will increase to 90% by 2015 and 95% before 2020. ▪ To invest in, complete the system of dykes, sea and river embankments, and enlarge river flows in order to ensure safety and strengthen capacity to control and combat floods and storms, mitigate natural disasters. <u>Water drainage works</u> ▪ To arrange synchronously surface water, sewage water and other underground structures, such as electric, telephone and signal cables, etc. according to the urban road standards. To improve, upgrade water drainage systems at old streets to prevent floods and ensure projects' quality. The density of water sluices will reach the standard of 200-300m/ha of construction of wastewater and rainwater by 2015.

ITEM	CONTENTS	
		Urban trees ▪ To enhance the planting of trees on the separation schemes of the urban roads of grade I or II, pavements, bus stations, car parks, etc., so as to create a beautiful landscape and environment up to the standard of 4-5m2 per head by 2010 and 9-10m2 per head by 2020.
	Social affairs	Population and family planning ▪ To continue enhancing the population and family planning work so as to sustain the natural population growth rate of around 1% and mechanical population growth rate of around 5%. Da Nang's population is forecasted to be around 1 million people by 2015 and 1.38 million people by 2020, of which the urban population will represent 92% by 2020. Education and training development ▪ To continue developing the network of schools and classes with a rational structure of disciplines and grades, which on the one hand, meets the learning needs of the people and, on the other hand, is compatible with the targets of expansion of the network of non-public establishments by 2020, i.e.,: kindergartens: 80%; preschools: 70%; primary schools: 5%; lower secondary schools: 5%; upper secondary schools: 40%; vocational schools: over 60%; colleges: over 60%, and universities: over 50%. There will be 60.3% of kindergartens and preschools, 85% of primary schools, 75% of lower secondary schools and 80.6% of upper secondary schools up to the national standards. ▪ To consolidate and expand boarding schools for ethnic minority pupils. To develop two schools for pupils with disabilities into key schools of the region. To complete the universalization of secondary education by 2010. ▪ To broaden, on a reasonable scale, the collegial university and vocational training. To create a breakthrough in vocational training, striving to increase the percentage of trained laborers and laborers of the age range entitled to training to more than 70% by 2020, from preliminary to intermediate, college and university levels. Healthcare development ▪ To invest in material foundations and other conditions for the grassroots healthcare, ensuring 100% of ward and commune healthcare stations meet the national healthcare standards. ▪ To raise the quality of healthcare at all levels in the domains of disease prevention, medical examination and treatment, and functional rehabilitation. To pay attention to boosting intensive healthcare, applying scientific and technological advances as well as medical achievements in the care for and protection of the people's health. ▪ To reduce the rates of infection with and deaths caused by contagious diseases and epidemics; to hold back at the lowest rate of infection with and deaths caused by cholera, typhoid, petechial fever, malaria, hepatitis B, Japanese encephalitis, and sexually transmitted diseases, to control at the lowest level the number of people infected with HIV/AIDS. ▪ To prevent and control non-infectious diseases such as heart disease, mental illness, cancer, diabetes and obesity, etc. To enhance the supervision and prevention of occupational diseases, accidents and injuries as well as food poisonings ▪ To strive to have 100% of residential quarters meeting hygiene and health safety standards after 2015. ▪ To strive for 95% of children between 8-10 years of age to be vaccinated; the percentage of newborns weighing less than 2.5kg to fall to below 5%; the percentage of malnourished children under 5 years old to fall to below 10%; there will be 13-14 physicians per ten thousand

ITEM	CONTENTS	
		people, including one doctor of medicine or one physician with the second-class honors; 1.5 master of medicine or one physician with the first-class honors; 10 physicians and one pharmacist with university degree per ten thousand people. Culture, information and sports ▪ To continue well implementing the integrated programs to mobilize the entire people to unite in building a cultured lifestyle in residential quarters. To strive to increase the number of households, hamlets and communes that meet the set cultural standards, and enhance inspection, urge the solid maintenance of the awarded titles. ▪ To preserve and promote the city's traditional, historical and cultural values so as to increase the pride for the motherland's traditions. To attach the preservation and embellishment of historical and cultural relics with the formation of tourism routes and spots. ▪ To well implement the socialization work in culture. To encourage the development of the physical training movement among the people of all strata, develop mass sports movements with schools and state agencies serving as the core, to regularly organize sport competitions. Other social affairs ▪ To generate jobs for 32,000-35,000 laborers and 35,000-45,000 laborers on average annually during 2006-2010 and 2011-2020, respectively.

In accordance with the above master plan on Da Nang city's socio-economic development plan through 2020, the following listed projects are given priority for investment study during 2010-2020.

Table 1-11: List of Da Nang city's projects prioritized for investment study during 2010-2020

Project types	Project Titles
A. Projects invested by ministries and branches in Da Nang city	▪ Da Nang-Quang Ngai expressway project ▪ Project on relocation of Da Nang railway station from the city's center ▪ Da Nang airport upgrading project ▪ Lien Chieu port project ▪ Da Nang university village project
B. Projects of which the city is the investor	**Projects invested with central capital** ▪ Project on building a storm shelter for fishing ships of 600CV or more in Man Quang bay ▪ Man Quang dyke and embankment construction project ▪ Project on embankment upgrading at the Han river mouth, section from Tuyen Son bridge to Hoa Hai ▪ Project on upgrading the 604 urban road, section crossing Da Nang city **Project invested with central support capital and local budget capital** ▪ Tran Thi Ly-Nguyen Van Troi new bridge ▪ Salvage and rescue roads in the frequently flooded areas ▪ Da Nang hi-tech park ▪ IT industrial zone ▪ Equipment for the Da Nang cancer hospital ▪ Student dormitories ▪ The Central region's bio-tech center in Da Nang ▪ Da Nang scientific and technological information center **Projects invested with local capital** ▪ Southern belt road (from Son Tra-Dien Ngoc to Highway 14B) ▪ Nguyen Tri Phuong road to Hoa Quy ▪ A new bridge crossing Han river (Rong bridge) ▪ The extended Nguyen Van Linh road-the new bridge crossing Han river, leading to Son Tra-Dien Ngoc

Project types	Project Titles
	▪ The extended Tran Hung Dao road ▪ The building of a general science library ▪ Ngu Hanh Son cultural park ▪ Municipal administration center ▪ Da Nang environmental protection project
C. Projects calling for investment from different economic sectors	**Infrastructure facilities of industrial parks** ▪ Building of infrastructure of Hoa Khuong industrial park **Industry** ▪ Building of the Tho Quang canned meat and fish food factory with a capacity of 5,000tons/year ▪ Building of a metal mold manufacturing plant in Lien Chieu, with a capacity of 1,000tons/year ▪ Building of a motor engine-, motor engine part-, and internal combustion engine-manufacturing plant of a capacity of 15,000 sets in the Hoa Khanh industrial park. ▪ Investment in an auto tire production chain with a capacity of 2-3 million sets ▪ A cable and peripheral equipment production plant with a capacity of 130,000 products/year **Tourism and services** ▪ Olalani resort ▪ Thien Thai Eden tourism site ▪ Vinacapital marine tourism site project ▪ Ba Na-Suoi Mo eco-tourism complex project ▪ Dong No tourism site ▪ Eco-tourism site along Hoa Xuan river ▪ Da Phuoc urban center project ▪ Meridian Far Eastern twin tower project ▪ Golden Square project

1.5 Revenue and Expenditure of Da Nang

The local revenue of Da Nang City has been steadily increasing with the growth of local economy. It is estimated to reach 21.3 trillion VND (101 billion JPY or 1 billion USD) in 2011. Land use tax is the biggest source of local revenue with 5.5 trillion VND, followed by value added tax of import goods with 1.8 trillion VND. As to the local budget expenditure, it is estimated to be approximately 15 trillion VND in 2011, of which 7.6 trillion is capital expenditure for the city's development. Out of the total operation expenditure of 3.75 trillion VND, the expenditure related to environment protection is 96 billion VND in which the budget allocation for SWM of about 53 billion VND in 2011.

Table 1-12: Da Nang State Revenue and Expenditure during 2008-2011

(Unit: VND million)

Item	2008	2009	2010	2011(Est.)
GDP in the Province at current prices	20,255,442	24,388,881	30,754,765	39,021,725
Total Local Budget Revenue	12,509,500	14,109,700	16,580,800	21,318,600
I. Export and Import Duties	915,000	1,618,100	971,300	782,300
II. Value Added Tax of Import	1,431,900	976,600	1,134,100	1,805,600
III. Domestic Revenue	6,100,200	5,463,700	9,527,900	11,422,400
1. Revenue from Central Enterprises	117,600	108,100	108,900	146,900
2. Revenue from Local State Enterprises	707,100	731,300	880,700	840,500
3. Revenue from Foreign Investment	492,600	500,700	760,400	896,900
4. Revenue from Non-State Enterprises	633,400	676,700	1,280,400	1,674,300

Item	2008	2009	2010	2011(Est.)
5. Income Tax	136,900	232,600	435,900	538,100
6. Registration Fees	174,100	229,700	309,300	365,400
7. Other Fees	114,700	263,100	583,500	818,300
8. Land and Housing Taxes	3,408,200	2,322,400	5,055,200	5,506,200
(1) Land Use Tax	3,042,100	2,242,800	4,606,000	5,431,100
(2) Housing Tax	20,400	24,100	26,800	29,600
Total Local Budget Expenditure	6,299,500	7,988,300	10,474,300	15,056,400
I. Local Government Expenditure	5,897,700	6,877,900	9,304,200	11,436,100
1. Capital Expenditure	3,705,400	4,894,800	6,226,300	7,626,500
2. Current Expenditure	1,889,400	1,964,500	3,046,000	3,750,300
(1) Education/Training	525,300	586,100	827,100	1,002,400
(2) Health	404,100	331,000	716,500	909,000
(3) Science and Technology	8,400	13,900	14,000	25,200
(4) Culture and Information-gym, sport	45,500	57,800	88,500	102,900
(5) Social Welfare	149,300	113,500	208,000	285,100
(6) Economic Development	143,800	155,900	237,600	293,800
(7) Environment Protection	42,400	39,700	78,700	96,000
(8) Administrative Expenditure	345,200	420,900	545,800	677,000
(9) Miscellaneous Expenditure	126,400	159,300	222,400	214,800
3. Transfer to Financial Reserve Fund	5,000	10,000		20,000
4. Transfer to Next Year's Budget			406,900	2,854,700
II. Additional Expenditure under Budget	401,500	469,500	543,600	750,600
III. Others	300	640,900	219,500	15,000

Source: Da Nang Statistical Yearbook 2011.

2 Solid Waste Management in Da Nang City

2.1 Generation Characteristics of Solid Waste

The solid waste in Da Nang city is mainly categorized into the following types:

- Municipal solid waste,
- Industrial solid waste
- Medical waste

The current conditions of the above solid waste are outlined below.

2.1.1 Municipal Solid Waste

According to the survey data of URENCO, Da Nang City collected about 268 thousand tons of municipal solid waste in 2013, and the collection rate for 2012 was 92%. Per capita waste generation in Da Nang City is 0.675 kg per day in 2010. Although the majority of municipal solid waste comes from households, the wastes from non-household sources such as hotels, restaurants, markets, and other business/commercial establishments also show significant growth their amount with the growth of economy in the city. Recently, the waste generated from coastal tourism and resort areas is also problematic in terms of keeping these areas clean and valuable for the domestic and foreign tourists.

Table 2-1: Waste Collection by URENCO (2007-2013)

Unit: tons/year

Type of waste	2007	2008	2009	2010	2011	2012	2013
Municipal solid waste	No data	No data	205,009	223,521	232,233	252,504	262,182
Industrial non-hazardous waste	No data	No data	2,914	3,242	3,917	3,723	4,199
Medical non-hazardous waste	No data	No data	1,257	1,372	1,553	1,889	2,216
Sub-total (non-hazardous)	No data	No data	209,180	228,135	237,703	258,116	268,597
Industrial hazardous waste	Not collected	Not collected	219	415	267	404	359
Medical hazardous waste	Not collected	Not collected	144	150	185	209	217
Sub-total (hazardous)	Not collected	Not collected	363	565	453	613	576
Total	**191,002**	**194,000**	**209,663**	**228,700**	**238,156**	**258,938**	**269,390**
Septic tank sludge	7,320	8,296	11,482	16,776	22,616	N/A	N/A

Source: URENCO

Table 2-2 shows the result of URENCO's survey on composition of municipal solid waste in Da Nang. It clearly indicates its high domination of organic waste in Da Nang's municipal solid waste, which causes serious sanitary and environmental issues during collection, transportation and final disposal.

Table 2-2: Composition of Municipal Solid Waste in Da Nang City (2010)

Type of Waste	Percentage (%)
Papers/Cardboards	5.16
Food/garden waste	74.65
Wood waste	0.67
Fabric and textile waste	3.18
Leather waste	0.83
Rubber waste	1.29
Plastic waste (PET)	0.07
Plastic waste (PVC)	0.62
Nylon wrappers	11.58
Multi-component plastics	0.42
Scrap metals	0.19
Ceramic waste	0.55
Glass waste	0.74
Household hazardous waste (battery, spray cans, light bulbs, etc.)	0.03
Medical waste (needles, expired drugs, etc.)	0.02

Source: URENCO (2010)

Since the data in the table above is based on the analysis of waste at Khan Son landfill after removal of valuable materials by waste-pickers, the percentage of recyclable wastes such as scrap metals and plastics is very low except nylon wrappers (plastic bags).

2.1.2 Industrial Solid Waste

As of 2010, there are 7,148 business enterprises in Da Nang City, of which 779 enterprises belong to manufacturing industry, the sources of industrial waste. Although URENCO estimated that the industrial waste in Da Nang would be about 6-7% of the total solid waste generated, the amount of industrial waste collection only occupied 1.7% of the total solid waste collected in 2011. URENCO also indicated that there still remains 50% of the total number of enterprises having no official contract of waste collection treatment while they dispose the waste on site or may illegally dumped them at unauthorized areas.

The issue becomes far more serious about industrial hazardous waste. The Report on "Da Nang State of Environment 2005 -2010 and Orientation to 2015" mentioned that there were 98 industrial enterprises registered as the source of hazardous waste generation with their annual estimated generation of about 10,000 tons. However, the amount of industrial hazardous waste disposed at Khanh Son landfill remained at only 267 tons in 2011. The above report also indicates that there will be more sources of industrial hazardous waste not officially registered. URENCO estimated potential generation of hazardous waste by types of industry as shown in the table below.

Table 2-3: Potential Hazardous Waste Generation by the Industry Sector in Da Nang

Type of Industry	Type of hazardous substances potentially generated
Chemical industry (Chemical fertilizers, synthetic plastic, pharmaceutical)	Hazardous organic/inorganic substances, metal dust, chemical dust, hazardous/toxic gases
Basic chemical industry	Organic/inorganic acids and alkalis, and gases
Paint and ink production	VOCs (Volatile Organic Compounds) such as waste oil, xylene, toluene, and organic/inorganic dust
Glass production	Dust, VOCs such as Arsenic trioxide (AS_2O_3), hydrogen fluoride (HF), Boron trioxide (B_2O_3), Antimony trioxide (Sb_2O_3), etc.
Battery production	Metal dust, VOCs, Mercury (Hg)
Fertilizers	Hydrogen Fluoride (HF)
Plant protection drugs	Active chemical substances, solvents, etc.
Leather and leather products	Acid gases, solvents, Hydrogen sulfide, Ammonia, Trivalent

	Chrome, etc.
Electric/electronic industry	Metal dust, chemical substances, solvents, etc.
Machinery	Metal dust, chemical substances, solvents, etc.

Source: URENCO (2010)

2.1.3 Medical Waste

The medical waste collected by URENCO is only about 1,700 tons in 2011, of which hazardous ones is 185 tons. According to a survey of health sector, however, the total hazardous medical waste generation in 18 major hospitals in Da Nang City is estimated around 820 kg per day or about 300 tons per year. Including the estimation of hazardous medical waste generation from private clinics and communal health stations, which was carried out by the Department of Natural Resources and Environment in 2008, it is totally estimated to reach approximately 350 tons per year.

As to the composition of medical waste, the Department of Health conducted a survey in 2008 with the result as shown in the table below.

Table 2-4: Composition of Medical Waste in Da Nang (2008)

Type of Waste	Percentage (%)
Waste papers (all kinds)	3.00
Scrap metals, cans	0.70
Glassware, syringes, drug vials, needles and other plastics	3.20
Bandages, gypsum bandages for bone fracture	8.80
Bottles and plastic bags of all kinds	10.10
Specimens	0.60
Organic wastes	52.57
Other wastes	21.03

Source: Department of Health (2008)

Approximately 26% of the medical waste above can be defined as hazardous ones though there are other potentially hazardous wastes that are not well categorized here, such as blood, body fluids, secretions, body organs, needles and other sharps, pharmaceutical chemicals, radioactive materials, and so forth.

2.2 Current Solid Waste Management Mechanism (Collection, Treatment and Disposal)

2.2.1 Collection and Transportation of Solid Waste in Da Nang City

a. Municipal Solid Waste

There are approximately 6,000 trash boxes placed in Da Nang City for primary collection of municipal solid waste. As to the places where trash boxes are not available, especially in the alleys and some residential areas, the so-called bell collection with pushcarts is carried out by URENCO workers. The wastes collected by pushcarts are brought to transfer stations for transshipment of waste by compactor trucks to Khanh Son final disposal landfill. There are currently 6 transfer stations in operation as shown in the figure below. Approximately 97 tons of wastes are collected by pushcarts daily in Da Nang city.

Figure 2-1: Locations of Transfer Stations in Da Nang

The collection of waste from the permanently placed trashcans is carried out by compactor trucks and directly transported to Khanh Son landfill. The amount of waste collected by these compactor trucks is about 400 tons per day. The waste collection from rural areas is carried out by specialized dump trucks. The table below is the list of waste collection and haulage trucks currently in operation in URENCO.

Table 2-5: List of Waste Collection and Transport Trucks and Machinery in Operation by URENCO (2012)

Type of Vehicles	Year of Production	Starting Year of Use	Country of the Product	Capacity	Number
Compactor Truck	1994	2001	Germany	10 ton	1
Compactor Truck	2011	2011	Japan	10 ton	1
Compactor Truck	2010	2010	Japan	10 ton	1
Compactor Truck	2007	2007	Japan	10 ton	1
Compactor Truck	2008	2009	Japan	10 ton	2
Compactor Truck	2002	2002	Japan	10 ton	6
Container Truck	2002	2002	Japan	10 ton	5
Compactor Truck	2011	2011	Japan	6.8ton	2
Compactor Truck	1995	1996	Korea	9 m^3	3
Compactor Truck	1994	1995	Korea	9 m^3	2
Compactor Truck	2011	2012	Japan	4.5 ton	3
Compactor Truck	2006	2006	Japan	4.275 ton	2
Compactor Truck	2010	2010	Japan	4.5 ton	2
Compactor Truck	2008	2008	Japan	3.5 ton	2
Compactor Truck	1990	1997	Japan	6.3 m^3	3
Compactor Truck	1998	1998	Japan	7.5 m^3	6
Street Sweeper (Unimog)	1998	1999	Japan	-	2
Street Sweeper (Unimog)	1998	1999	USA	-	1
Wheeled Squirter	2004	2004	China	5 m^3	8
Wheeled Squirter	2009	2010	China	15 m^3	1
Bulldozer	2010	2010	China	-	1
Wheel Loader	2002	2002	USA	250CV	1
Bulldoxer	1999	2001	China	90CV	1
Dump Truck	1997	1997	China	4 m^3	2
Medical Waste Container Truck	2008	2008	Korea	-	1
Vacuum Car (septic tank sludge)	1984	1997	France	7 m^3	1
Vacuum Car (septic tank sludge)	2004	2004	Japan	4 m^3	2
Vacuum Car (septic tank sludge)	1978	1979	Germany	5 m^3	1
Sand Filter Machine	2000	2003	-	-	2
Generator	2001	2003	USA	40KVA	2

Source: URENCO (2012)

The chart below illustrates the flow of municipal solid waste in Da Nang City.

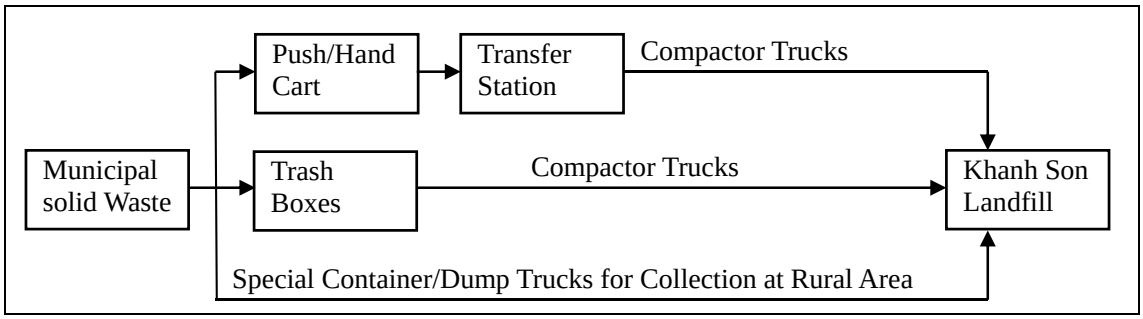


Figure 2-2: Municipal Solid Waste Collection in Da Nang City

Majority of the municipal solid waste generated in Da Nang City is collected from trash boxes located along the roads or streets while pushcart collection is carried out in the areas where trash boxes is not available within the urban area. The collection at rural areas is carried out by special container/dump trucks.

Waste collection and cleaning works along the beach sides and tourism areas are also carried out by URENCO manually and semi-mechanically with sand screening equipment. Approximately 6,000 tons of waste are generated annually and mostly collected from these areas.

2.2.2 Industrial Solid Waste

Industrial solid waste, which accounts for 6 to 7% of the total solid waste generated in Da Nang City, comes from more than 200 industrial establishments located within the industrial zones and complexes as well as outside. In general, industrial solid waste is separated by types of waste mainly into recyclables and non-recyclables. The recyclable wastes are sold or reused or recycled within the factory while non-recyclables are disposed by landfill or open dumping, stored on site, or taken by the authorized waste collection haulage agents based on the contract. As to the hazardous waste, its method of collection, transportation, treatment and disposal is strictly provided by law (Decree No. 59/2007/ND-CP). The industrial establishment that generates hazardous waste must register themselves as the hazardous waste generators and conduct a proper management of hazardous waste by themselves or making contracts with officially authorized hazardous waste management (collection, transportation, treatment, and disposal) bodies.

In the case of Da Nang City, hazardous wastes generated from industrial establishments are collected by the officially authorized (registered) waste management contractors including URENCO and other private waste collection and/or treatment companies. URENCO currently have some contracts with several industrial establishments on hazardous waste collection, treatment and disposal. The waste collected by URENCO is brought to Khan Son landfill for its proper treatment and disposal. Some private waste management companies having such contracts with the industrial establishments in Da Nang transport the waste to Khanh Son landfill or other treatment and disposal facilities outside Da Nang.

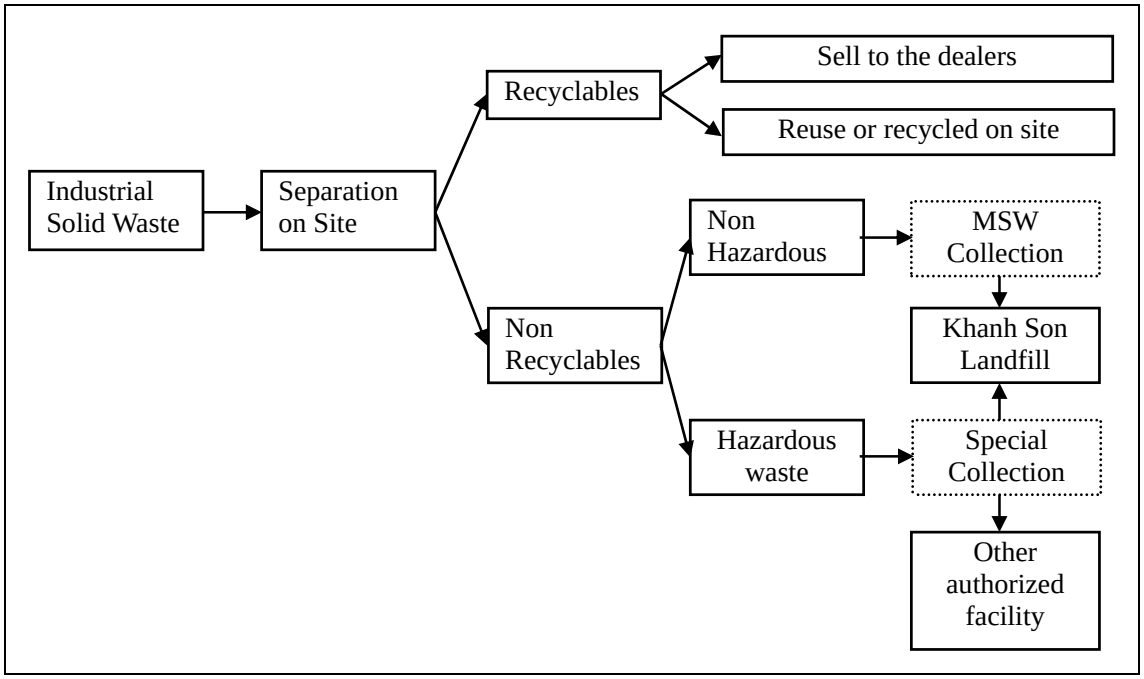


Figure 2-3: Industrial Waste Collection in Da Nang City

In Da Nang City, industrial wastes from seafood processing factories make up a high percentage. It is estimated that about 1,500 -3,000 tons of waste is generated from Da Nang Aquatic Services Industry Zone annually. According to the report on "Da Nang State of Environment 2005 -2010 and Orientation to 2015", the organic wastes from fishery activities, seafood processing factories and

fishing markets are collected by specially designed trucks and transported to Khanh Son landfill for their treatment and disposal. The seafood processing residues at Da Nang aquatic Services Industry Zone are pretreated on site for mitigating the odor with a certain biological agent before their collection.

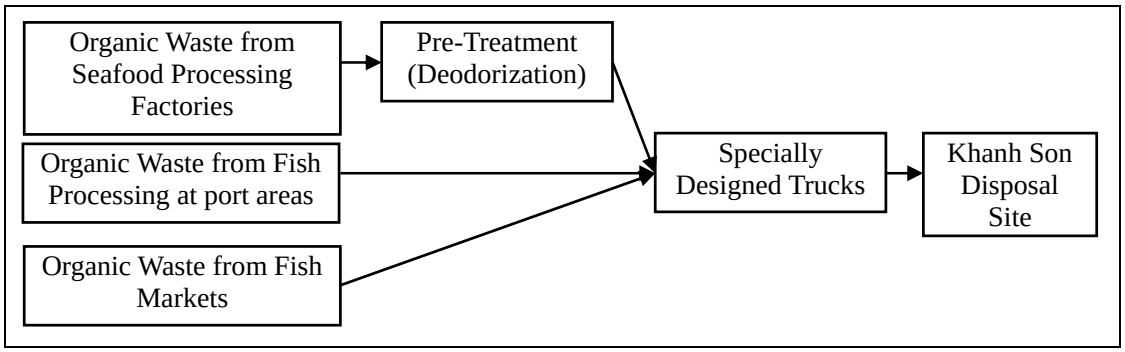


Figure 2-4: Organic Waste Collection from Seafood Processing in Da Nang

As to the hazardous waste generated from the industry, its total amount has not yet been identified due to limited investigations conducted so far. Although there are 98 industrial enterprises registered as the generators of hazardous waste with the estimated annual generation of about 10,000 tons as mentioned in the previous section, only 16 enterprises have official contracts with the authorized collectors and treaters of hazardous waste with the relative hazardous waste amount of about 220 tons per year. A Study on environment management by the industrial establishments in Da Nang in 2011 indicated that the percentage of industrial establishments that does not comply with the laws and regulations on hazardous waste treatment reaches around 40%. It implies that a large amount of hazardous waste is not properly handled and become a serious potential threat to the environment.

2.2.3 Medical Waste

Management of medical waste in Viet Nam is regulated by the Decision No. 43/2007/QD-BYT, which specifies the separation, storage, collection and haulage, treatment, and disposal methods. Medical waste is required to be strictly separated from municipal solid waste in any waste handling processes. The sources of medical waste generation such as hospitals, clinics, and other health establishments are required to have contracts with the authorized collectors/treaters of medical waste including non-hazardous as well as hazardous ones. Medical hazardous waste is separately collected by specially designed trucks and incinerated at Khanh Son Landfill.

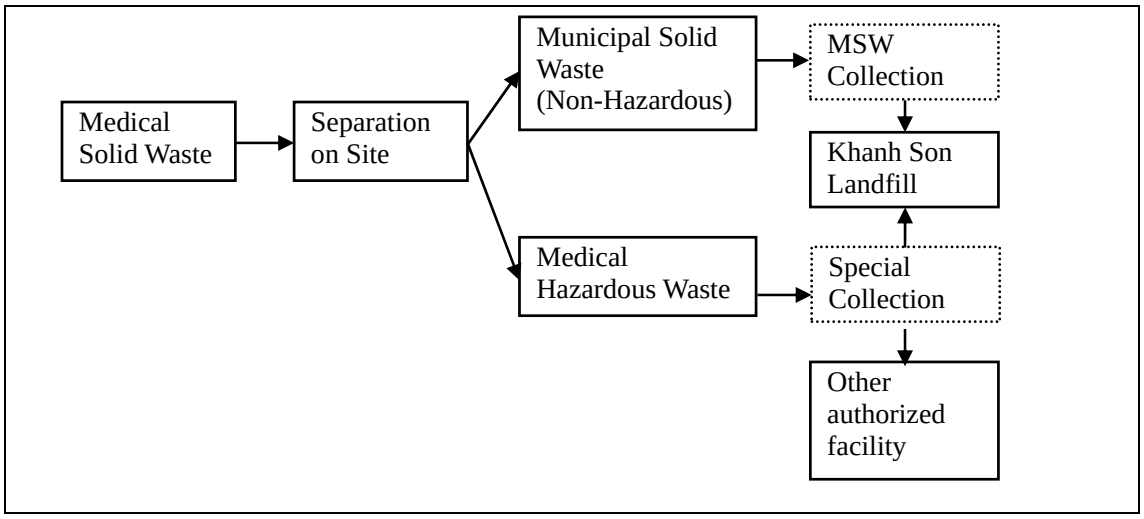


Figure 2-5: Medical Waste Collection in Da Nang City

The report by DONRE pointed out very few hospitals and clinics properly handles medical hazardous waste in accordance with the regulations. Proper separation of medical hazardous waste is generally insufficient and sometimes discharged with municipal solid waste indiscriminately. The storage place of medical hazardous waste in the hospitals and clinics are also not safely managed in most of

the cases.

Hazardous waste treatment at Khanh Son landfill by the newly established treatment plant (incineration and solidification) has started in 2009. By the time, the hazardous waste generated in the city is collected and transported to outside Da Nang city for its proper treatment. Currently, URENCO collected medical hazardous waste from 26 hospitals and health establishments with average daily collection of 400kg, which is far below the estimated amount of medical hazardous waste generation per day.

2.2.4 Septic Tank Sludge Collection

Septic tank sludge is a significant source of solid waste generated in Da Nang City. According to the study carried out in 2008 on "Integrated Development Strategy for Da Nang City and Its Neighboring Area in the Socialist Republic of Vietnam (DaCRISS), the percentage of household having its own septic tank was about 80%, while only 15.7 % of the household were connected to the drainage/sewer system. URENCO collected approximately 22.6 thousand tons of septic tank sludge in 2011 for treatment at Khanh Son landfill. The collection of septic tank sludge is also carried out by other private collectors with its destination for treatment and disposal unidentified. It is assumed that some of them come to Khanh Son landfill while the remaining amount may be recycled or illegally disposed at unidentified areas.

2.3 Recycling Activities and Markets

The Study conducted a questionnaire and interview survey to various recycling players ranging from waste-pickers and door-to-door collectors to recyclers and dealers of recyclables. The total number of recycling players interviewed was 256 as specified in the table below.

Table 2-6: Number of recycling players interviewed

No	Recycling players	Unit	No. of respondents
1	Scavengers and door-to-door collectors	Persons	94
2	Recyclable wastes pickers at Khanh Son landfill	Persons	20
3	Food waste collectors	Persons	22
3	Dealers, junk shops, and recycling centers	Shops	103
4	Recyclers	Facilities	10
5	Recycled product selling shops	Shops	8
Total			**257**

2.3.1 General flow of recyclable materials

Based on information obtained from the questionnaire and interviews with the recycling players listed above, a general flow of recyclable materials in Da Nang city was illustrated as shown in the chart below. Recyclable materials are usually collected either at sources by door-to-door collectors or at the final disposal landfill by waste-pickers. The collected recyclables are sold to the recyclable dealers including junk shops and recycling centers while the purchased recyclables are finally sold to domestic recyclers for manufacturing recycled products or exported. In the case of Da Nang, many of collected recyclable materials are brought outside such as Hanoi and Ho Chi Minh as there is only limited number of the manufacturers of recycled products in Da Nang City.

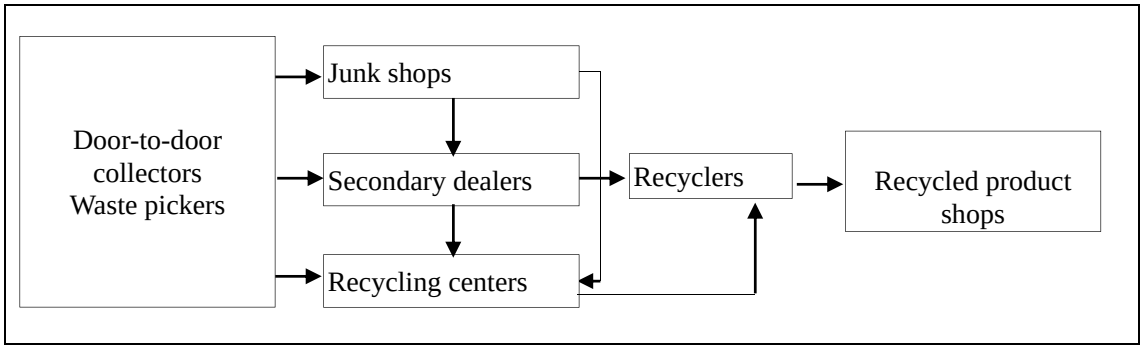


Figure 2-6: General Flow of Recyclable Materials in Da Nang City

2.3.2 Current Flow of Recyclable Materials by Types

a. Paper waste

The amount of paper waste disposed at Khanh Son landfill is approximately 27 tons daily, accounting for 4% of the total daily waste disposal. On the other hand, the amount of waste papers collected for recycling is estimated around 21 tons per day. The majority of paper waste collection is conducted at generation sources where door-to-door collectors buy paper wastes and sell to the dealers of recyclable materials. Salable paper wastes such as newspapers, magazines, and cardboards are well separated at sources. The percentage of paper waste collected at final disposal landfill is minimal in terms of its percentage of the total amount of collected paper waste.

Most of the collected paper wastes are brought to paper recyclers in Da Nang while some of them are brought outside Da Nang such as Hanoi and Ho Chi Minh for recycling. The paper recyclers in Da Nang imports paper waste from other regions to meet their demand for economically feasible scale of recycled paper production.

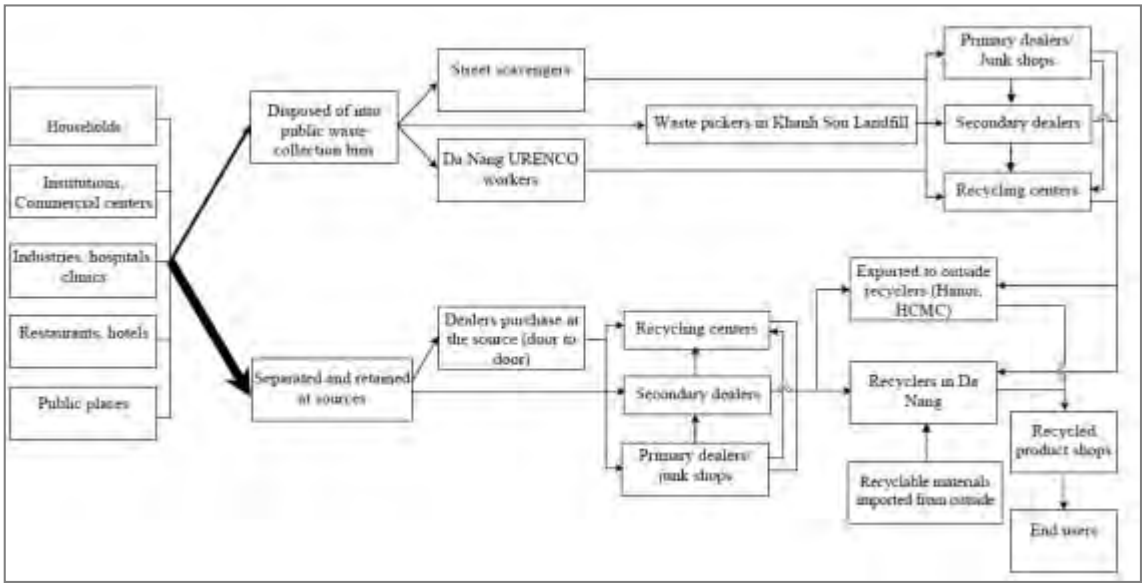


Figure 2-7: Flow of Paper Wastes in Da Nang City

The buying prices of paper wastes at primary dealers and junk shops are different depending upon the types of scrapped papers as shown in the table below.

Table 2-7: Prices of paper wastes by types at primary dealers and junk shops

Types	Price (VND/kg)
ONP (Old Newspaper), old magazines	2,000-3,000
Printing papers	2,000-3,500
Writing papers	3,000-4,000
Cardboard	1,500-2,400
Paper bags for cement	200-500

b. Scrap metals

Scrap metals are mostly collected and bought at sources by door-to-door collectors or primary dealers while there are little amount collected at final disposal site. Our survey estimated that approximately 100 tons of scrap metals are collected daily in Da Nang. The recyclable metals collected include steel and aluminum cans, copper wires, steel and metal scraps from construction/demolition sites, and so forth. There are several end-users of scrap metals in Da Nang and other cities, e.g. Hanoi and Ho Chi Minh. For these recyclers, domestic supply of scrap metals is not enough for economically feasible production of recycled products without additional procurement by inter-regional or international imports.

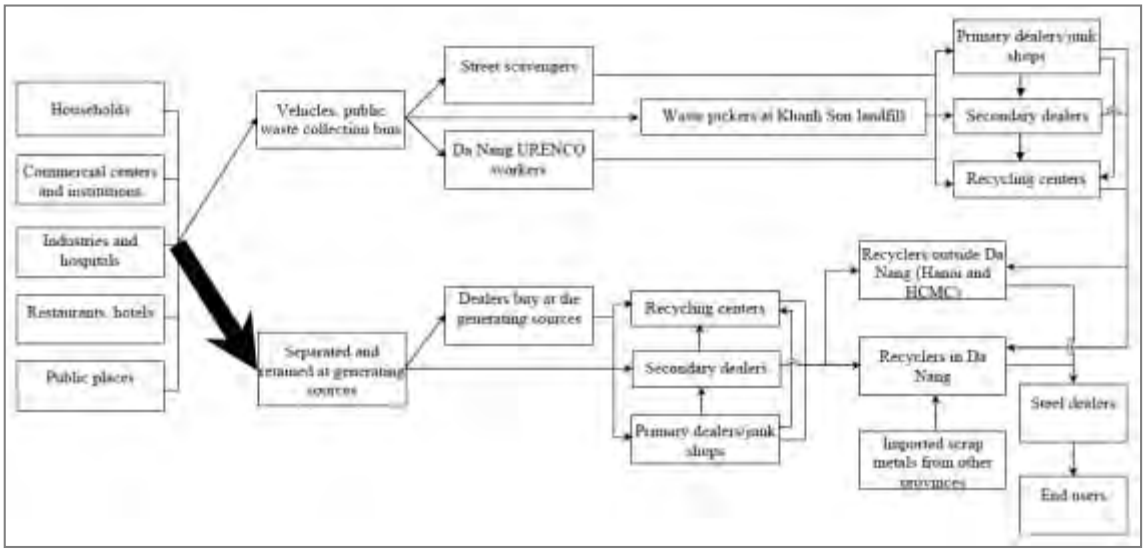


Figure 2-8: Flow of Scrap Metals in Da Nang City

According to the questionnaire/interview survey conducted in the Study, the buying price of scrap metals at primary dealers is as shown in the table below.

Table 2-8: Prices of scrap metals by types at primary dealers and junk shops

Types	Price (VND/kg)
Aluminum can	18,000-24,000
Steel can	3,500-5,000
Scrap metals	7,000-7,500
Aluminum scrap	20,000-26,000
Copper scrap	80,000-114,000

c. Plastic waste

According to the result of waste amount and composition survey, the estimated amount of plastic waste disposed at landfill is approximately 67 tons daily while the amount collected is more or less 10 tons per day. Some of the plastic wastes such as PET bottles that are comparatively easy to handle and have higher prices are mainly separated at sources and bought by door-to-door collectors while other plastic wastes like plastic bags are collected more at final disposal landfill by waste-pickers. The collected plastic wastes are mostly sold to the recyclers in Da Nang or other cities in Viet Nam (e.g. Hanoi, Ho Chi Minh) with an exception of PET bottles that are mainly exported to China.

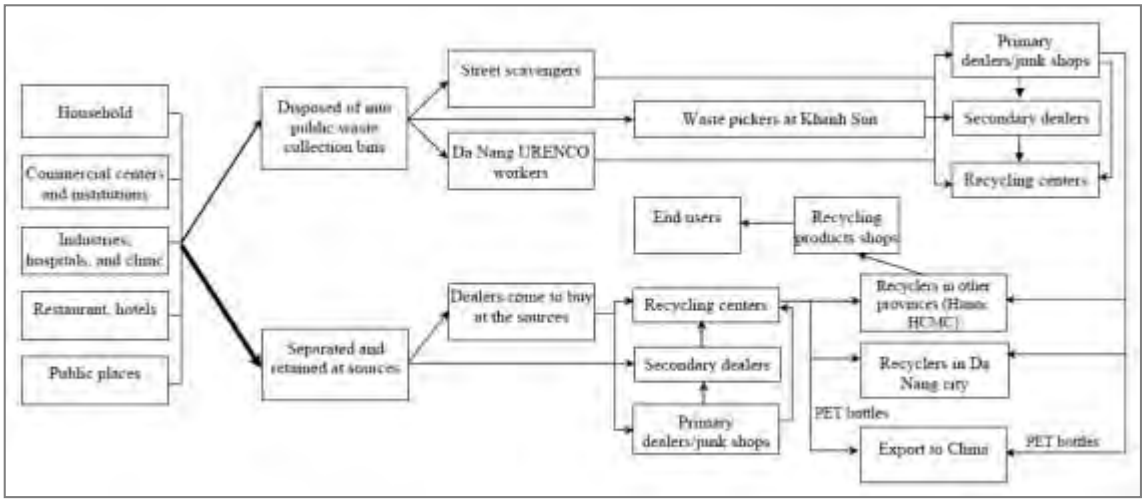


Figure 2-9: Flow of Plastic Wastes in Da Nang City

Buying prices of plastic wastes at primary dealer level have a high variety with its types, as shown in the table below.

Table 2-9: Prices of plastic wastes by types at primary dealers and junk shops

Types	Price (VND/kg)
PET bottles	4,000-8,500
Colored plastics	4,000-8,000
Black and hard plastics	500-2,500
PVC pipes	2,500-5,000
Plastic bags	12,000

d. Food Wastes

Organic wastes such as food leftovers and the wastes from large generations sources such as wet markets (vegetables/fruits, meats, fishes), restaurants, hotels are sometimes collected by specialized collectors and buyers to sell them to the farmers or livestock breeders. Organic wastes generated from small sources such as households are mostly not separated; therefore they are usually collected and disposed at landfill by URENCO.

e. E-wastes

As E-waste is mostly collected at sources by door-to-door collectors, its amount disposed at landfill is minimal. The collected e-waste is either repaired or reconditioned to sell or dismantled to collect valuable materials. The table below shows the buying prices of E-waste by types at primary dealer level according to the questionnaire/interview survey conducted in the Study.

Table 2-10: Prices of E-wastes by types at primary dealers and junk shops

Types	Price (VND/unit)
TV set	20,000-50,000
Amplifier	100,000
Computer	30,000
Electric Fan	30,000
Refrigerator	200,000

2.4 Solid Waste Management Administration by URENCO

2.4.1 Organization and Human Resources

Municipal solid waste management in Da Nang City is the responsibility of the Urban Environment Company (URENCO) of Da Nang. URENCO consists of 1,130 employees under the organization structure shown in the figure below. The members of the management board are shown in the table below.

Table 2-11: Management Board Members of Da Nang URENCO

No.	Department	Number of officers
I	**Office Department**	67
1	**Board of General Director (1 General Director and 3 Deputy General Director)**	4
2	**Control Board**	1
3	**Professtional Division**	
	Admin and Organization Division	18
	Investment and Planning Division	8
	Accounting- Finance Division	7
	Technique Division	10
	Environment and Technology Division	9
	Sales Division	10
II	**Subordinate units**	258
1	Inspection Board	20
2	Hai Chau 1 Environment Enterprise	23
3	Hai Chau 2 Environment Enterprise	24
4	Thanh Khe 1 Environment Enterprise	22
5	Thanh Khe 2 Environment Enterprise	19
6	Cam Le Environment Enterprise	20
7	Hoa Vang Environment Enterprise	13
8	Lien Chieu Environment Enterprise	18
9	Son Tra Environment Enterprise	20
10	Ngu Hanh Son Environment Enterprise	15
11	Service Enterprise No.1	13
12	Service Enterprise No.2	16
13	Transport Enterprise	11
14	Landfill Management Enterprise	18
15	Consulting Center for Environmental Technology Investment and Development	6

Source: URENCO Da Nang

2.4.2 Current SWM Services by URENCO

According to the information and data provided by URENCO Da Nang, the recent record of solid waste collection is as outlined in the table below.

Table 2-12: Waste Collection by URENCO (2007-2013) (reproduction of Table 2-1)

Unit: tons/year

Classification	2009	2010	2011	2012	2013
Domestic Waste	205,009	223,521	232,233	252,504	262,182
Industrial Non-Hazardous Waste	2,914	3,242	3,917	3,723	4,199
Medical Non-Hazardous Waste	1,257	1,372	1,553	1,889	2,216
Sub-total	209,180	228,135	237,703	258,116	268,597
Hazardous Waste	363	565	453	404	359
Industrial Solid Waste	*219*	*415*	*267*	209	217
Medical Waste	*144*	*150*	*185*	613	576
Total (Hazardous + Non-hazardous)	**209,633**	**228,700**	**238,156**	**258,938**	**269,390**
Septic Tank Sludge	11,482	16,766	22,616	19.688	29.200

Source: URENCO Da Nang

According to the latest information, the total amount of waste collected by URENCO reached about 270,000 tons in 2013, which means that about 730 tons of waste are daily collected and transported to Khanh Son Landfill daily. Waste collection service coverage by URENCO has reached 92% in 2012. Majority of Da Nang Province have access to SWM services except rural villages in mountainous areas.

2.4.3 Revenue and Expenditure of URENCO Da Nang

The table below shows the revenue and expenditure of URENCO Da Nang during 2008-2012. The total revenue in 2012 is approximately 132.4 billion VND, which is equivalent to 6.2 million US dollar. About a half of revenue comes from direct collection of SWM service fees from various sources of waste generation such as households, business/commercial entities, industrial establishments, medical facilities, and so forth. The remaining half of the revenue is provided from Da Nang City government as budget allocation.

Table 2-13: Revenue and Expenditure of URENCO (2008-2012)

Unit: million VND

Item	2008	2009	2010	2011	2012
1. Revenue	66,300	78,176	84,776	105,589	133,150
1.1 Public Service Fees	23,561	25,674	29,247	36,256	47,290
1.2 Operation Budget	34,880	41,801	43,033	53,416	67,256
a. Business contract	32,033	38,117	42,012	-	67,096
b. Other budget allocations	2,047	3,484	1,020	-	160
c. Septic tank collection	800	200	0	-	0
1.3 Services for industrial waste	7,265	5,192	6,365	8,735	11,321
1.4 Services for hazardous waste	594	5,508	5,982	6,080	6,536
1.5 Miscellaneous services	0	0	150	1,101	747
2. Expenditure	64,902	76,953	83,659	104,826	132,064
2.1 Materials	13,875	13,894	16,260	22,516	29,712
2.2 Labors	29,133	46,255	47,219	60,269	75,523
2.3 Service Consignment	1,306	1,670	1,520	4,231	4,144
2.4 Miscellaneous expenses	18,904	12,764	13,426	12,155	16,481

Source: URENCO Da Nang

According to "The 2012 Annual Report on Solid Waste Management in Da Nang City", which was prepared by URENCO Da Nang and submitted to Department of Construction of the Da Nang People's Committee, the municipal solid waste management cost is reported as shown in the table below.

Table 2-14: Municipal Solid Waste Management Cost by type of activities (2012)

City	Waste Collection (VDN/ton)	Waste Transportation (VND/ton)	Waste Treatment and Disposal (VND/ton)	Total Cost of Domestic Waste Management (million VND/year)
Da Nang	By hand carts: 116,055		25,473	58,838 (233,018VND/ton)
	By trash box collection with trucks 167,016			
	By curbside collection with trucks 166,214			

Remark: Waste treatment and disposal cost only covers the current running cost of Khanh Son Landfill.

The unit cost of municipal SWM carried out by URENCO is approximately 233 thousand VND (USD 11.7) per ton of waste handled including collection, transportation and disposal. The above table also shows that the cost of waste treatment and disposal is only 25,473 VND (or 1.3 USD) per ton of waste.

On the other hand, the budget allocated for municipal SWM to URENCO is approximately 157 billion VND in 2013, of which 58.754 billion VND is the direct collection of SWM fee from waste generation sources. The budget allocation from Da Nang City is 6,214 million VND while no budget allocation from the National Government of Viet Nam.

Table 2-15: Budget Allocation for Municipal SWM by Da Nang URENCO (2012)

Unit: million VND

Year	National Budget	City Budget	Income from waste management fee	In addition, income from service fee	Total budget for domestic waste management
2012	0	67,255	47,290	18,604	133,150
2013	0	74,388	58,754	24,155	157,298

Note:
(1) This data is the financial report in the end of 2012 and 2013 that has been done and stamped by audit department
(2) Da Nang allocated 67.2 billion VND for environmental management activities including waste management. The budget allocated for Khanh Son disposal site was 6.214 billion VND (only 10% of the total budget)

2.4.4 SWM Service Fee Rate

SWM service fee collection from various waste generation sources is the major income source of URENCO for its operation. The SWM service fee is collected through door-to-door visits of waste generators by URENCO staff members (fee collectors). About 65,000 million VND are collected in 2012, accounting for 50% of the URENCO's income. The SWM service fee is collected from all types of waste generators including households, business/commercial establishments, factories, and so forth. The fee rate of SWM service is provided in accordance with the decision of Da Nang People's Committee. The latest fee rate of SWM services is as shown in the table below.

Table 2-16: Fee Rate of SWM Services in Da Nang

No.	Generation Sources/SWM Service Users	Fee Levels	
		Unit	Amount
I	**Households without any businesses**		
1	Households at the street frontage, and the first floor of the high rise condominium	VND/Household/month	20,000
2	Households at the alley; households at the high rise condominium (except the 1st floor)	VND/Household/month	15,000
3	Low income households at the condominium, inn, temporary houses	VND/Household/month	10,000
II	**Households with businesses**		
1	Street type 1, and 2	VND/Household/month	60,000
2	Street type 3,4 and 5; Streets without name, and not classified streets	VND/Household/month	45,000
3	Alleys	VND/Household/month	30,000
III	**Schools, kindergartens, offices, administrative offices, dormitory, armed forces camps**		
1	Waste amount < 1m3 per month	VND/unit/month	100,000
2	Waste amount > 1m3 per month above	VND/m3 waste	125,000
IV	**Enterprises, shops, hotels, restaurants**	VND/m3 waste	160,000
V	**Hospital, medical centers**		
1	Domestic waste from the medical centers at wards or commune levels.	VND/unit/month	100,000
2	Domestic waste from hospital and other medical centers	VND/m3 waste	160,000
VI	**Factory and manufacturing facilities**		
	Domestic waste	VND/m3 waste	160,000
VII	**Train stations, bus stations and other areas**	VND/m3 waste	160,000
VIII	**Small business traders on the pavement**	VND/unit/month	1,500
IX	**Hazardous waste**		
1	Medical hazardous waste		
1.1	Hospital; district medical centers	VND/kg	10,000
1.2	Commune medical center	VND/unit/month	200,000
1.3	Ward medical center	VND/unit/month	300,000
1.4	Private medical centers conducting the surgery	VND/unit/month	300,000
1.5	Private medical centers without conducting the surgery	VND/unit/month	200,000
2	Hazardous industrial waste		
2.1	Processed by incineration method	VND/kg	6,000
2.2	Processed by solidification method	VND/kg	5,000

Source: Decision 40/2011 QD-UBND dated Dec.31, 2011 by Da Nang People's Committee.

2.4.5 Operation of Waste Transfer Stations

URENCO is currently operating 6 transfer stations in Da Nang. At these transfer stations, the wastes collected by push/handcarts and small collection trucks are transferred to bigger container trucks before transporting to Khanh Son final disposal landfill. Among the six transfer stations, the outline of Thanh Loc Dan and Hoa An stations are summarized in the tables and figures below.

Table 2-17: Outline of Thanh Loc Dan Transfer Station

Item	Content
Total Area	400m^2
Collection areas covered	The extent within a radius of 1km from the station (mainly wastes from households, market, and offices)
Average amount waste received	16 tons/day
Loading capacity of compactor container	2 units of 8 ton compactor containers
Operation hours	AM5:00-PM9:00
Number of staff	Transfer station operators: 4 Waste collection workers: 30 staffs
Collection method	Domestic waste from household is disposed at trash boxes located on the streets while URENCO regularly collects domestic waste from these trash boxes by trucks or pushcarts and brought into transfer station.
Considerations to the neighborhood	Deodorization system is installed at waste transfer station to prevent dispersion of offensive odor from waste.

Overview of the facility

Collection of trash box by pushcart

Containers (compactors are behind them)

Trush boxes collected by pushcarts

Figure 2-10: Photos of Thanh Loc Dan Transfer Station

Table 2-18: Outline of Hoa An Station

Item	Content
Area	400m^2
Target area of waste collection	The extent within a radius of 1km from the station (mainly collect wastes from households, markets, restaurants, and offices)
Designed capacity	80 tons/day
Current capacity	24 tons/day
Average amount of treated waste	20 tons/day
Method of transfer	Compactor container method (using 2 compactor containers)
Loading capacity	8 tons/container
Operation hours	PM6:00-AM4:00
Number of staffs	Transfer station operators: 4 Waste collection workers: 30
Collection method	The waste collectors go around the community with carts or small cars, ringing a bell to collect waste. The people who hears the bell comes out and put the waste into the trash boxes carried by collectors.
Considerations to the neighborhood	Deodorization system is installed at waste transfer station to prevent dispersion of offensive odor from waste.

Overview of the facility

Container truck

Containers (compactors are behind them)

Waste inside the compactor

Figure 2-11: Photos of Hoa An Station

2.4.6 Operation of Khanh Son Final Disposal Landfill

a. Outline of Khanh Son Final Disposal Landfill

The table below summarizes the physical structure and current operation of Khanh Son final disposal landfill.

Table 2-19: Physical Structure and Current Operation of Khanh Son Landfill

<table>
<tr><th>Item</th><th>Contents</th></tr>
<tr><td>Period of use</td><td>From 2007</td></tr>
<tr><td>Address</td><td>No. 471 Nui Thanh St., Da Nang City</td></tr>
<tr><td>Landfill area and structure</td><td>Total landfill area: 13.83 ha (consisting of 5 cells)
<table>
<tr><th>Cell</th><th>Area</th></tr>
<tr><td>1</td><td>2.27 ha</td></tr>
<tr><td>2</td><td>2.73 ha</td></tr>
<tr><td>3</td><td>2.61 ha</td></tr>
<tr><td>4</td><td>2.85 ha</td></tr>
<tr><td>5</td><td>3.37 ha</td></tr>
<tr><td>Total</td><td>13.83 ha</td></tr>
</table>
NOTE: Area of cells were estimated by the JICA Survey Team through CAD drawing data</td></tr>
<tr><td>Facilities</td><td>▪ Leachate treatment facility
▪ Septic tank sludge treatment facility
▪ Incinerator for medical and hazardous waste
▪ Administration building</td></tr>
<tr><td>Waste received</td><td>▪ 736 tons/day on average in 2013.
▪ Landfill area Cell No.1 and 2 has been used for 5 years and have received approximately 1.2 million tons of waste.</td></tr>
<tr><td>Structure and method of landfill</td><td>▪ Structure: Controlled landfill with bottom liners, pipes for leachate collection, and regular soil cover.
▪ Planned height of landfill is 52 meter above ground level.
▪ Bulk density of disposed waste at landfill is regularly checked.
▪ Odor prevention chemical is sprayed twice per day.
▪ Insect prevention chemical is sprayed once a week on average, depending upon the condition of landfill.</td></tr>
<tr><td>Landfill equipment</td><td>▪ 3 bulldozers (40 ton, 30 ton and 20 ton capacity)
▪ No compaction is carried out.</td></tr>
<tr><td>Waste pickers</td><td>▪ There are approximately 200 waste pickers who registered themselves at Khanh Son Landfill.
▪ Waste pickers mainly collect materials such as papers, scrap metals, and plastics.</td></tr>
</table>

Landfill Cell No. 1 and 2

Edge of landfill Cell No. 2

Landfill Cell No. 3, 4 and 5

Waste pickers at landfill site

Figure 2-12: Photos of Khanh Son Final Disposal Site

b. Remaining Landfill Capacity of Khanh Son Final Disposal Site

The Study estimated the total and remaining landfill capacity of Khanh Son final disposal site based on the result of measurement survey. The capacity was estimated with the assumptions that the target height of landfill is 52 meter with a gradient of 1:2.0. The total landfill capacity was estimated as 3.42 million cubic meter of which 880 thousand cubic meters has already been occupied. Its remaining capacity was estimated to be approximately 2.54 million cubic meters.

The table and figure below outline the above estimation.

Table 2-20: Estimation of the Total and Remaining Landfill Capacity of Khanh Son

Item	Volume (m^3)	Remark
Total landfill capacity	3,415,242	Estimated based on the result of measurement survey
Volume already filled by disposed waste	672,271	Ditto
Volume of covered soil	207,450	Thickness of midterm soil cover (50 cm) Thickness of final soil cover (1m)
Remaining landfill capacity	2,535,521	

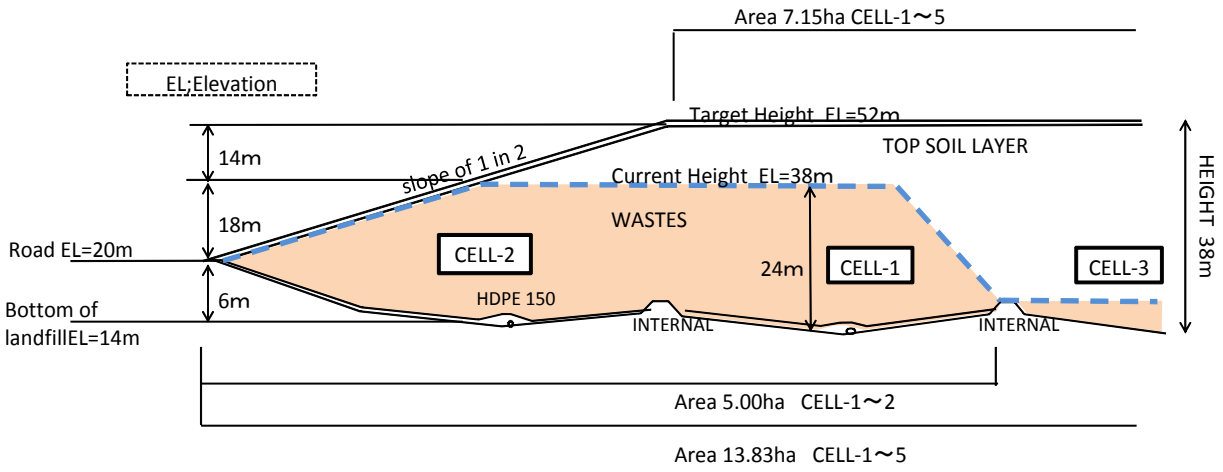


Figure 2-2-13 : Cross-Section View of Khanh Son Landfill

c. Leachate Treatment Facility

The leachate treatment facility at Khanh Son Landfill daily treats 300m^3 of leachate with by physicochemical treatment process that goes through 4 sedimentation tanks as shown in the table and figure below. The operation of leachate treatment facility is contracted out to a private operator by DONRE.

Table 2-21: Outline of the Leachate Treatment Facility in Khanh Son Landfill

Treatment capacity	300m^3/day
Operator	Quoc Viet Ltd. (private company) contracted by DONRE
Inspection	- URENCO inspects the “volume” of treated water - DONRE inspects the “quality” of treated water (water should meet standard B level of QCVN 25: 2009/BTNMT) **URENCO certifies the treated quantity and then DONRE pays to Quoc Viet Ltd.*

Anaerobic Pond No.1 (covered lagoon)

1st Reaction tank where $FeSO_3$ is added

1st Sedimentation tank

No retention pond

Figure 2-14: Photos of Leachate Treatment Facility

The table on next page compares the quality between before and after treatment. The data shows that the values of BOD_5 (20°C) and general nitrogen exceed the effluent standard for Viet Nam.

Table 2-22: Quality of Leachate before and after Treatment

Analysis Parameter	**Unit**	**Results**		**Wastewater Standard QCVN25：2009/BTMNT**
		Leachate before treatment	Leachate after treatment	**B1**
pH	-	6.8	6.9	—
TSS	mg/l	690	247	—
COD	mg/l	11,340.0	186.0	400
BOD5 (20℃)	mg/l	7,088.0	124.0	100
Ammoniac NH4+ (based on N)	mg/l	125	19.8	25
General Nitrogen	mg/l	247	341.6	60
General Phosphorus	mg/l	68.2	12.5	—
General Coliform	SL/100 ml	120,000	47,000	—

Remark: Samples taken on July 12, 2011

2.5 Current situation, challenges, and measures to be taken regarding 3R promotion activities

2.5.1 Current Situation

a. Sorted collection

In the past, sorted collection of organic and inorganic wastes was conducted as a pilot project for two months in a specific area within Da Nang City. However, the activity could not be expanded to the whole city for reasons such as lack of collection equipment and budget. URENCO had the plan to compost the collected organic wastes with mechanical biological treatment and to make oil with the collected plastics, but such facilities have not yet been constructed.

b. 3R in schoold and communities

DPC has the intention to promote 3R in schools and in communities, but has not yet been able to implement such activities for lack of finance and knowhow.

c. 3R in supermarkets

Some supermarkets in the city are promoting waste reduction through charging for shopping plastic bags. However, such efforts have not expanded and are implemented in only limited areas.

d. Environmental education

Environmental education was conducted simultaneously when conducting the pilot project on sorted collection.

2.5.2 Challenges and measures for improvement

Although there is the growing interest to promote 3R activities among DPC, URENCO, and certain supermarkets, 3R activities have been limited to only small-scale activities such as pilot projects. The challenges are the lack of financial and technical resources (i.e. know-how). In order to overcome these challenges, Japan could provide both of these resources.

Many Japanese municipalities have abundant experience in promoting 3R for municipal solid wastes from households and businesses. In addition, the Japanese consulting firms have also abundant experience in preparing master plans, conducting feasibility studies, and implementing technical cooperation projects. Thus, dispatching such local government officials and consultants from Japan to Vietnam could contribute to overcoming the problem of lack of technical know-how. In relation to financial issues, re-examining current environmental infrastructure system could lead to cost reduction. In addition, 3R activities that would lead to lower carbon consumption could be financially supported with JCM subsidies.

3 Examination of Intermediate Treatment Facility (ITF) Options

3.1 Determination of SWM Service Area and Population Framework

Khanh Son final disposal landfill currently deals with all the municipal solid waste generated within Da Nang city. The planned ITF will also cover the same waste for intermediate treatment. The population covered by the planned SWM services is estimated below.

As to the projected population up until 2030, the Study adopted the figure of 1.2 million, which is provided in the "Adjustment of Master Plan of Da Nang City to 2030 and Vision 2050 (AMPDC)"

The population growth between 2030 and 2036 was estimated based on regression analysis of the growth during 2010-2030. The projected population in 2036 will reach 2.4 million, which 2.6 fold of the population in 2010.

YEAR	Population	Relative increase rate from previous year
2010	926,018	103.52%
2011	951,684	102.77%
2012	973,800	102.32%
2013	1,000,000	102.65%
2014	1,027,000	102.65%
2015	1,054,000	102.65%
2016	1,082,000	102.65%
2017	1,111,000	102.65%
2018	1,140,000	102.65%
2019	1,170,000	102.65%
2020	1,200,000	102.63%
2021	1,263,000	105.24%
2022	1,329,000	105.24%
2023	1,399,000	105.24%
2024	1,472,000	105.24%
2025	1,549,000	105.24%
2026	1,630,000	105.24%
2027	1,715,000	105.24%
2028	1,805,000	105.24%
2029	1,900,000	105.24%
2030	2,000,000	105.24%
2031	2,062,000	103.09%
2032	2,126,000	103.09%
2033	2,192,000	103.09%
2034	2,260,000	103.09%
2035	2,330,000	103.09%
2036	2,400,000	103.09%

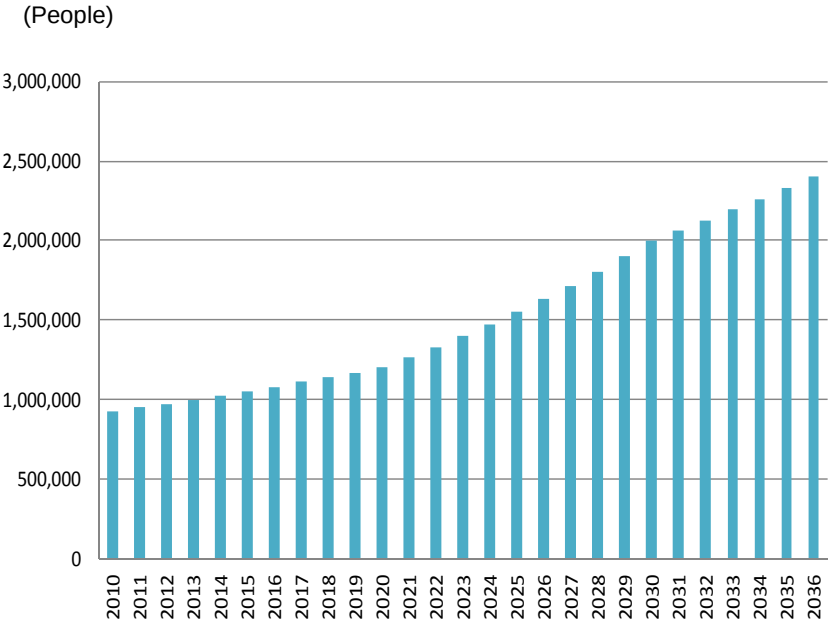


Figure 3-1: Projection of Population of Da Nang

3.2 Estimation of the Amount of Waste Generation and Treatment

3.2.1 Projection of Future Waste Generation and Treatment

The amount of future waste generation and treatment in Da Nang city is estimated as shown in the equation below.

(The amount of treatment)
= (Amount of waste generation)×(1.0 - Waste minimization ratio at sources)×(Collection coverage)
Where:
Amount of waste generation=(Population)×(Per capita waste generation)×(365 days/pear)
Collection coverage: The area or waste generation sources covered by waste collection service
Waste minimization ratio at sources: Percentage of waste reduced at sources by generators' efforts

Each factor defined in the above equation is assumed as shown in the table below.

Table 3-1: Assumptions in Estimating the future waste generation and treatment

Item	Assumptions
Per capita waste generation	According to the estimation on AMPDC, per capita waste generation in 2030 is set at 1.3 kg/day for urban area and 1.2 kg/day for rural area respectively. The average per capita waste generation in Da Nang city is 1.275 kg/day in 2030. Based on this estimation, the Study assumed that the average per capita waste generation will increase by 0.026kg/day every year during 2012-2030 while it will remain unchanged after 2030.
Collection coverage	Based on the target collection coverage of 97.5% in 2030 set in AMPDC, the Study assumed that it will proportionally increase between 2012 and 2030 to reach 97.5% and be kept after 2030.
Waste minimization ratio at sources	Waste minimization ratio at sources is assumed to increase by approximately 1.2%/year on average. It will reach 40% in 2030 and finally grow up to 50%. This waste minimization will be achieved by the following efforts at sources of waste generation: ▪ Waste reduction at sources ▪ Composting of organic waste at sources ▪ Separation of recyclable materials at sources

Table 3-2 shows the results of estimation on future amount of waste generation and treatment in Da Nang city.

Table 3-2: Projected Amount of Waste Generation and Treatment

Year	Population	Generated waste			Collection ratio	Recycle ratio	Waste to be treated		
		Annual amount	Daily amount	Per capita			Annual amount	Daily amount	Per capita
	persons	tons/year	tons/day	kg/capita/day			tons/year	tons/day	kg/capita/day
	(1)	(2)=(3)x365or 366	(3)=(4)x(1)	(4)	(5)	(6)	(7)=(8)x365 or366	(8)= (3)x(5)	(9)=(8)/(1)
2010	926,018	262,224	718	0.776	0.870	0.00	228,135	625	0.675
2011	951,684	271,661	744	0.782	0.875	0.00	237,703	651	0.684
2012	975,000	288,335	788	0.808	0.880	0.00	253,638	693	0.711
2013	1,001,000	304,714	835	0.834	0.885	0.00	269,735	739	0.738
2014	1,027,000	322,375	883	0.860	0.890	0.00	286,890	786	0.765
2015	1,054,000	340,853	934	0.886	0.895	0.03	297,475	815	0.773
2016	1,082,000	361,163	987	0.912	0.900	0.05	308,904	844	0.780
2017	1,110,000	380,031	1,041	0.938	0.905	0.08	318,280	872	0.786
2018	1,139,000	400,769	1,098	0.964	0.910	0.10	328,135	899	0.789
2019	1,169,000	422,418	1,157	0.990	0.915	0.13	338,355	927	0.793
2020	1,200,000	446,154	1,219	1.016	0.920	0.15	348,798	953	0.794
2021	1,263,000	480,340	1,316	1.042	0.925	0.18	366,460	1,004	0.795
2022	1,329,000	517,935	1,419	1.068	0.930	0.20	385,440	1,056	0.795
2023	1,399,000	558,815	1,531	1.094	0.935	0.23	404,785	1,109	0.793
2024	1,472,000	603,534	1,649	1.120	0.940	0.25	425,658	1,163	0.790
2025	1,549,000	647,875	1,775	1.146	0.945	0.28	443,840	1,216	0.785
2026	1,630,000	697,150	1,910	1.172	0.950	0.30	463,550	1,270	0.779
2027	1,715,000	750,075	2,055	1.198	0.955	0.33	483,625	1,325	0.773
2028	1,805,000	808,494	2,209	1.224	0.960	0.35	504,348	1,378	0.763
2029	1,900,000	866,875	2,375	1.250	0.965	0.38	522,680	1,432	0.754
2030	2,000,000	930,750	2,550	1.275	0.976	0.40	547,500	1,500	0.750
2031	2,062,000	959,585	2,629	1.275	0.976	0.42	547,500	1,500	0.727
2032	2,126,000	992,226	2,711	1.275	0.976	0.43	549,000	1,500	0.706
2033	2,192,000	1,020,175	2,795	1.275	0.976	0.45	547,500	1,500	0.684
2034	2,260,000	1,051,930	2,882	1.275	0.976	0.47	547,500	1,500	0.664
2035	2,330,000	1,084,415	2,971	1.275	0.976	0.48	547,500	1,500	0.644
2036	2,400,000	1,119,960	3,060	1.275	0.976	0.50	549,000	1,500	0.625

3.3 Estimation of the Remaining Capacity and Years of Khanh Son Final Disposal Landfill

Based on the current remaining capacity of Khan Son Landfill (2,535,521 cubic meter) at the time of October 2012 and the result of estimation on future waste generation and treatment above, the Study estimated the remaining years of Khan Son Landfill as shown in the table below.

Table 3-3: Projected Trend of Waste Disposal at Khan Son Landfill

Year	Annual solid waste amount (ton/year)	Annual sludge amount (ton/year)	Annual cover soil amount (ton/year)	Annual landfill amount (ton/year)	Annual landfill volume (m^3/year)	Remaining capacity of landfill (m^3)
2012	-	-	-	-	-	2,535,521
2013	268,597	2,920	16,291	287,808	287,808	2,247,713
2014	286,890	2,999	17,393	307,282	307,282	1,940,431
2015	297,475	3,078	18,033	318,586	318,586	1,621,844
2016	308,904	3,168	18,724	330,796	330,796	1,291,048
2017	318,280	3,244	19,291	340,815	340,815	950,233
2018	328,500	3,329	19,910	351,739	351,739	598,494
2019	338,355	3,416	20,506	362,277	362,277	236,217
2020	348,798	3,514	21,139	373,451	373,451	-137,234

Remark: Average specific gravity of waste is assumed at 1.0 ton/m3 based on the result of waste amount and composition survey conducted in the Study.

The Khan Son Landfill will be fully occupied by 2020 if all the waste collected is disposed without any treatment for volume reduction. The volume of landfilled wastes in Khanh Son disposal site and its lifetime is shown below.

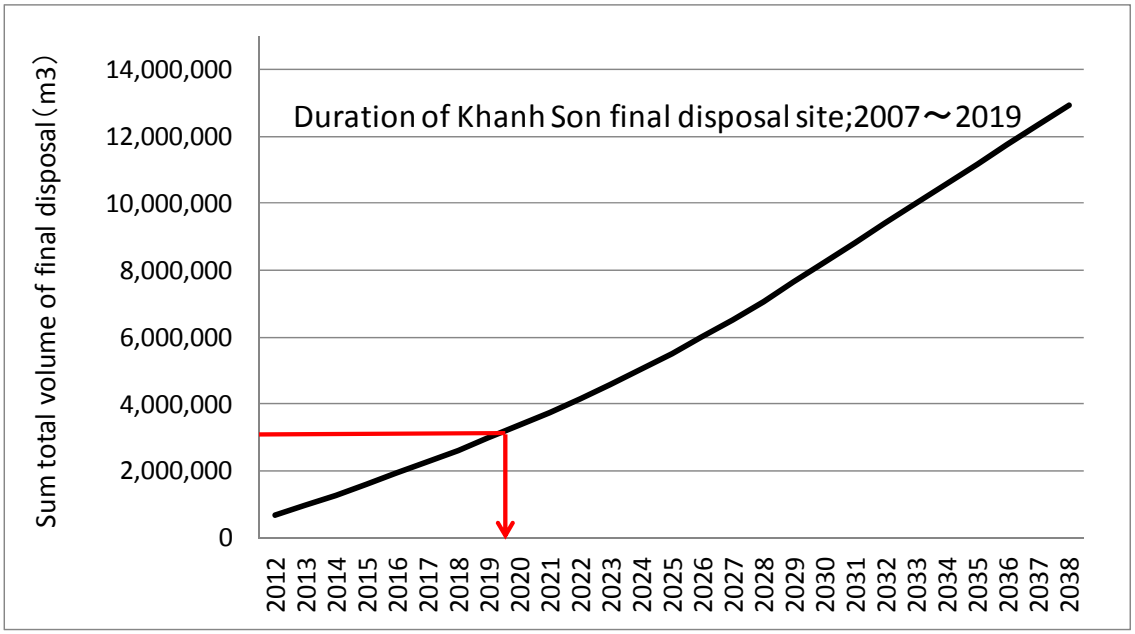


Figure 3-2: Lifetime of Khanh Son Disposal Site

3.4 Selection and Assessment of Intermediate Treatment Facility (ITF) Options

3.4.1 Selection of Intermediate Treatment Method

Intermediate treatment methods for wastes that are currently being commercialized are incineration, mechanical biological treatment (MBT or mechanical composting), and bio-gasification. These methods are compared in the table below.

Table 3-4 Comparison of Waste Intermediate Treatment Methods

	Incineration and Power generation	Non-incineration	
		MBT (mechanical composting)	Bio-gasification
Waste to be treated	Municipal solid waste, industrial waste (there is no need for careful sorting or selection before incineration)	Mainly for organic wastes such as kitchen wastes or night soil treatment residue (careful sorting and selection is necessary at collection or before treatment)	Mainly for organic wastes such as kitchen wastes or night soil treatment residue (careful sorting and selection is necessary at collection or before treatment)
Recoverable resource	Electric power	Compost	Biogas (can be used as fuel)
Final residue	Bottom ash, fly ash	Residue after selection	Residue after selection
Advantages	• It can treat various types of wastes • It can flexibly adapt to change in waste characteristics • Large amount of wastes can be treated in large-scale plants • Technology is mature as many plants have been constructed and operated • The power needed for the operation can be self-supplied • Power generation efficiency can be improved by simple pre-treatment depending on waste quality	• It can be introduced in a small scale • It can treat wastes that are not adaptable for incineration such as those with high water content • It does not generate combustion exhaust gas • If an independent facility for this technology is to be constructed, its CAPEX would be lower than incineration facility	• It can be introduced in a small scale • It can treat wastes that are not adaptable for incineration such as those with high water content • It does not generate combustion exhaust gas • If an independent facility for this technology is to be constructed, its CAPEX would be lower than incineration facility
Disadvantages	• If it is introduced in a small scale, the cost-effectiveness will lower. • Cost is relatively high	• Facility to treat residue after selection must also be constructed. • The market price of compost will largely affect the revenue. • Production of high-quality product will require high-quality pre-treatment. • If an independent facility for this technology is to be constructed, as there would be no power generation facility, power would have to be purchased. • If an independent facility for this technology is to be constructed, it must be equipped with odor prevention facilities.	• Facility to treat residue after selection must also be constructed. • Safe operation will require high-quality pre-treatment • If biogas is to be sold instead of electric power (as selling biogas is generally more profitable than selling electric power), the bio-gasification plant would have to purchase electric power for its operation • If an independent facility for this technology is to be constructed, it must be equipped with odor prevention facilities.

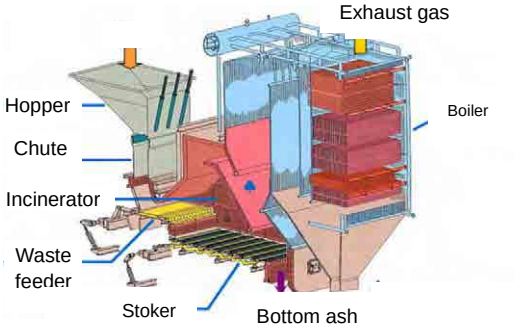
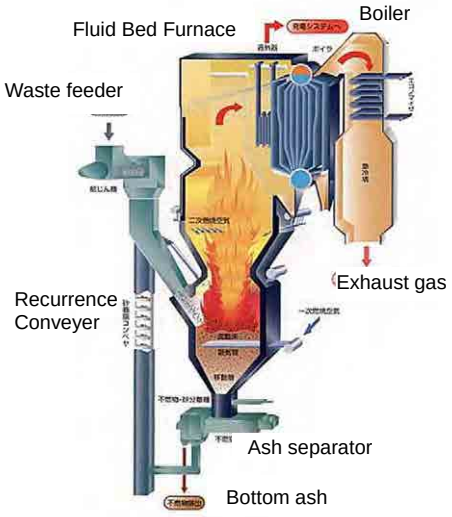
As shown in the table above, the feasibility of MBT will greatly depend on the market price of compost. Furthermore, both production of high-quality compost and production of biogas in a safe manner will require high-quality pretreatment and thus bring high investment risk. In addition, as both of these treatment methods will require treatment facility for residues, there is little impact to prolong the lifetime of the current disposal site. For these reasons, feasibility of introducing treatment facilities for incineration was examined in this Study.

3.4.2 Incineration Methods

a. Major Incineration Methods

In Japan, there are mainly two types of incinerators, namely stoker furnace and fluid bed furnace. The outline of these furnaces is explained in the table below.

Table 3-5 Outline of Stoker Furnace and Fluid Bed Furnace

	Stoker Furnace	Fluid Bed Furnace
Conceptual diagram		
Outline	Wastes move slowly upwards on the moving stoker. The combustion air blows from the lower part of the stoker, and wastes are combusted for an extended time through three steps of drying, combustion, post-combustion. Finally, ash is left as residue. Although most of the incombustibles and the ash content in the wastes are emitted from the end of the stoker, a part of the ash flies into the combustion gas and collected by dust collector as fly ash.	Wastes are instantly combusted when they contact high-pressure combustion air blowing from the bottom of the furnace and the high-temperature fluid sand. The incombustible wastes such as metal and rubble are discharged from the fluid bed with the fluid sand, and the ash content flies into the gas with the combustion gas and collected by the dust collector. The sand that is emitted from the bed is later separated with the incombustible wastes and is put back in the furnace to be re-utilized.

b. Selection of Incineration Method

The characteristics of the two incineration are compared in the table below.

Table 3-6 Comparison of Incineration Methods

	Stoker Furnace	Fluid Bed Furnace
Waste to be incinerated	Many plants for incineration of municipal solid waste and industrial waste have been operated. Wastes with size of about 300mm can be incinerated.	It is especially suitable for incineration of sludge. The wastes should be crushed to about 50mm or smaller.
Final produce	Bottom ash, fly ash	Bottom ash, fly ash
Advantage	• It can treat various types of wastes. • It can flexibly adapt to change in waste characteristics. • Large scale plants can be constructed. • Technology is mature as many plants have been constructed and operated.	• It is especially suitable for incineration of sludge. • Operation can be easily stopped in a short time.
Disadvantage	• It cannot incinerate wastes with significantly high calorie (3,000kcal/kg or higher) • As stopping its operation will take longer time compared to fluid bed furnace, it is not suitable to be operated for intermittent operation such as 8 operation of 8 or 12 hours per day.	• Wastes must be crushed or shredded • There have been no large scale plants that have been constructed and cooperated • There is a large amount of fly ash as the sand which is the combustion catalyst flies • The temperature and pressure in the furnace will be affected by waste amount and quality as wastes will be instantly combusted. Thus, controlling of waste and oxygen will need special attention. Dioxin level will rise if combustion becomes unstable
Construction cost	There is no significant difference although it would depend on scale of facility	
Operation cost	There is no significant difference although it would depend on scale of facility	
Power generation	There is no significant difference although it would depend on scale of facility	
Largest capacity per furnace in Japan	600 t/d	315 t/d

The Study Team selected the storker furnace as the most appropriate option for thermal treatment of the municipal solid waste in Da Nang for the following reasons:

- Storker furnace has the most operation records in the world as the thermal treatment technology of municipal solid waste and
- Stoker furnaces have enough flexibility against a variety of size and shape found in municipal solid waste.

JFE Engineering Corporation, a member of the Study Team has built and operated about 150 storker-type incinerators while constructing them in China, Taiwan, and Thailand with enough capacity of design, construction and operation.

3.4.3 Necessity and Basic Requirement for Establishment of Intermediate Treatment Facility (ITF) Options

With its high growth of population at 42% during 2000-2012, the waste generation in Da Nang City also increases with high rate at 28% during 2009-2013. This high pace of increase in waste generation is expected to continue with the projected population growth in the future with the rate of 3.5% per year.

Currently, all the municipal solid waste generated in Da Nang City is collected and transported through 6 transfer station to Khanh Son Landfill, the only destination of final disposal waste in the city.

Although its landfill capacity is approximately 3,420 thousand cubic meters, if collected wastes are directly landfilled at the rate of 200 to 300 thousand tons per year, the disposal site will become full by 2020.

Considering the growth of socio-economic development and urbanization of Da Nang city in the future, the city will need to acquire vast area of land in order to construct a new disposal site. Furthermore, environmental problems arising from the current Khanh Son landfill such as offensive odor, leakage and outflow of leachate especially in rainy season, and unsanitary conditions in the neighboring area will not be completely solved as long as the current direct disposal of waste without any treatment continues.

Therefore, when considering the waste treatment option for Da Nang city, it is most important that the amount of wastes to be landfilled and negative environmental impact decrease through introduction of intermediate treatment facility. In addition, the ability of the intermediate facility to provide energy is also a key element when considering the rising demand for energy and energy security.

Taking these issues into account, the followings options were considered based on the following evaluation criteria.

Intermediate treatment options

Option 0:	Direct landfill (business-as-usual scenario)
Option 1:	Introduction MBT facility
Option 2:	Introduction of incineration (and power generating) facility with treatment capacity of 1,000t/day
Option 2-1:	Introduction of incineration (and power generating) facility with treatment capacity of 1,500t/day
Option 3:	Introduction of incineration (and power generating) facility with treatment capacity of 300t/day and material recovery facility (MRF) for pre-treatment

Evaluation criteria

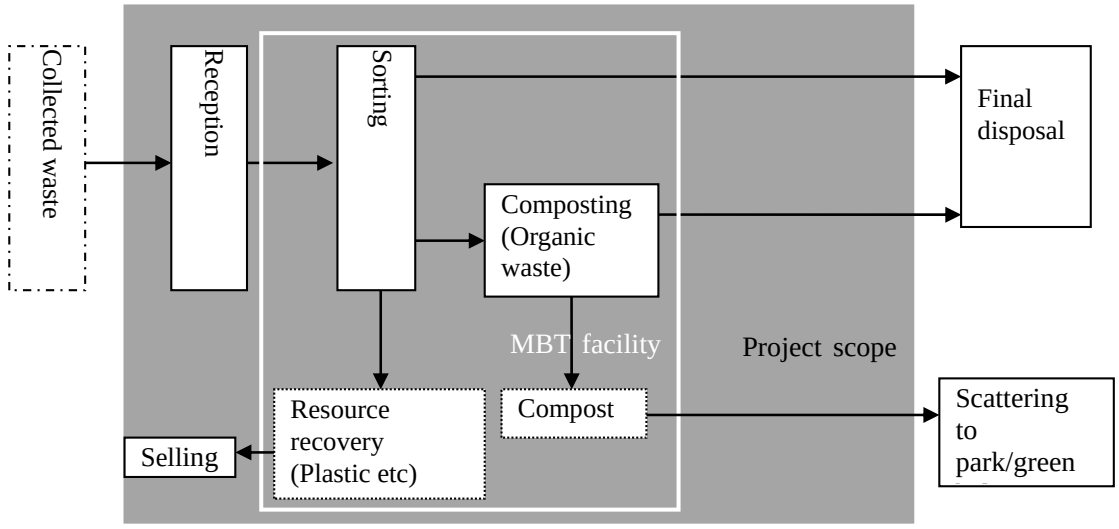
- Financial and economic feasibility taking into consideration the current budget for waste management
- Power generation potential
- Waste volume reduction rate
- Contribution to the solution of environmental issues arising from the current landfill

3.4.4 Intermediate Treatment Facility (ITF) Options

a. Option 1: Mechanical Biological Treatment (MBT)

a.1. Treatment Process

In this process, the received waste is first manually and mechanically separated into organic waste, recyclable materials (metal scraps, glass bottles, plastics, etc.) and other wastes. Separated organic waste is treated in aerobic condition to reduce its amount and produce compost-like material while the recyclables are to be sold to the dealers. The produced compost-like materials are to be used as soil (soil conditioner) in the park or roadside trees or cover soil of the landfill. Although the produced compost-like materials can possibly be sold as soil conditioner with limited use (since strict quality control is required for use of compost as fertilizer or soil conditioner to agricultural land.), the potential income from their sale is not accounted as the project revenue taking into account its high uncertainty. Remaining other wastes (inorganic non-recyclable waste) are disposed at landfill. The figure below illustrates the waste flow in this option.



a.2. Outline of Facilities

Outline of the facilities under Option 1 is shown in the table and figure below.

Table 3-7: Outline of Facilities in Option 1

Facilities	Treatment Capacity	Outline Specification
Waste Sorting/Separation Facility	1,000-1,500 ton/day	▪ After removing the waste bags, the unloaded waste is put on the belt conveyor to manually separate recyclable, non-combustible and hazardous materials ▪ Remaining waste is mechanically shredded and screened to collect organic waste. Recyclable materials are again collected manually from the remaining waste. ▪ Separated organic waste will be brought into aerobic treatment (composting) process ▪ Remaining residues is disposed at landfill
Aerobic treatment (composting) facility	540-840 ton/day	▪ Mechanical composting with compost turners and shovel loader is applied.

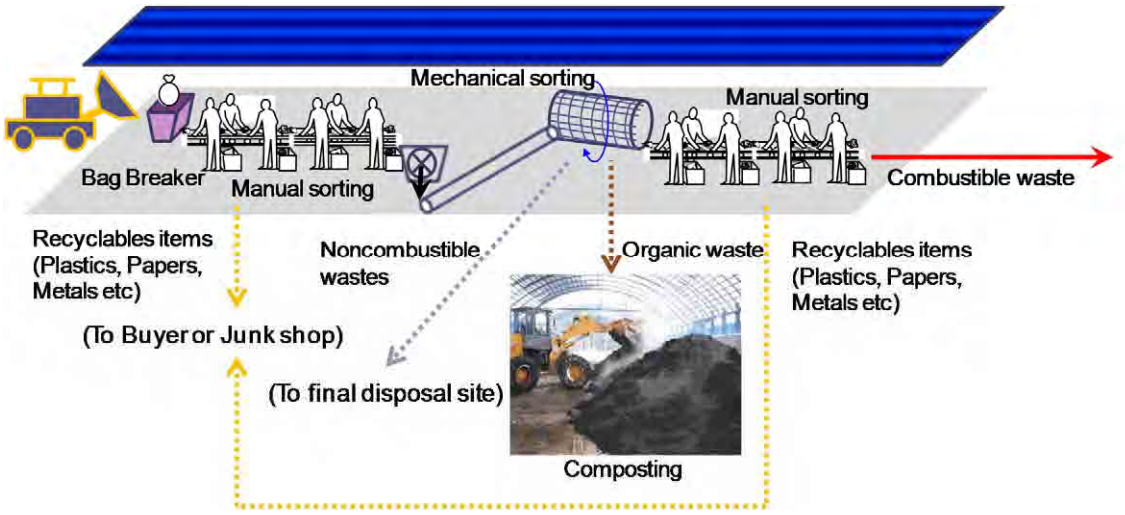


Figure 3-4: Image View of MBT Facility

a.3. Cost and Waste Reduction Rate of Option 1

The intermediate treatment cost of Option 1 is estimated to be 27.2 billion JPY (15.9 billion JPY for CAPEX[1] 11.3 billion JPY for OPEX[2]). Furthermore, the waste reduction rate by MBT facility (calculated by 100 – (landfilled wastes)/ (amount of wastes) x 100) is estimated to be approximately 40%.

b. Option 2: Waste-to-Energy (1,000 tons/day)

b.1. Treatment Process

Received waste is first placed at desiganted waste yard, where waste-pickers are allowed collect recyclable materials. Subsequently the remaining waste is incinerated while the heat produced are collected for power generation. Incineration residue will be disposed at landfill after proper treatment of hazardous materials. The figure on next page illustrates the flow of waste in this option.

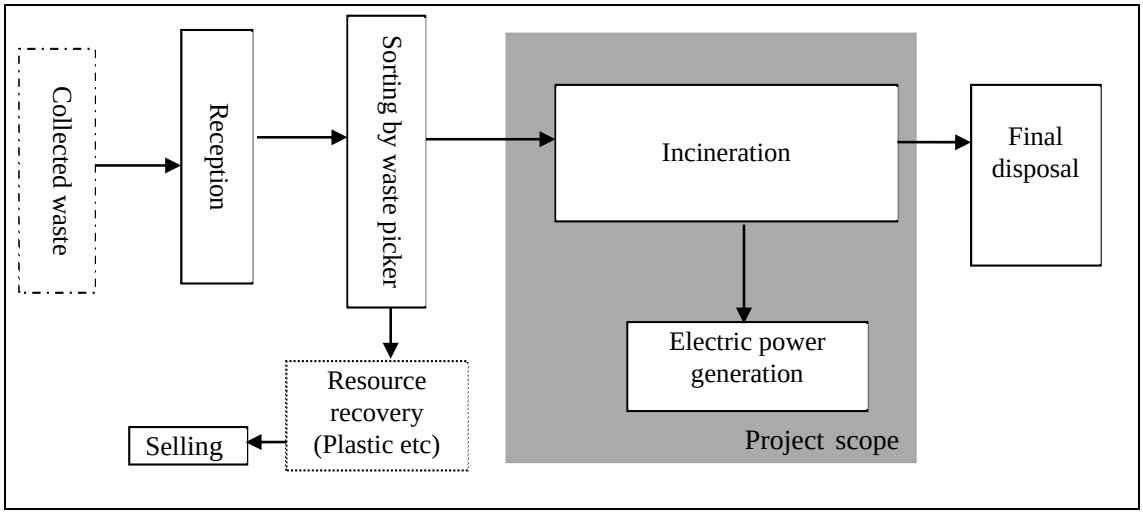


Figure 3-5: Waste Flow in Option 2

b.2. Outline of Facilities

Outline of the facilities is shown in the table and figure below.

[1] CAPEX: Capital Expenditure
[2] OPEX: Operational Expenditure

Table 3-8: Outline of Facilities in Option 2

Facilities	Capacity	Outline Specification
Waste-to-Energy Facility	1,000 ton/day (24hrs/day and 310-330 day/year operation) The amount exceeding 1,000 ton/day capacity will be directly disposed at landfill.	▪ 500 ton/day/unit * 2 units ▪ Power generation facility

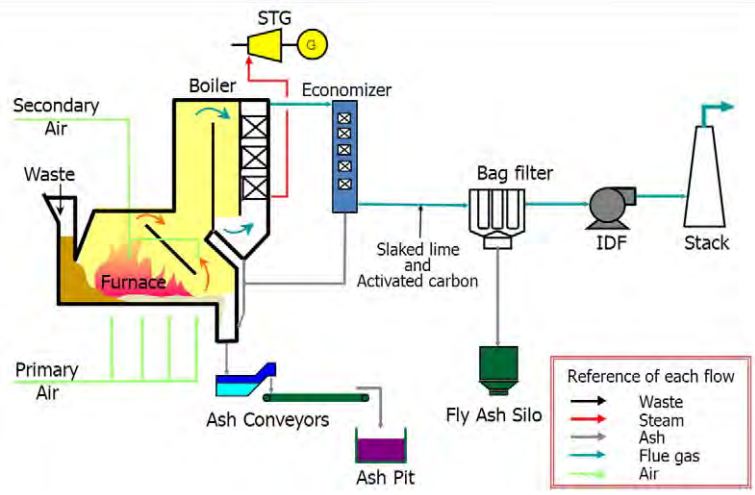


Figure 3-6: Image View of Waste-to-Energy Facility

b.3. Cost and Waste Reduction Rate of Option 2

The intermediate treatment cost of Option 1 is estimated to be 21.8 billion JPY (11 billion JPY for CAPEX and 10.8 billion JPY for OPEX). Furthermore, the waste reduction rate is estimated to be approximately 90% (as the receiving waste amount would exceed the treatment capacity, the reduction rate will become lower).

b.4. Cost and Waste Reduction Rate of Option 2-1

Under Option 2-1, an incinerator with treatment capacity of 500 t/day will be added to the facilities under Option 2. The intermediate treatment cost is estimated to be 30.5 billion JPY (16.7 billion JPY for CAPEX and 13.8 billion JPY for OPEX). The waste reduction rate is approximately 90%.

c. Option 3: MRF (Material Recovery Facility) with treatment capacity of 1,000-1,500 ton/day + Waste-to-Energy (300 ton/day)

c.1. Treatment Process

In this process, the received waste is first manually and mechanically separated into combustible wastes, recyclable materials (metal scraps, glass bottles, plastics, etc.), and other wastes. The recyclable materials would be sold to the middlemen who buy such items. Other combustible wastes are incinerated by the waste-to-energy facility. The incineration residue would be appropriately landfilled in the disposal site. Other wastes would be directly landfilled in the disposal sites. The figure below illustrates the treatment flow in this option.

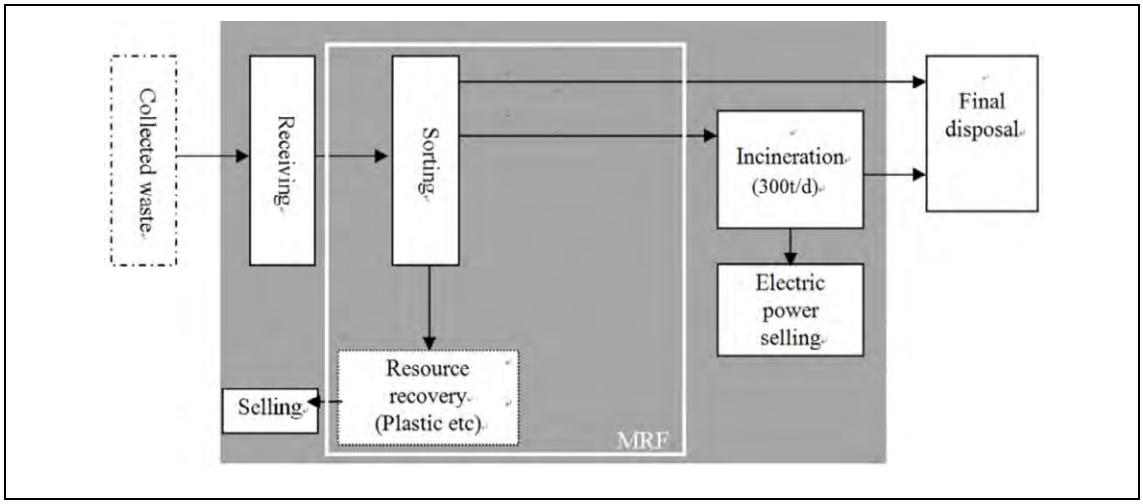


Figure 3-7: Waste Flow in Option 3

c.2. Outline of Facilities

Outline of the facilities is shown in the table below.

Table 3-9: Outline of Facilities in Option 3

Facilities	Treatment Capacity	Outline Specification
Waste Sorting/Separation Facility	1,000-1,500ton/day	▪ After breaking the waste bags, the unloaded wastes are dumped on the belt conveyor. Recyclable, non-combustible and hazardous materials are manually removed. ▪ Remaining wastes are mechanically shredded and sorted. The combustible wastes are sent to the waste-to-energy facility as RDF. ▪ Other wastes will be landfilled.
Waste-to-Energy Facility	300 tons/day (24hrs/day operation)	▪ 300ton/day/unit * 1 unit ▪ Equipped with power generation facility

c.3. Cost and Reduction Rate of Option 3

The intermediate treatment cost of Option 3 is estimated to be 12.2 billion JPY (6.3 billion JPY for CAPEX and 5.9 billion JPY for OPEX). Furthermore, the waste reduction rate for MRF and waste-to-energy facility is 70% compared to the volume of received wastes and approximately 90% if only considering the waste-to-energy facility.

3.4.5 Comparison of ITF Options

Table below compares the ITF options mentioned above by several different criteria.

Table 3-10: Comparison of ITF Options

	Option 0	Option 1	Option 2	Option 2-1	Option 3
Treatment Process	Direct Landfill	MBT	Waste-to-Energy	Waste-to-Energy	MRF + Waste-to-Energy
Treatment Capacity	-	MBT: 1,000 to 1500 ton/day	Waste-to-Energy: 1,000 ton/day	Waste-to-Energy: 1,500 ton/day	MRF: 1,000 ton/day Waste-to-Energy: 300 ton/day
Amount of waste treated	927 to 1,500 ton/day	927 to 1,500 ton/day	850 to 900 ton/day	1,274 to 1,356 ton/day	850 to 900 ton/day
Annual working days	365 days	365 days	310 to 330 days	310 to 330 days	310～330 days
The expected waste reduction rate of waste disposed at landfill	0%	40%	Approximately 90%	Approximately 90%	Approximately 70% (If the focus is only on incineration facility, approximately 90%)
Required landfill volume until 2018	9.8 million m^3	3.6 million m^3	3.3 million m^3	1.0 million m^3	7.8 million m^3
Total cost for introduction of intermediate treatment facility (CAPEX and costs for 20 years between 2019 and 2038)	4.2 billion JPY	27.2 billion JPY	21.8 billion JPY (excluding income of 19 billion JPY from power sales)	30.5 billion JPY (excluding income of 23.2 JPY from power sales)	12.2 billion JPY (excluding income of 6.6 billion JPY from power sales)
Tipping fee (JPY/ton)	130 JPY/ton*	6,700 JPY/ton**	5,350 JPY/ton	5,360 JPY/ton※2	3,000 JPY/ton※2

* The actual unit price for treatment and disposal is 25,473 VND per ton of waste (approximately 1.3 USD)

** Economic Internal Rate of Return (EIRR) was assumed to be 18%

The cost of "Option 0: Direct Landfill" is estimated based on the cost records of construction and operation of the existing Khanh Son Landfill with the assumption that the new landfill can be built on same conditions. Therefore, it does not include the incremental cost of transportation due to further location of new landfill and compensation for the people who may be relocated to other places due to construction of new landfill.

Currently, Da Nang City does not have any concrete plan of new landfill construction with no activity of potential land identification. The future plan of new landfill will be examined after receiving assessing the proposals of intermediate treatment facilities from investors including the result of this Study.

Table 3-11: Total Unit Cost for Installation and Operation of New Landfill Site

Item	Unit Cost (JPY/waste ton)
Land Acquisition	110
Construction (Landfill area and Leachate treatment facility)	100
O & M cost for Landfill operation	130
O & M cost for Leachate treatment operation	90
Total	430

Source : estimated by the study team based on the existing data

Note : not include solid waste transportation cost and various type of compensation cost

3.4.6 Selection of Optimum ITF Option

The optimum ITF option for Da Nang City is selected in consideration of cost performance in accordance with the waste reduction rate and the tipping fee.

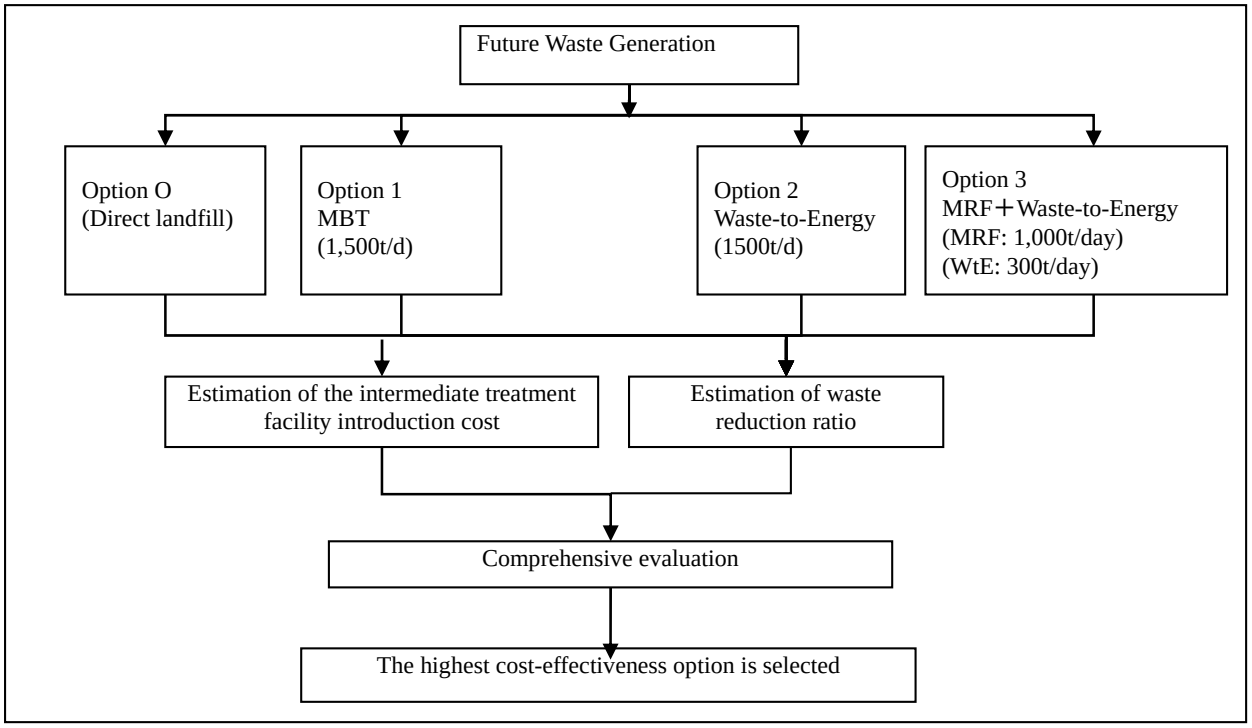


Figure 3-8: Procedure for Selecting the Optimum ITF Option

Considering the remaining capacity of the current Khanh Son disposal site and the vision of Da Nang city to become an "environmental city", introduction of large-scale waste incineration and power generation facilities under Option 2 (capacity of 1,000 ton/day) or Option 2-1 (capacity of 1,500 ton/day) is the best option. However, if the options are evaluated based on the cost effectiveness for reducing wastes, Option 3 would be the most cost effective, as it would reduce 1 ton of waste with the lowest cost.

Considering the current financial conditions of Da Nang city, the tipping fee under Option 2 and Option 2-1 which is 5,350 JPY/ton is believed to be too high. However, acquiring new land for a new disposal would be very difficult if not possible. Even if it is possible, it is clear that it would cause the same social and environmental problems that Khanh Son final disposal has caused such as bad odor, water pollution, and resettlement of residents.

Therefore, it can be said that the best option would be to first introduce Option 3 with the tipping fee of 2,500 JPY/ton in order to reduce the amount of final disposal and then to introduce Option 2 and Option 2-1 if financial capacity of Da Nang City improve.

The proposed tipping fee of 2,500 JPY/ton is considered reasonable in consideration of the maximum tipping fee set in the international bidding of "Waste-to-Energy" facilities in Jakarta and Bandung, Indonesia as shown in the table below.

Table 3-12: Comparison of Tipping Fees

City	Da Nang	Jakarta	Bandung
Treatment Capacity (ton/day)	300	1,000	700
FIT Power selling price	JPY 10/kwh	JPY 25/kwh	JPY25/kwh
Tipping Fee	JPY 2,500/ton	JPY4,000/ton	JPY3,750/ton

Source: Bisnis Indonesia (26 July 2013)

3.5 Impact of the project to the existing leachate treatment facility and countermeasures

3.5.1 Impact to the leachate quality

The change in leachate quality (i.e. BOD) from Khanh Son disposal site under Option 3 has been calculated. Here, the change of landfilled wastes due to introduction of incineration facilities has been examined. Thus, the change of water quality (BOD) from Option 0 to Option 2 has been calculated as shown in Figure 3-9 and Table 3-13.

Under Option 2, as most of the wastes to be landfilled would be ash (bottom ash), BOD would be below 1,700 mg/l after approximately 1 year after start of operation. Meanwhile. The BOD under Option 0 would be above 1,700 mg/l over long years.

Under the business-as-usual scenario, if direct landfill is continued until 2036 regardless of the landfill capacity (here named Option 0), BOD would be in the long term between 2,000 and 2,500 mg/l. For these reasons, it can be concluded that Option would greatly contribute to improvement of leachate quality.

Table 3-13: Change in leachate quality (BOD) from change in wastes to be landfilled in Khanh Son Disposal Site

Year	Option 0-1 Direct landfill (business-as-usual)	Option 2 Waste incineration and power generation (maximum treatment capacity: 1,500t/d)
2017	2,498	1,651
2018	2,471	1,598
2019	2,498	1,595
2020	2,347	1,687
2021	2,223	1,193
2022	2,320	1,042
2023	2,288	950
2024	2,194	462
2025	2,237	556
2026	2,073	541
2027	1,926	716
2028	1,811	1,200
2029	1,981	1,480
2030	2,004	1,469
2031	1,906	1,534
2032	1,986	1,574
2033	1,867	1,463
2034	1,736	1,459
2035	1,689	749
2036	1,596	776

Calculation method

- BOD was calculated based on change in BOD over the years in each cell and the amount of leachate in each cell
- The amount of leachate from the cells was assumed to be $50m^3$/ha based on the current conditions of leachate treatment.

- The initial BOD level of leachate was established for each landfilled wastes as follows and it was assumed that the BOD level would decrease by 50% in 5 years.

Type of landfilled wastes	Leachate quality (BOD)	Basis
Directly landfilled wastes, septic sludge	3,000 mg/l	Average of results measured between May 2009 and October 2012
Incombustibles, ash, residue from compost	250 mg/l	Source: Toshihiko Matsuto, "*Analysis, planning and evaluation of municipal solid waste treatment system*"

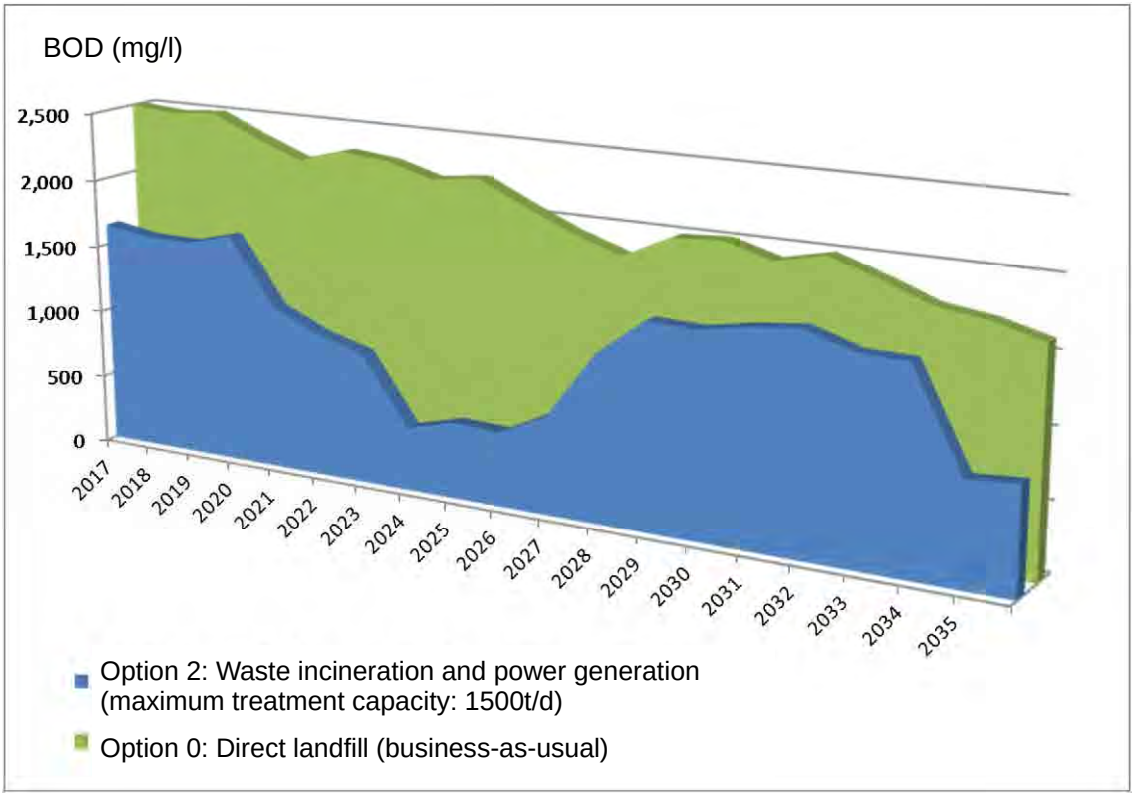


Figure 3-9 Change in leachate quality

3.5.2 Treatment capacity of leachate treatment facility and measures for improvement

Currently at Khanh Son disposal site, Cell 3 is being landfilled. As Cell 4 and 5 would be landfilled in the future, the catchment area for leachate would increase and thus the amount of leachate would also increase. In this section, the amount of leachate that would be generated in the future was calculated and whether the treatment capacity of the existing facilities would be sufficient was examined. The calculation was conducted for the following cases.

Table 3-14: Cases for calculating the necessary leachate treatment capacity at Khanh Son Disposal Site

Case		Stage of landfill	Area		
			Area being landfilled (m^2)	Area already covered with soil (m^2)	Area with impermeable liner (m^2)
Current situation	Case 1	Landfilling Cell 3	26,100 Cell 3	50,000 Cell 1-2	- -

Case		Stage of landfill	Area		
			Area being landfilled (m^2)	Area already covered with soil (m^2)	Area with impermeable liner (m^2)
When leachate amount is maximum	Case 2	Landfilling Cell 5	33,700	104,600	-
			Cell 5	Cell 1-4	-
	Case 2-1		33,700	28,500	76,100
			Cell 5	Cell 4	Cell 1-3
After completing landfill	Case 3	Landfill is completed	-	138,300	-
			-	Cell 1-5	-
	Case 3-1		-	88,300	50,000
			-	Cell 4	-

a. Assumptions for calculation

a.1. Rainfall

The amount of rainfall in Da Nang City for the last ten years are shown in table below. The rainfall range from 1375mm in 2004 to 3719mm in 2011, and the average is 2416mm. In the calculations, the data in 2008 was used as it was considered closest to the average rainfall in the ten years.

Table 3-15: Rainfall data of Da Nang City

No		1	2	3	4	5	6	7	8	9	10
Year		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Number of days		365	365	366	365	365	365	366	365	365	365
Annual rainfall (mm/year)		2365.8	1739.5	1375.1	1871.2	2258.7	3097.9	2462.7	3036.1	2236.8	3715.9
Average daily rainfall(mm/d)		6.5	4.8	3.8	5.1	6.2	8.5	6.7	8.3	6.1	10.2
Month	Jan	32.7	22.0	87.9	36.0	98.8	157.3	84.3	152.1	87.9	163.2
	Feb	30.6	20.2	6.9	5.8	36.1	0.6	34.5	24.7	0.0	0.0
	Mar	3.7	37.6	9.5	36.4	2.6	58.8	55.2	35.0	10.3	33.2
	Apr	13.3	17.8	12.8	12.0	9.9	56.6	67.2	171.7	4.7	8.8
	May	38.5	110.3	43.7	20.2	69.7	160.1	159.4	67.3	62.1	35.5
	Jun	104.3	95.7	154.3	22.0	2.7	1.6	36.2	36.8	76.1	101.8
	Jul	30.2	12.7	244.1	136.3	140.2	26.2	21.4	188.2	245.2	13.2
	Aug	375.8	85.7	69.1	209.8	342.2	156.1	58.8	153.9	326.3	144.5
	Sep	526.9	478.0	128.6	236.0	421.1	255.0	223.0	1412.6	166.1	817.3
	Oct	527.4	412.6	266.1	510.1	599.1	1179.5	952.0	431.8	656.3	810.8
	Nov	470.2	295.2	258.1	432.2	279.1	876.7	571.1	196.6	549.2	1241.1
	Dec	212.2	151.7	94.0	214.4	257.2	169.4	199.6	165.4	52.6	346.5
Highest daily rainfall in the month	Jan	20.2	8.0	29.5	22.7	45.4	44.6	33.0	32.7	39.6	104.9
	Feb	15.5	16.1	6.9	2.8	10.0	0.3	21.8	19.1	0.0	0.0
	Mar	1.5	27.1	8.2	18.0	2.1	24.1	15.5	20.0	5.9	6.9
	Apr	11.1	9.0	10.5	4.2	3.4	26.2	60.9	65.3	3.5	6.9
	May	24.2	58.7	26.3	8.9	42.5	70.3	76.5	23.0	36.1	18.7
	Jun	46.8	26.5	68.0	9.5	2.5	0.9	11.8	32.4	36.4	72.5
	Jul	9.0	8.6	112.5	43.4	41.1	15.4	12.4	47.7	153.1	8.3
	Aug	156.6	38.7	19.2	166.6	76.6	81.5	13.5	74.5	153.8	92.6
	Sep	126.1	136.0	26.7	57.2	161.2	67.9	96.1	287.7	71.1	207.6
	Oct	135.3	90.8	82.5	77.2	165.4	295.2	110.1	90.9	119.1	214.0
	Nov	103.0	111.3	58.9	293.4	202.7	307.1	202.1	84.8	173.2	447.7
	Dec	75.5	52.1	23.7	63.8	53.3	41.1	49.5	99.3	15.2	73.1
Highest in first half		46.8	58.7	68.0	22.7	45.4	70.3	76.5	65.3	39.6	104.9
Highest in second half		156.6	136.0	112.5	293.4	202.7	307.1	202.1	287.7	173.2	447.7

Source: Data of Station: Da Nang, Province/City: Da Nang

a.2. Leachate coefficient

The monthly leachate coefficients which were calculated based on monthly average temperature and monthly sunshine hours are shown in the table below. The calculations for examination were conducted using monthly leachate coefficients.

Table 3-16: Monthly leachate coefficient

Month	Under landfill works C1	Landfill completed C2
Jan	0.62	0.37
Feb	0.00	0.00
Mar	0.00	0.00
Apr	0.00	0.00
May	0.00	0.00
Jun	0.00	0.00
Jul	0.13	0.08
Aug	0.60	0.36
Sep	0.88	0.53
Oct	0.93	0.56
Nov	0.93	0.56
Dec	0.86	0.52
Annual average	0.41	0.25

Possible evaporation amount was calculated by the penman method based on average monthly temperature and monthly sunshine hours.

When possible evaporation amount was equal to or larger than monthly rainfall, the leachate coefficient was set as zero.

a.3. Leachate retention potential

The leachate retention potential of Khanh Son disposal site are shown in the following table and figure.

Table 3-17: Area from which leachate is generated

Landfill area	Internal retention area	Depth of retention area	Porosity	Internal retention potential*
13.83ha	9.68ha	4.5m	20%	87,120 m3

* Landfill area x 70% x Depth of retention area (4.5m) x Porosity (20%)

* Internal retention area was calculated as 70% of landfill area

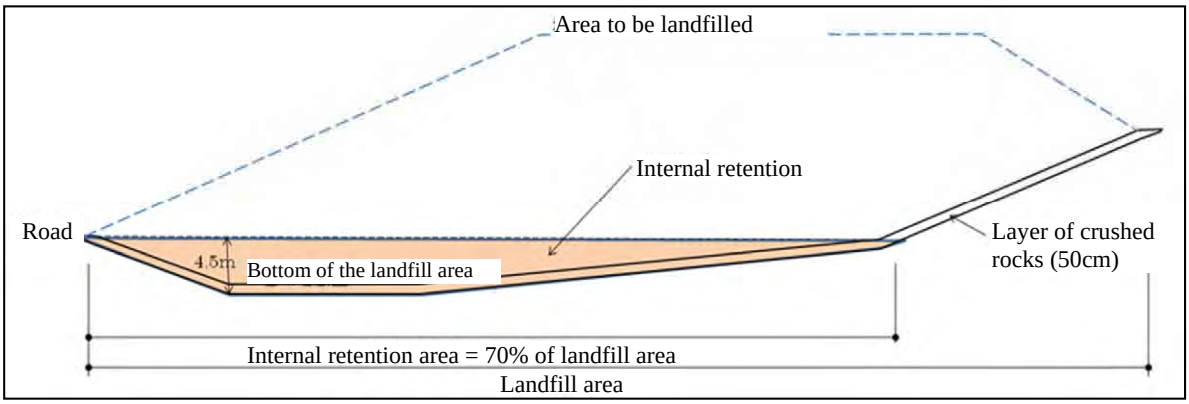


Figure 3-10: Internal leachate retention area

b. Results of calculations

The results of the calculations are shown in Table 3-18. As a result, if rainfall is at the average level, when landfilling Cell 3, the existing treatment capacity would be sufficient to treat the daily leachate. However, when starting to landfill Cell 4 and 5 and if area from which leachate would be collected increase, amount of leachate would increase and treatment of leachate would be difficult unless there are measures taken to decrease the amount of leachate.

It was concluded in this analysis that the treatment capacity of the existing facilities may be enough if areas where landfilling works have completed are covered with impermeable liner. When actually capping the areas with impermeable sheets, considerations should be taken for issues such as how the area would be used in the future, drainage of water on the sheets, and countermeasures for gas from the landfilled area.

Table 3-18: Summary of leachate balance calculations

Stage of landfill	Area			Possibility of treatment with existing facilities		
	Area being landfilled (m^2)	Area already covered with soil (m^2)	Area with impermeable liner (m^2)	Daily treatment capacity	Maximum internal retention	Evaluation
Landfilling Cell 3	26,100 Cell 3	50,000 Cell 1-2	- -	Can be treated with 96% of treatment capacity of 300m3/d	Will not exceed internal retention capacity	Possible
Landfilling Cell 5	33,700 Cell 5	104,600 Cell 1-4	- -	Treatment over 300m3/d would continuously be needed	Will exceed internal retention capacity	Not possible
	33,700 Cell 5	28,500 Cell 4	76,100 Cell 1-3	Can be treated with 76% of treatment capacity of 300m3/d	Will not exceed internal retention capacity	Possible
Landfill is completed	- -	138,300 Cell 1-5	- -	Treatment over 300m3/d would continuously be needed	Will exceed internal retention capacity	Not possible
	- -	88,300 Cell 4	50,000 -	Can be treated with 87% of treatment capacity of 300m3/d	Will not exceed internal retention capacity	Possible

In relation to septic tank sludge, the sludge is treated together with the leachate in anaerobic pond no.1 after solid-liquid separation.

As shown above, the amount of leachate will increase as landfill works advance. The amount of septic tank sludge may also increase in the future along with the increase of number of septic tanks. Therefore, the treatment facilities must be properly operated so that the pollution load will be constant and within the treatment capacity of the facilities.

4 Preliminary design

4.1 Planning basis

Planning basis for this study is shown in below table.

Item	Unit	Option 2	Option 3
Treated Waste	-	Collected wastes	Collected wastes
Plant Capacity	-	1,500 t/d (500 t/d x 3 lines)	300 t/d (300 t/d x 1 line)
Average lower calorific value of waste	kJ/kg (kcal/kg)	6,700 (1,600)	6,700 (1,600) After treatment by MRF, 9,200 (2,200)
Flue gas emission regulation	-	QCVN30:2010/BTNMT (for industrial incinerator)	QCVN30:2010/BTNMT (for industrial incinerator)
Water quality regulation (waste water)	-	QCVN40:2011/BTNMT-B (for industrial wastewater)	QCVN40:2011/BTNMT-B (for industrial wastewater)

As for Option 2, there are two methods to arrange the third furnace.

(1) First plant (Option 2) is constructed with space for line No.3. If it is decided to add line No.3, the first plant is modified and No.3 line is added.
(2) Individual 1-line plant is constructed near the first plant.

Necessity of No.3 line greatly depends on several societal backgrounds such as future waste management policy, economic development and so on. And if enough extending life of existing final treatment facility (landfill) is confirmed by Option 2, it may be supposed to be supported by introduction of other process. Therefore, latter method having high flexibility in future was applied as basis of following study.

With regard to Option 3, 3 lines with treatment capacity of 350 ton/day would be installed. In order to prepare for the increased wastes in the future, space for 1 additional line would be secured.

4.2 Outline and specification of the planned plant

4.2.1 Outline of the plant under Option 2

This plant mainly consists of the following facilities: waste receiving and charging system, incineration furnace system, flue gas cooling and heat recovery system (boiler), flue has cleaning system, heat utilization system (electric power generation), and ash (bottom & fly) discharging system. Incineration process flow is shown by below figure, and outline of each major system is described in following sections.

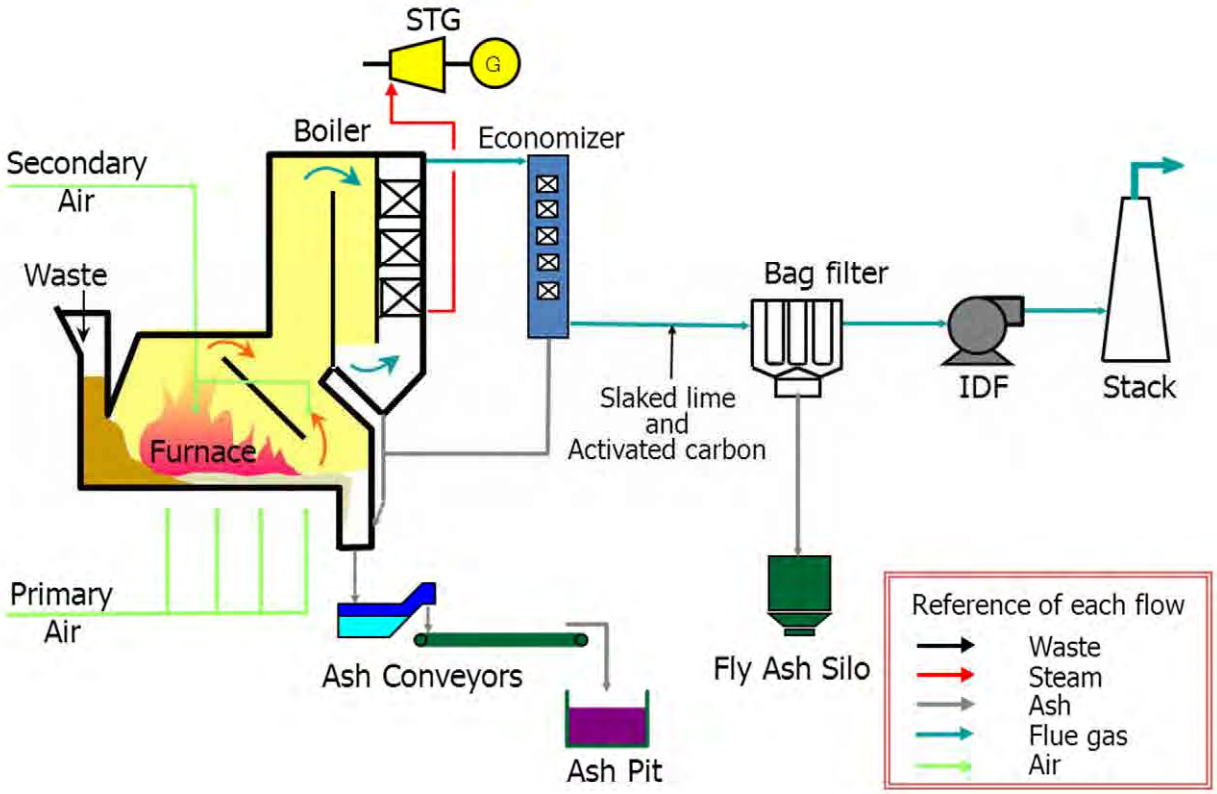


Figure 4-1 : Process Flow Sheet of Incineration System

a. Waste receiving and charging system

Waste is kept in waste pit temporarily after being weighted by truck scale. Waste pit has the volume for storing 3 days' furnace incineration capacity.

Waste inside pit is mixed up by waste crane and is charged into waste charging hopper.

b. Incineration furnace system

b.1. Waste charging hopper・chute

Waste charging hopper has a wide opening for not occurring bridges. With the combination of a waste chute having enough sealing height to prevent fire blow-off from furnace inside, it is able to bring waste into furnace smoothly.

b.2. Bridge-breakers are equipped inside the hopper for eliminating bridge.
Waste feeder

Charged waste is efficiently and smoothly fed to the furnace by a hydraulic driven pusher-type waste feeder. Waste amount fed by this feeder is controlled and/or set by automatic combustion controller or remote operation.

b.3. Combustion system (Combustion stoker)

Combustion system consists of movable grates and fixed grates. The type of grate is JFE-Hyper Grate, it has cooling fins inside grate piece, and therefore each grate piece can be cooled down efficiently

through combustion air (primary air) blowing in.
Speed of movable grates driven by hydraulic devices are controlled and/or set by automatic combustion controller or remote operation.
In addition, there are separated blocks to supply air for drying and combustion under the grates, and those supply air flow is controlled and/or set by automatic combustion controller or remote operation.

b.4. Furnace

In this plant, JFE Two-Way Flue Gas Stoker Furnace which has intermediate ceiling is proposed. Since Two-Way Flue Gas Stoker Furnace can accommodate stable waste combustion against wider calorific value of waste, it is optimum for Vietnam;

- Where has large difference of calorific value of waste between rainy season and dry season.
- Where increasing of calorific value of waste is assumed by economic growth.

Main combustion chamber consists of water cooling wall of boiler in order to maximize waste heat recovery. Inside furnace is lined with high heat resistant refractory, and for those parts where clinker relatively easily adheres, a structure of air cooling wall or water cooling wall is designed.

The intermediate ceiling divides flue gas into 2 streams which flow through flue gas main path and sub-path, and then turbulently mix up in secondary combustion chamber. Therefore, it is able to promote complete combustion by this raged confluence, while able to reduce generation of dioxins and NOx during combustion. And also, because this ceiling brings combusting waste effective thermal radiation, bottom ash quality is kept good condition, then it's possible to greatly reduce environmental impact to final landfill.

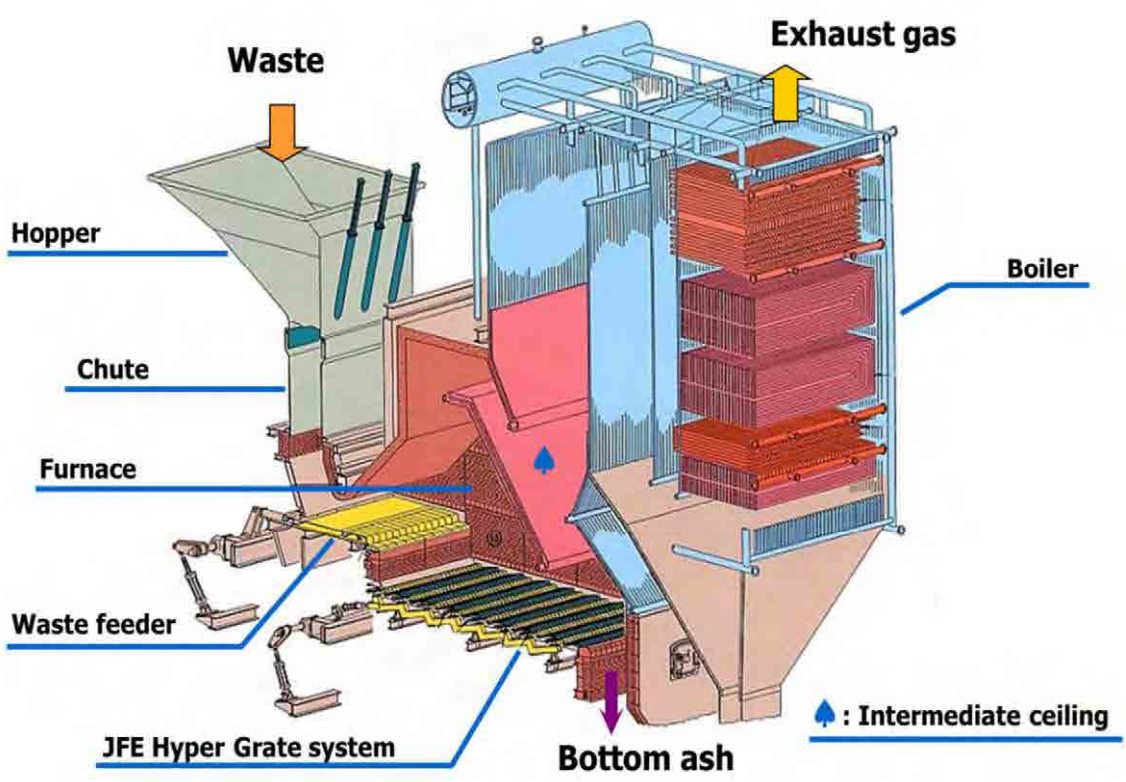


Figure 4-2 : Structure of JFE Two-Way Flue Gas Stoker Furnace

c. Automatic combustion control (ACC) System

Conventional automatic combustion control system was for keeping stability of combustion condition by feedback control which adjusts each operation values based on control value from waste incineration process.

Although feedback control is responsive to long-term change, it cannot be responded momentary change enough.

So JFE developed Hybrid ACC system which is able to respond momentary change by combining fuzzy control with conventional ACC system.

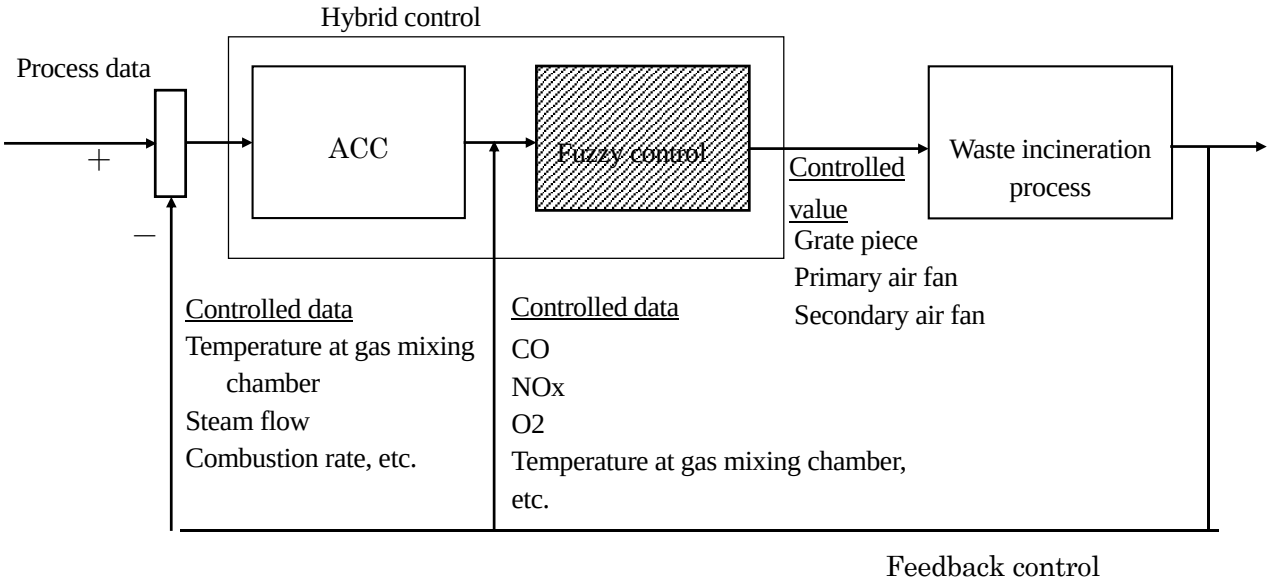


Figure 4-3 : JFE Hybrid ACC Concept

d. Flue gas cooling・Waste heat recovery system

Boiler is installed for cooling flue gas and for recovering waste heat to produce steam efficiently. A natural circulation boiler with single drum is applied for this planning.

Boiler drum is fed high temperature water which being deaerated in de-aerator and being pre-heated in economizer. Boiler water flows down in distribution pipe through falling down pipe by natural circulation, after being heated by heating pipe, heated water rises due to different specific gravity. Finally it returns to boiler drum, and then steam and water are separated.

High pressure saturated steam from boiler outlet is heated in super heater, and superheated steam is transported to steam turbine for power generation.

This boiler is operated under three component control: feed water flow, water level in boiler drum and produced steam flow, so it is excellently controllable, therefore this operation is especially optimum for a boiler adopted for a furnace which is selected for incinerating waste with variable calorie in wide range. These controls run automatically by setting steam flow.

Dust adhering to the surface of heat transfer pipes is cleaned by steam blow (soot-blower).

Surrounding equipment and ancillary equipment are also included in heat recover system, such as de-aerator, demineralizer, boiler chemical dosing unit, continuous blow-down unit, boiler water monitoring unit, etc.

e. Flue gas cleaning system

e.1. Acid gas (HCl: Hydrogen chloride, SOx: Sulfur oxide, HF: Hydrogen fluoride) removal equipment

Dry type system, slaked lime powder is injected into an inlet duct of a bag filter by high pressure air from an injection blower, is applied for this planning. This system consists of slaked lime silo, slaked lime feeding device, injection blower, etc.

Calcium chloride〔$CaCl_2$〕and calcium sulfide〔$CaSO_4$〕which are produced from HCl, SOx removal systems are powdery and captured in bag filter.

e.2. Dioxins removal equipment

Dry type system, activated carbon powder is injected into flue gas duct with slaked lime powder, is applied for this planning.

Activated carbon powder absorbs gaseous dioxins contained in flue gas. And these powders and dioxins particles are captured by bag filter.

Because JFE Two-Way Flue Gas Stoker Furnace is possible to restrain dioxins' generation by only adequate combustion control, it greatly contributes to decreasing activated carbon consumption.

e.3. Dust removal equipment

Bag filter is applied for this planning and removes dust including all solid products which occur in above mentioned harmful gas removal process.

Pulse jet method is adopted for removing those dusts sticking on the surface of filter cloth, which is realized by injecting compressed air through blow tubes every fixed time.

Removed dusts are discharged from bottom hoppers by bag filter conveyors, after that, those are transferred to a fly ash silo by fly ash conveyors.

e.4. Nitrogen oxides (NOx) removal equipment

Since JFE Stoker Furnace for this planning effectively promotes reduction reaction of NOx by two-way flue gas flow, it is possible to comply with the present environmental regulation by only appropriate furnace operation.

Therefore there is no plan about this equipment.

f. Waste heat utilization system

f.1. Steam turbine

Heat generated by waste incineration is recovered as steam, and steam is used for power generation by steam turbine.

Condensing extraction steam turbine is applied for this planning, and extraction steam is used for process equipment such as de-aerator.

f.2. Low pressure steam condenser

This is the equipment to cool and condense all exhaust steam from the steam turbine. Air cooled type condenser, which is not necessary to use large amount of cooling water, is applied for this planning,

g. Ash discharging system

g.1. Bottom ash

Completely combusted ash falls into bottom ash conveyor (water bath type) from bottom ash chute. Extinguished and humidified ash is temporarily stored at ash pit and is transported to final landfill by trucks at stated periods.

g.2. Fly ash

Fly ash discharged from bag filter is temporarily stored in fly ash silo. In this planning, fly ash is transported to outside (other stabilization facility or hazardous waste treatment facility) by bulk transporter without solidification and/or stabilization.

4.2.2 Outline of the plant under Option 3

This plant mainly consists of MRF facility composed of bag-breaking and sorting facilities and

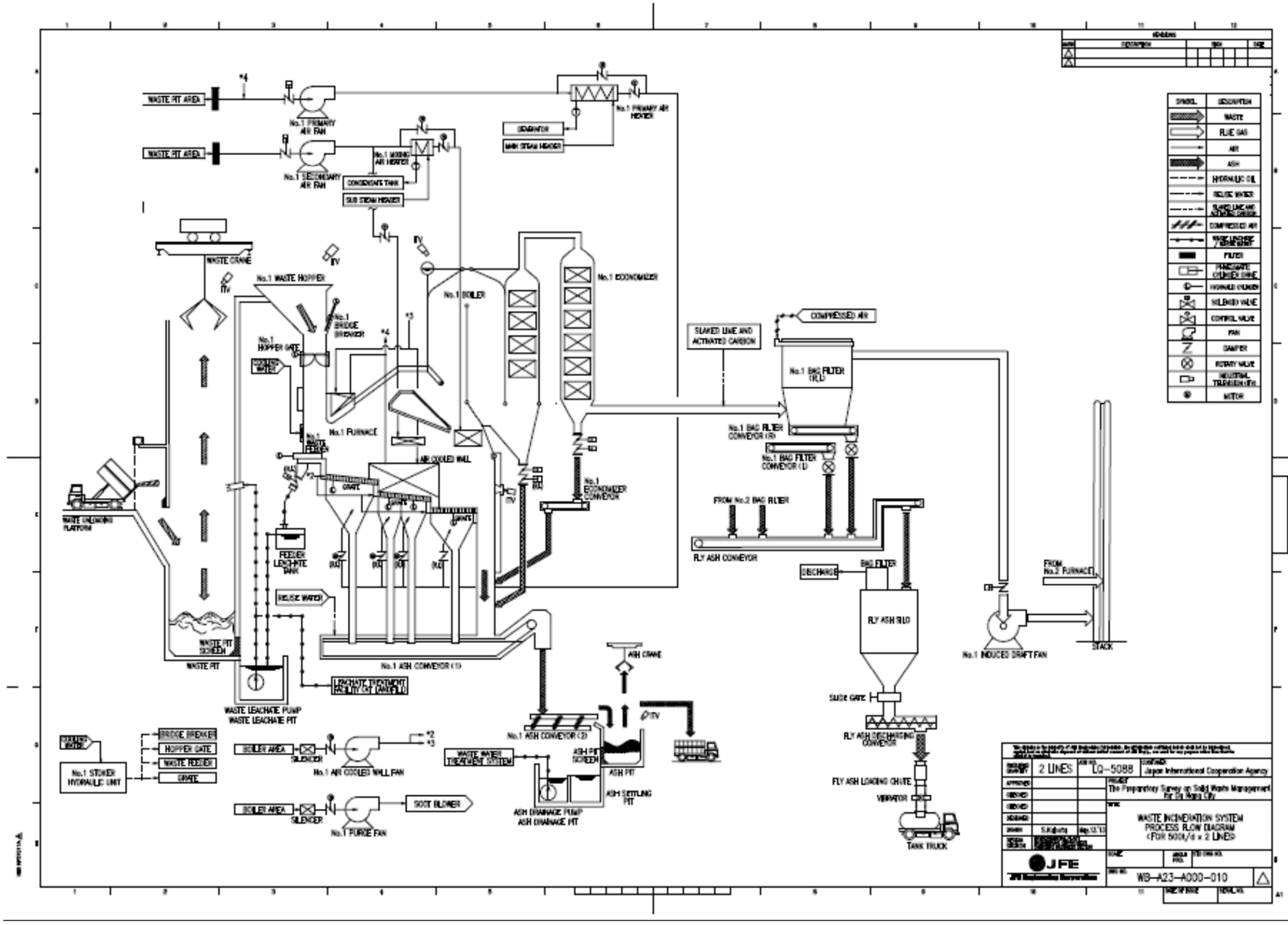
incineration facilities. The outline of MRF facilities are shown below. The wastes that are received are weighed and stocked in the waste pit. The capacity of the waste pit would be for receiving three days of wastes or more in order to adapt to the fluctuation of the wastes amount. The wastes in the waste pit are taken by the crane and discharged into the bag-breaker.

After the waste bags become broken in the bag-breaker facility, the wastes are discharged on the trommel screen and sorted by size. Wastes such as organic wastes would drop through the screen and the larger wastes such as plastics and paper would be left on top of the screen.

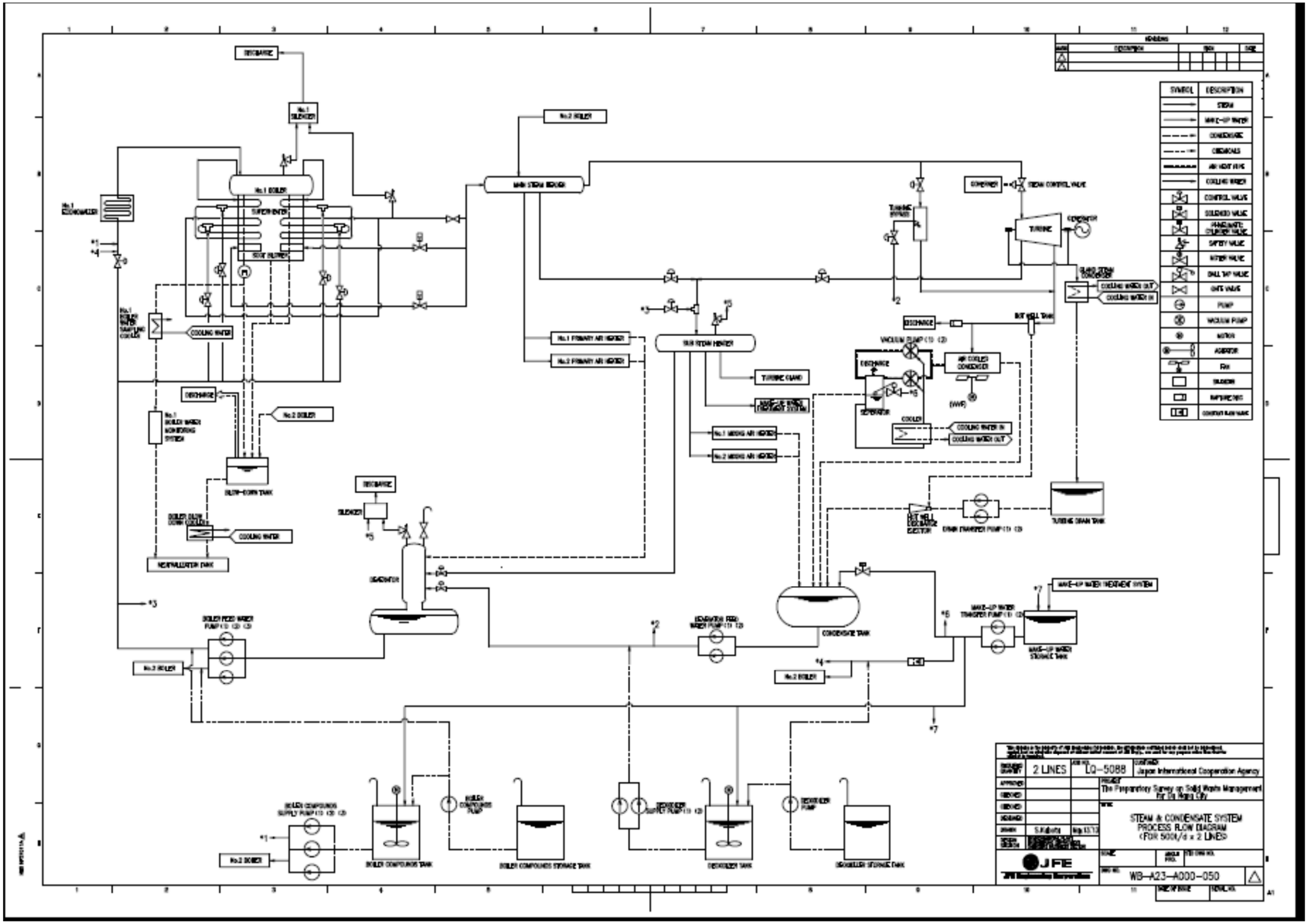
The wastes that are left on top of the screen are then discharged to the hand-sorting conveyor belt and the recyclable materials such as metals and glass are removed manually. After these materials are removed, the remaining wastes are sent to the incineration facilities as RDF. With regard to the wastes that have dropped through the screen, they would be landfilled in the final disposal site after removal of metals by magnetic sorter. The outline of the incineration facilities is the same with that under Option 2.

The process flow of Option 2, 2-1, and 3 are shown in the following pages.

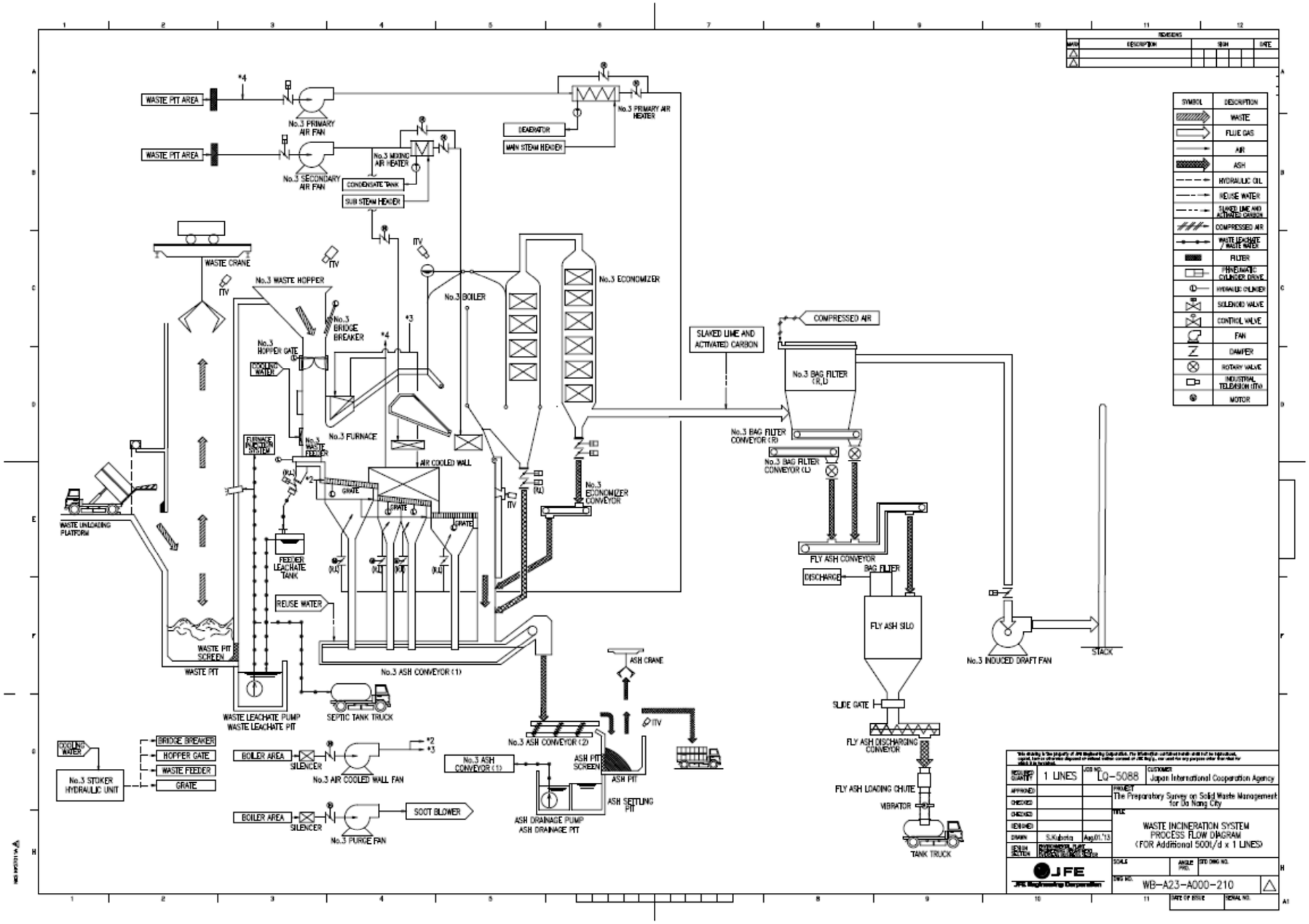
Option 2 Incineration System



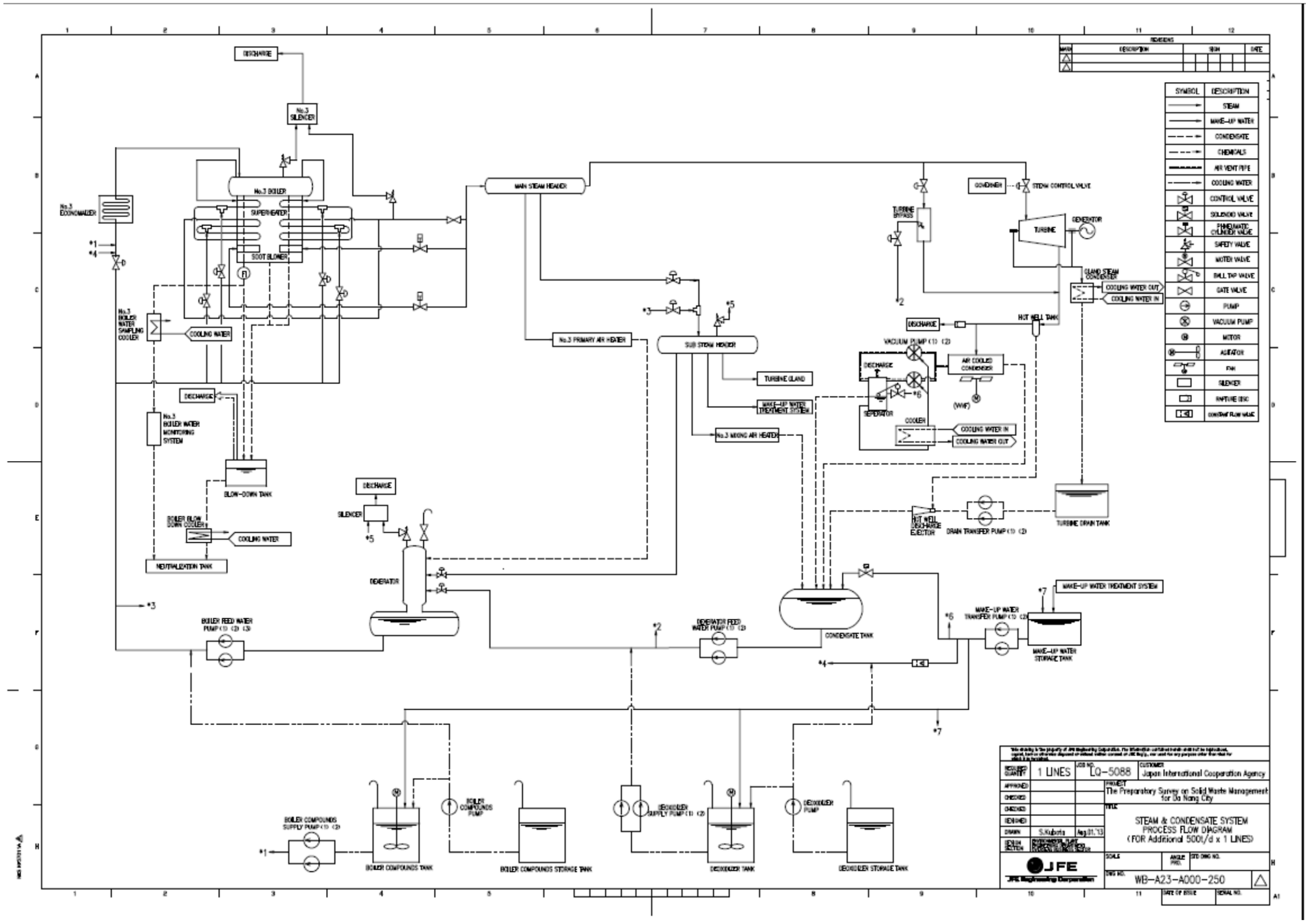
Option 2　Steam and Condensate System



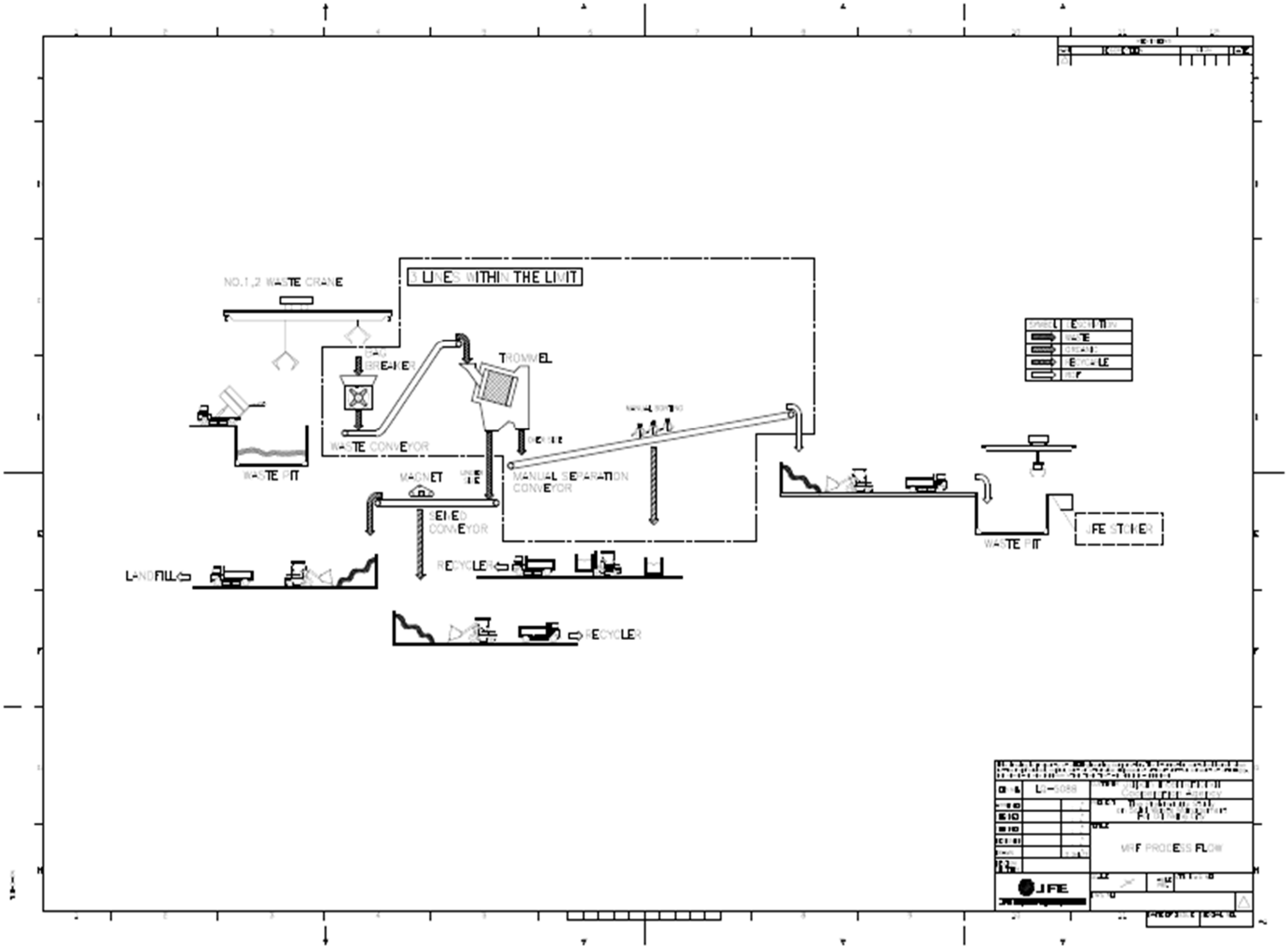
Option 2-1 Incineration System



Option 2-1 Steam and Condensate System



Option 3 MRF


3 LINES WITHIN THE LIMIT
NO.1,2 WASTE CRANE
TROMMEL
WASTE CONVEYOR
WASTE PIT
MAGNET
SEIVED CONVEYOR
MANUAL SEPARATION CONVEYOR
LANDFILL
RECYCLER
RECYCLER
WASTE PIT
RECYCLER
MRF PROCESS FLOW
JFE

4.2.3 Major specifications of plants

The major specifications of the plants are shown in the table below.

Table 4-1: Major specifications of the plants

Item	Unit	Option 2	Option 2-1	Option 3
MRF				
Type	-	—	—	Trommel + hand-sorting
Quantity	set	—	—	3
Capacity / set	t/d	—	—	350
Incinerator				
Type	-	JFE TWO WAY FLUE GAS STOKER FURNACE	JFE TWO WAY FLUE GAS STOKER FURNACE	JFE TWO WAY FLUE GAS STOKER FURNACE
Quantity	set	2	1	1
Capacity / set	t/d	500	500	300
Flue Gas Cooler				
Type	-	Single drum natural circulating boiler	Single drum natural circulating boiler	Single drum natural circulating boiler
Quantity	set	2	1	1
Designated steam pressure (at superheater outlet)	MPa(G)	4.0	4.0	4.0
Designated steam temperature (at superheater outlet)	Degrees Celsius	400	400	400
Steam generation (at rated thermal load)	t/h	46	46	46
Flue Gas Treatment				
Acid gas removal	-	Dry method (Powdery slaked lime injection)	Dry method (Powdery slaked lime injection)	Dry method (Powdery slaked lime injection)
Dioxins removal	-	Dry method (Powdery activated carbon injection)	Dry method (Powdery activated carbon injection)	Dry method (Powdery activated carbon injection)
Dust removal	-	Bag filter	Bag filter	Bag filter
Nitrogen oxide removal	-	Combustion control	Combustion control	Combustion control
Heat utilization				
Type		Condensing steam turbine with steam extraction + Synchronous generator	Condensing steam turbine + Synchronous generator	Condensing steam turbine + Synchronous generator
Quantity	set	1	1	1
Designated steam pressure (at inlet)	MPa(G)	3.8	3.8	3.8
Designated steam temperature (at inlet)	Degrees Celsius	395	395	395
Exhaust pressure	kPa(A)	25	25	25
Steam floe rate (at rated thermal load)	t/h	85	38	37
Generated power (at rated thermal load)	MW	16.0	6.4	6.2

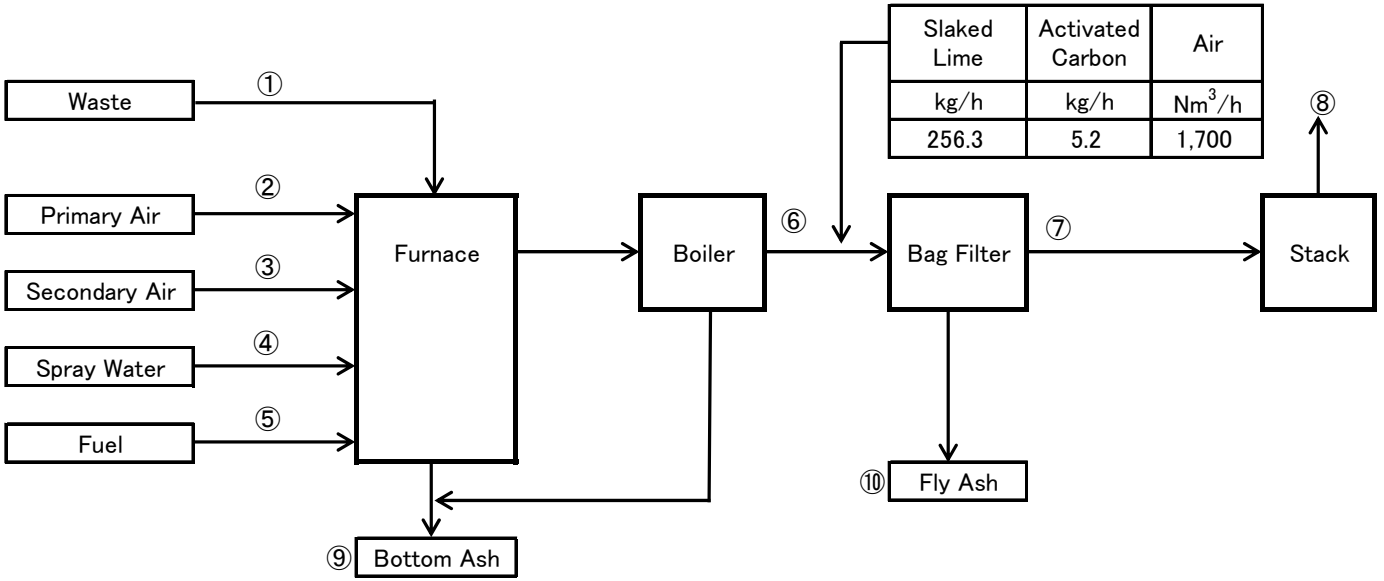
4.3 Material balance and heat balance

Material, heat, and water balance under each option in this study is shown in following pages.

Option 2

Material Balance of Case-2 (500t/d x 2 for Incoming Waste)

(This sheet shows the balance of 1 Line)



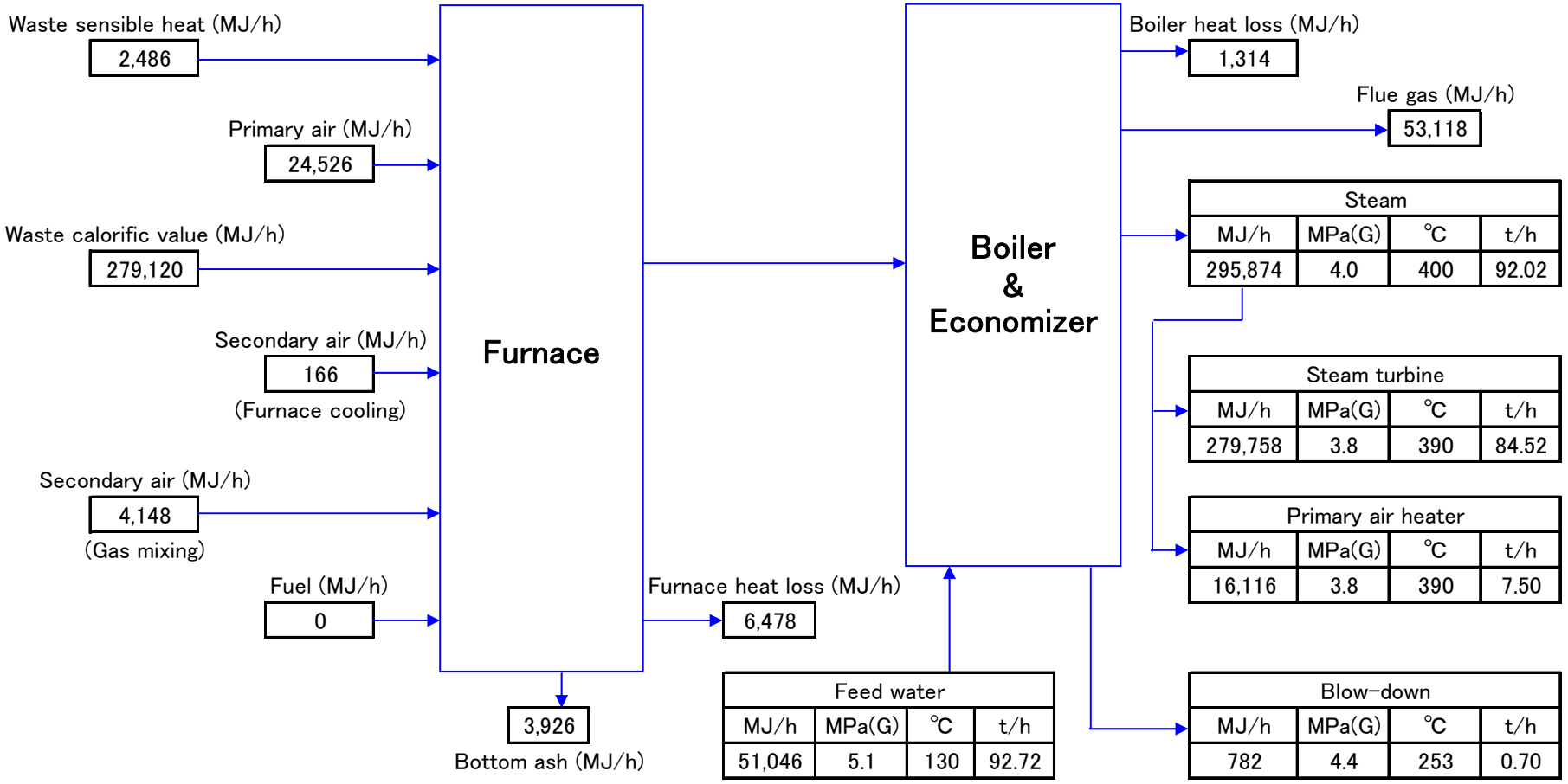
	①		②		③				④		⑤
Item	Waste		Primary Air		Secondary Air				Spray Water		Fuel
					Furnace Cooling		Gas Mixing				
Unit	kJ/kg	kg/h	Nm^3/h	℃	Nm^3/h	℃	Nm^3/h	℃	kg/h	℃	Liter/h
Average Waste	6,700	20,833	64,600	145	3,200	20	15,900	100	0	20	0

	⑥		⑦		⑧		⑨	⑩
Item	Boiler Outlet Gas		Bag Filter Outlet Gas		Stack Outlet Gas		Bottom Ash	Fly Ash
Unit	Nm^3/h	℃	Nm^3/h	℃	Nm^3/h	℃	kg/h	kg/h
Average Waste	103,100	180	104,800	175	104,800	170	1,060	550

Energy Balance of Case-2 (500t/d x 2 for Incoming Waste)

(This sheet shows the balance of 2 Lines)

	Waste Conditions			Energy Balance (MJ/h)	
Unit	kJ/kg	kcal/kg	kg/h	Input	Output
Average Waste	6,700	1,600	41,666	361,492	361,492

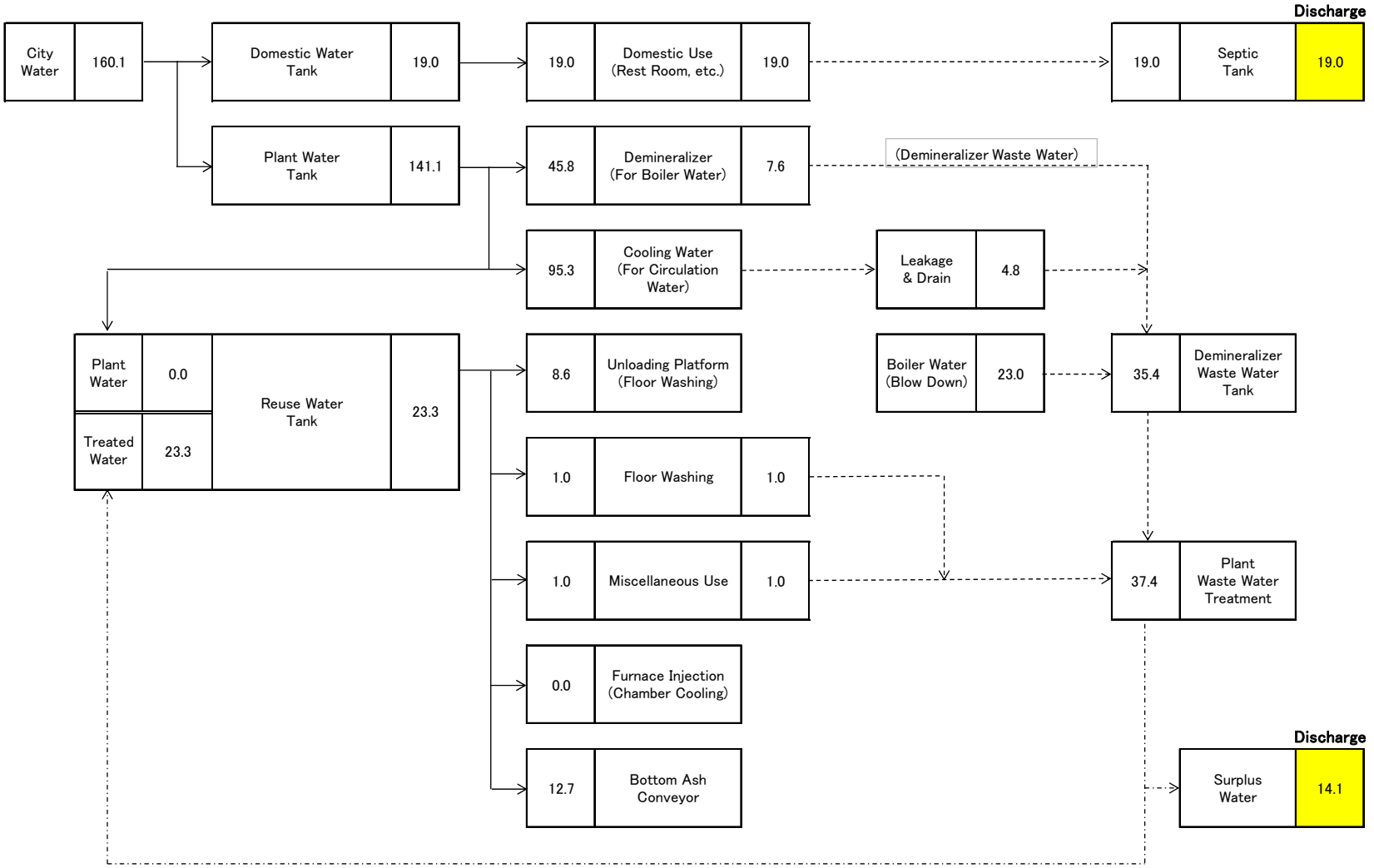


2013/8/1

Water Balance Sheet of Case 2 (500t/d x 2 Lines for Incoming Waste) : 2 Lines Operation

JFE Eng. S. Kubota

(This sheet shows the balance at average waste condition.) Unit : m3/day

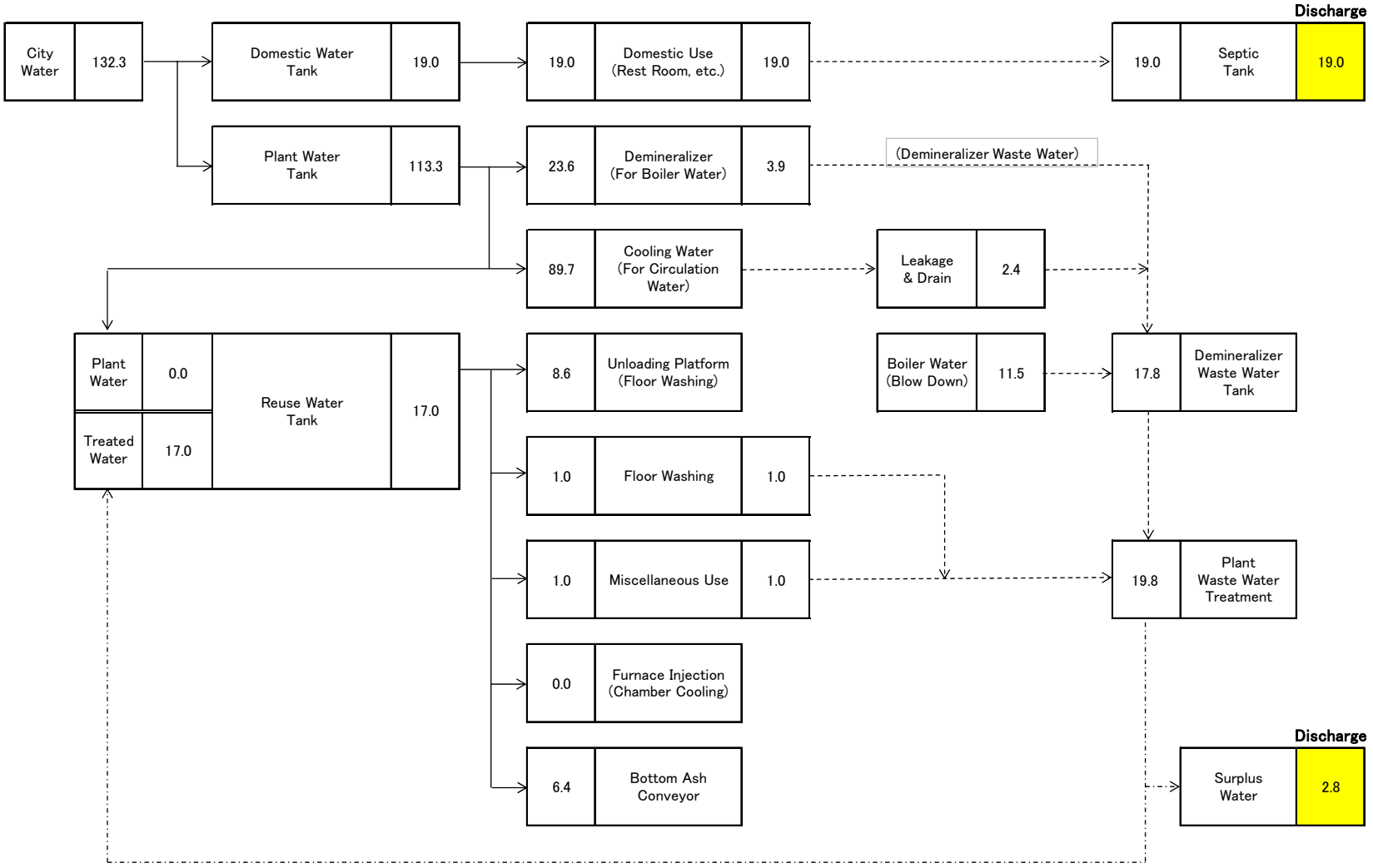


2013/8/1

Water Balance Sheet of Case 2 (500t/d x 2 Lines for Incoming Waste) : 1 Line Operation

JFE Eng. S. Kubota

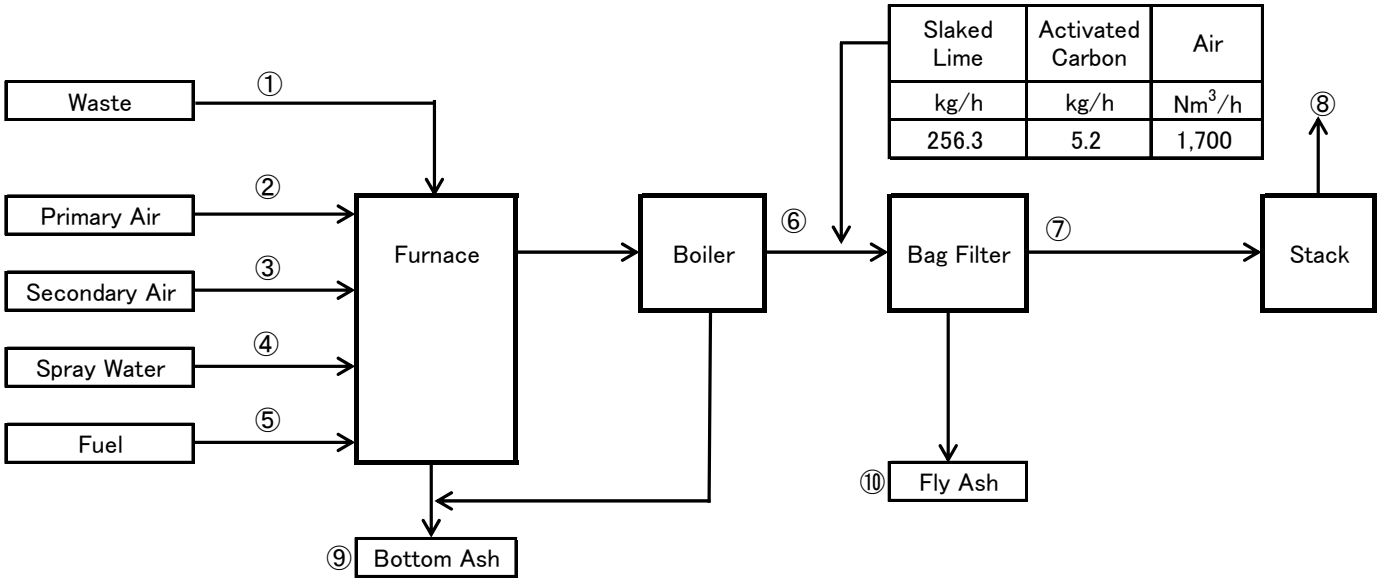
(This sheet shows the balance at average waste condition.) Unit : m3/day



Option-2-1 (Only for additional one line)

Material Balance of Case-2-1 (Additional 500t/d x 1 for Incoming Waste)

(This sheet shows the balance of 1 Line)



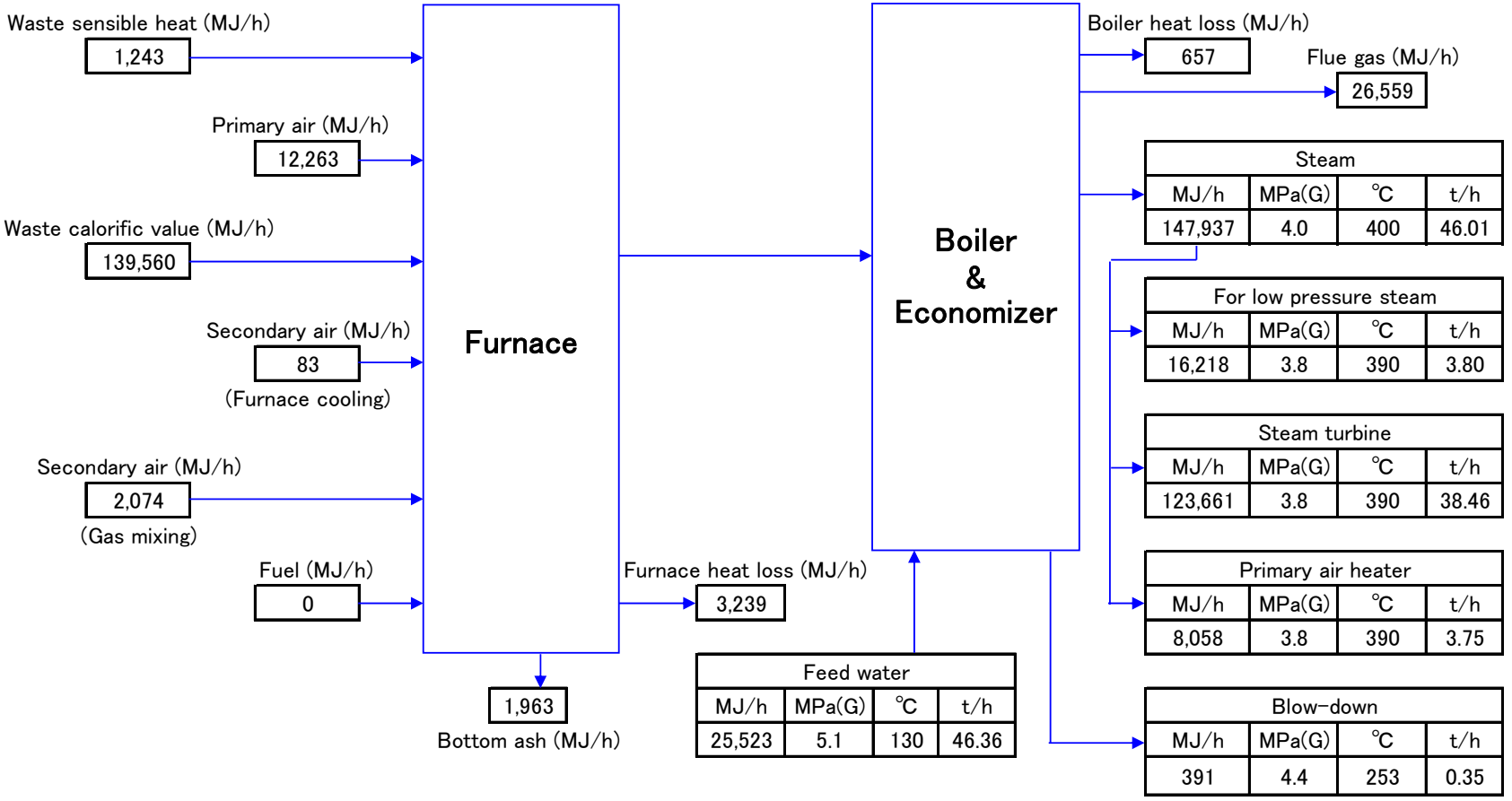
	①		②		③				④		⑤
Item	Waste		Primary Air		Secondary Air				Spray Water		Fuel
					Furnace Cooling		Gas Mixing				
Unit	kJ/kg	kg/h	Nm^3/h	℃	Nm^3/h	℃	Nm^3/h	℃	kg/h	℃	Liter/h
Average Waste	6,700	20,833	64,600	145	3,200	20	15,900	100	0	20	0

	⑥		⑦		⑧		⑨	⑩
Item	Boiler Outlet Gas		Bag Filter Outlet Gas		Stack Outlet Gas		Bottom Ash	Fly Ash
Unit	Nm^3/h	℃	Nm^3/h	℃	Nm^3/h	℃	kg/h	kg/h
Average Waste	103,100	180	104,800	175	104,800	170	1,060	550

Energy Balance of Case-2-1 (Additional 500t/d x 1 for Incoming Waste)

(This sheet shows the balance of 1 Line)

	Waste Conditions			Energy Balance (MJ/h)	
Unit	kJ/kg	kcal/kg	kg/h	Input	Output
Average Waste	6,700	1,600	20,833	180,746	180,746



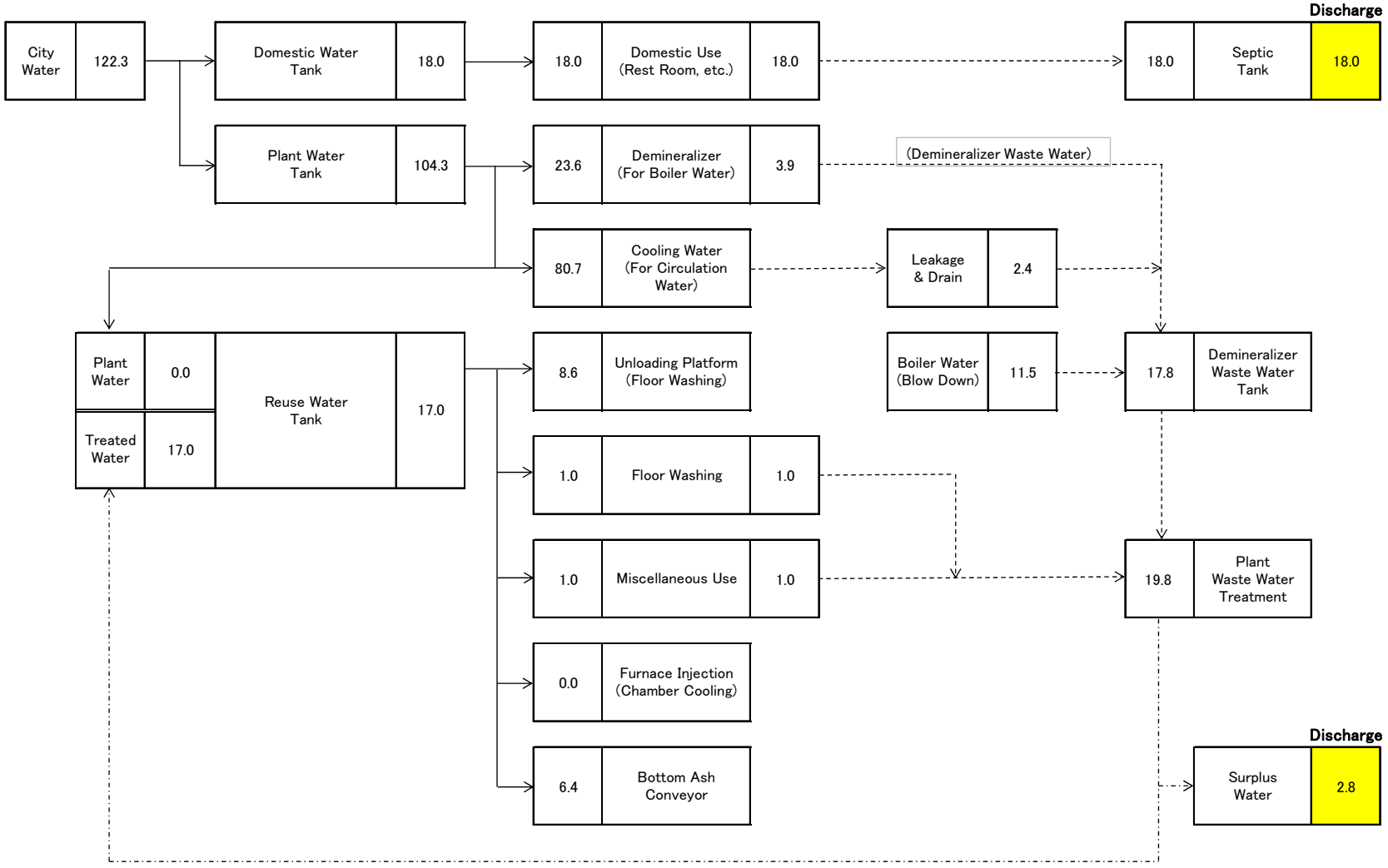
2013/8/1

Water Balance Sheet of Case 2-1 (Additional 500t/d x 1 Line)

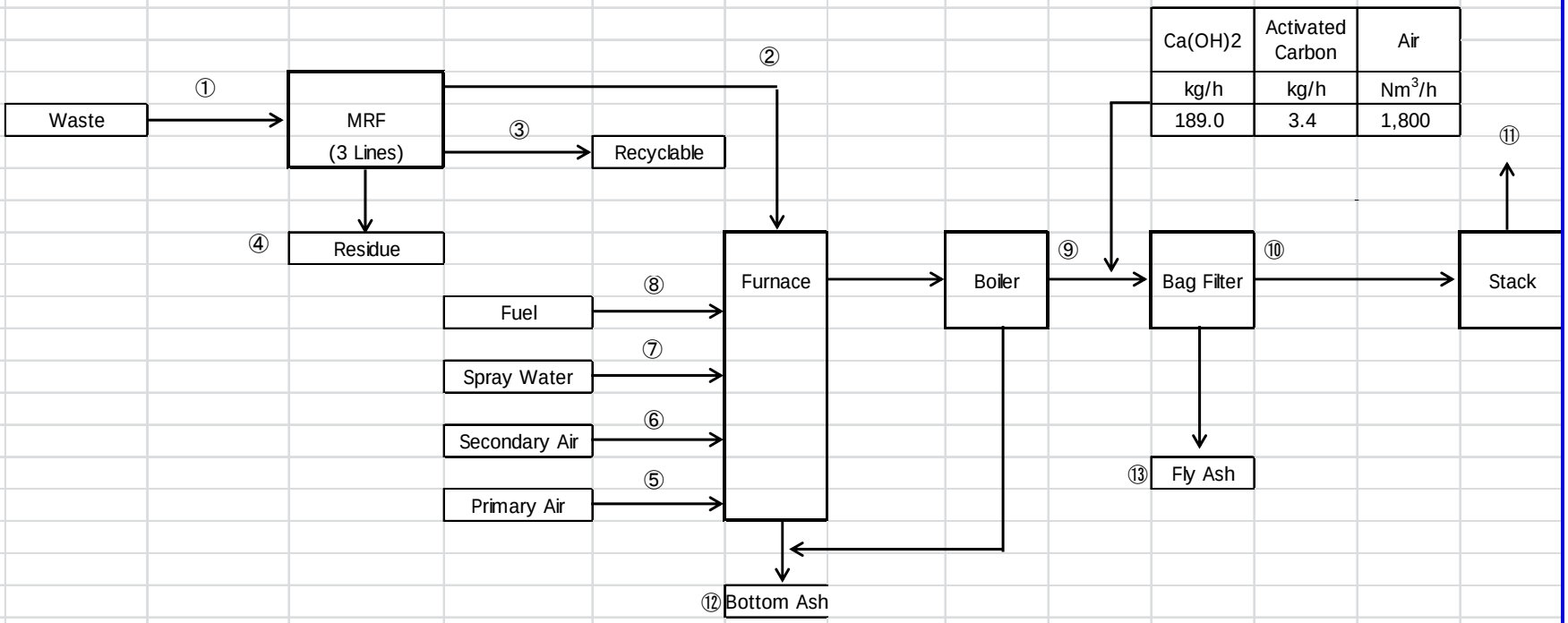
JFE Eng. S. Kubota

(This sheet shows the balance at average waste condition.)

Unit : m3/day

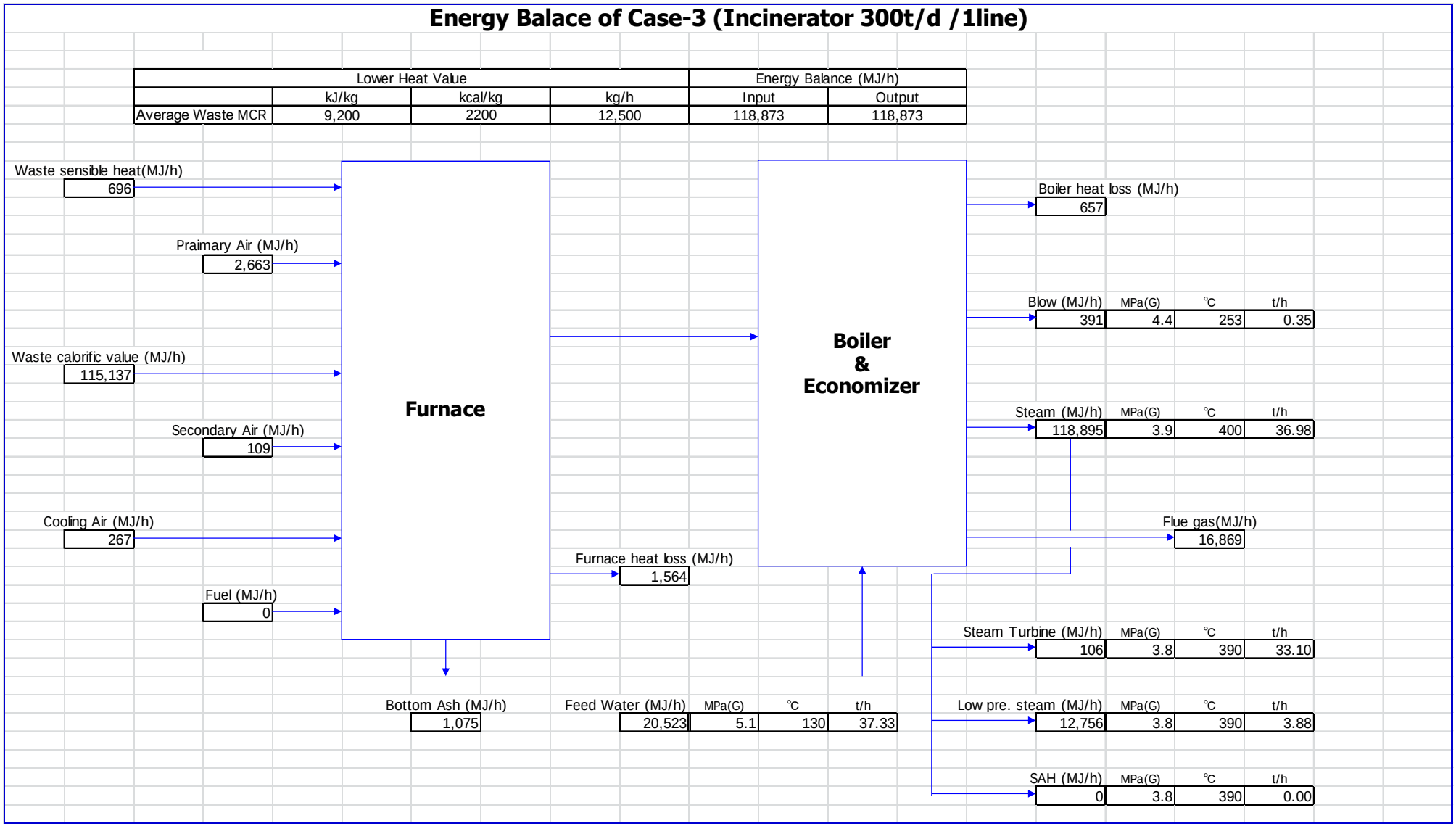


Material Balace of Case-3 (MRF 100t/d /3lines and Incinerator 300t/d /1line)



	①		②		③	④	⑤		⑥			
	Waste		RDF		Recyclable	Residue	Primery Air		Secondary Air			
	kJ/kg	kg/h	kJ/kg	kg/h	kg/h	kg/h	Nm3/h	℃	Nm3/h	℃	Nm3/h	℃
MCR	6,700	41,667	9,200	12,500	400	28,767	40,900	50	4,211	20	10,281	100

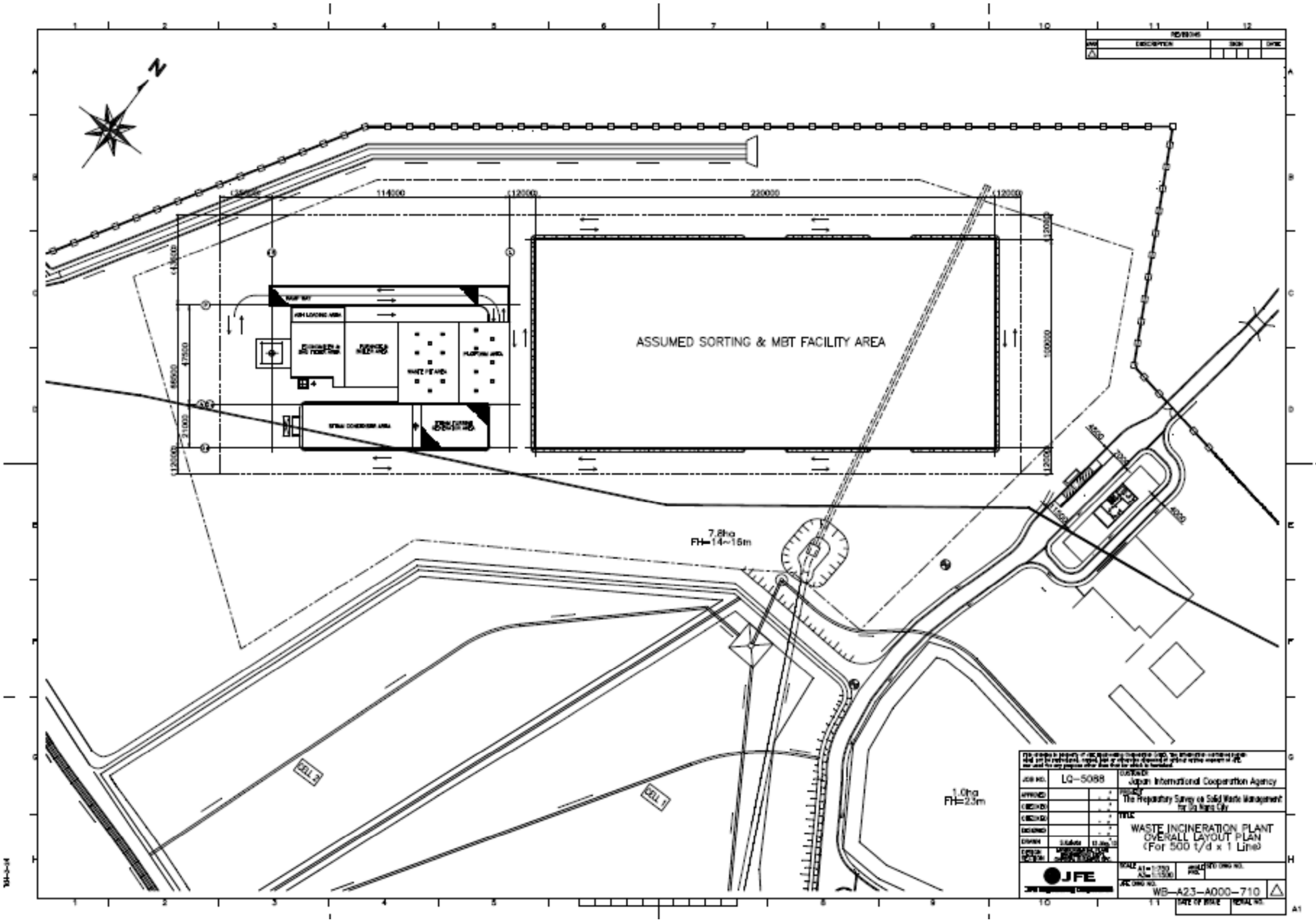
	⑦		⑧	⑨		⑩		⑪		⑫	⑬
	Spray Water		Fuel	Boiler Outlet Gas		Bag Filter Outlet Gas		Stack Outlet Gas		Bottom Ash	Fly Ash
	kg/h	℃	ﾘｯﾄﾙ/h	Nm3/h	℃	Nm3/h	℃	Nm3/h	℃	kg/h	kg/h
MCR	0	20	0	66,600	180	68,200	175	68,200	170	620	390

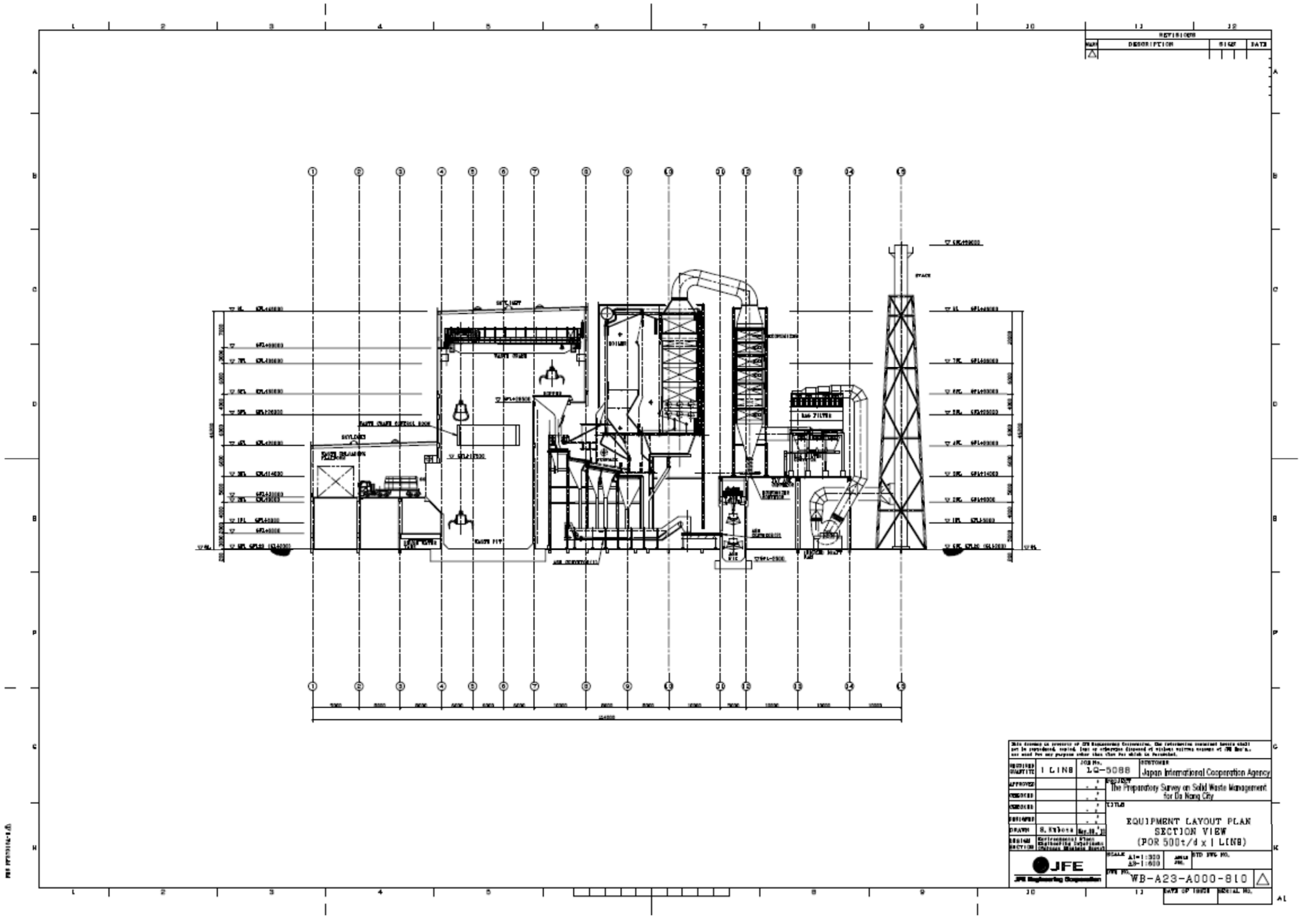

Energy Balace of Case-3 (Incinerator 300t/d /1line)
Lower Heat Value
Energy Balance (MJ/h)
kJ/kg
kcal/kg
kg/h
Input
Output
Average Waste MCR
9,200
2200
12,500
118,873
118,873
Waste sensible heat(MJ/h)
696
Praimary Air (MJ/h)
2,663
Waste calorific value (MJ/h)
115,137
Secondary Air (MJ/h)
109
Cooling Air (MJ/h)
267
Fuel (MJ/h)
0
Furnace
Boiler & Economizer
Boiler heat loss (MJ/h)
657
Blow (MJ/h) MPa(G) ℃ t/h
391 4.4 253 0.35
Steam (MJ/h) MPa(G) ℃ t/h
118,895 3.9 400 36.98
Flue gas(MJ/h)
16,869
Furnace heat loss (MJ/h)
1,564
Steam Turbine (MJ/h) MPa(G) ℃ t/h
106 3.8 390 33.10
Low pre. steam (MJ/h) MPa(G) ℃ t/h
12,756 3.8 390 3.88
SAH (MJ/h) MPa(G) ℃ t/h
0 3.8 390 0.00
Bottom Ash (MJ/h)
1,075
Feed Water (MJ/h) MPa(G) ℃ t/h
20,523 5.1 130 37.33

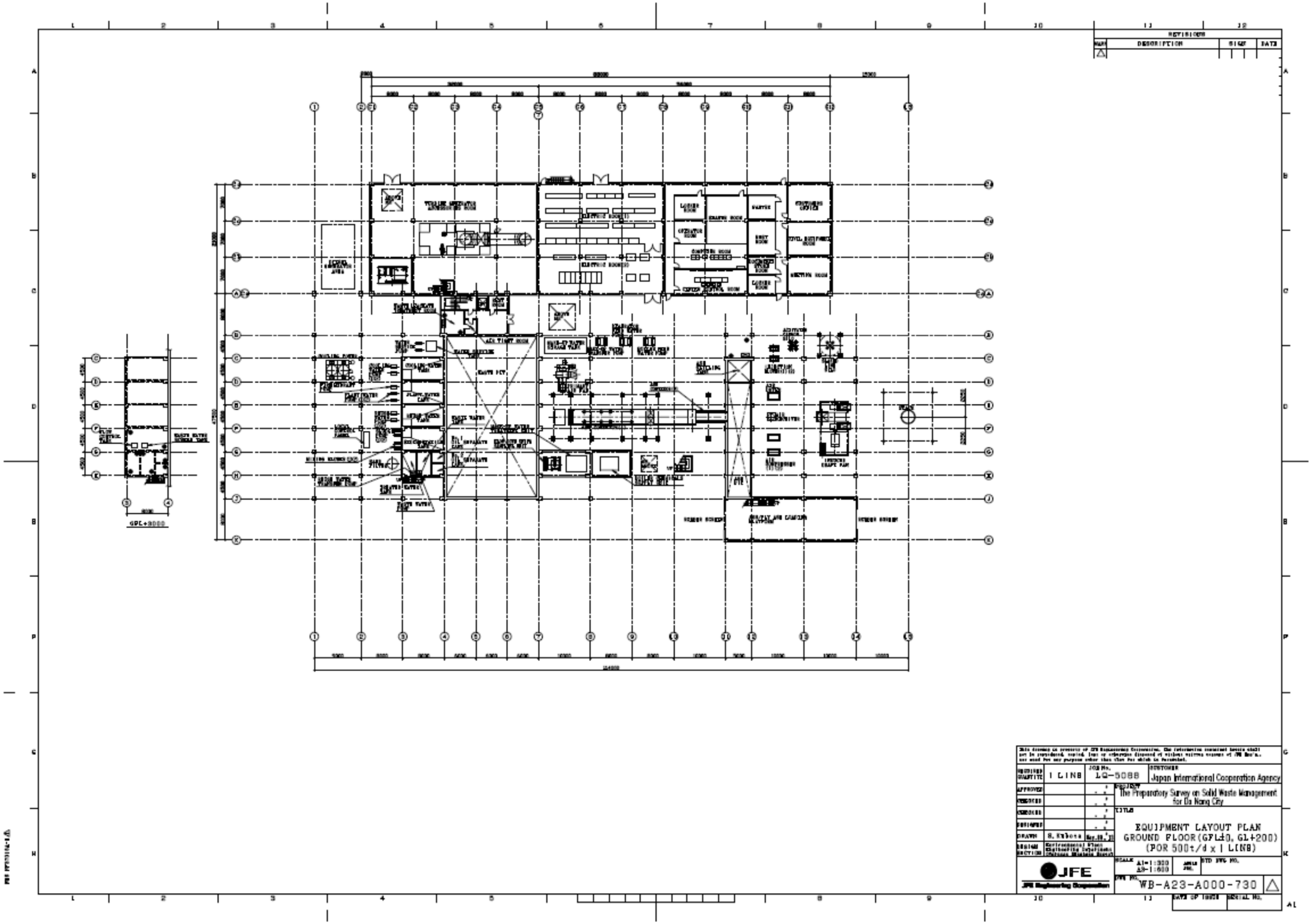
4.4 Layout plan

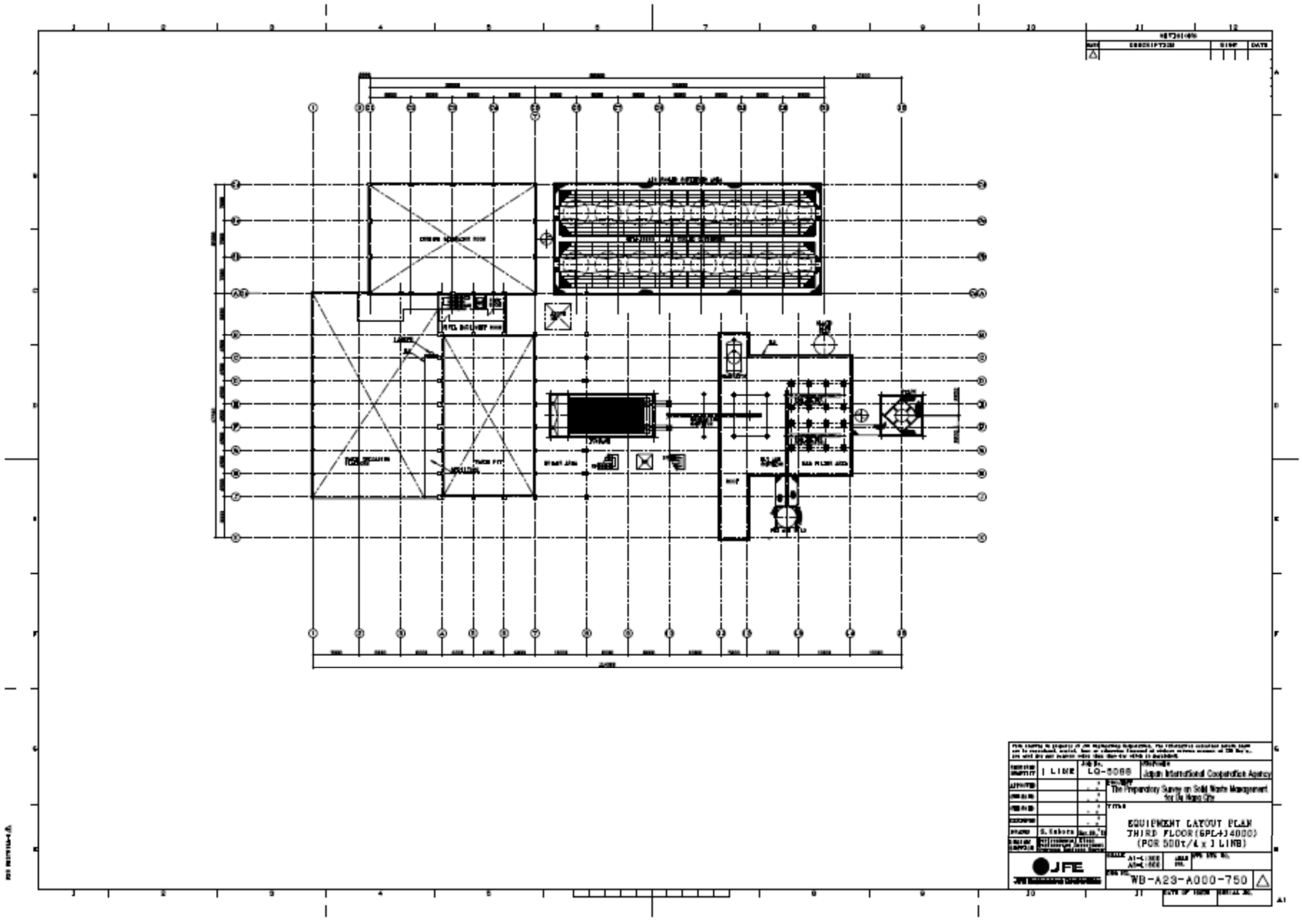
Facility and plant layout plans for Option 1, Option 2, and Option 3 are shown in following pages.

Option 1

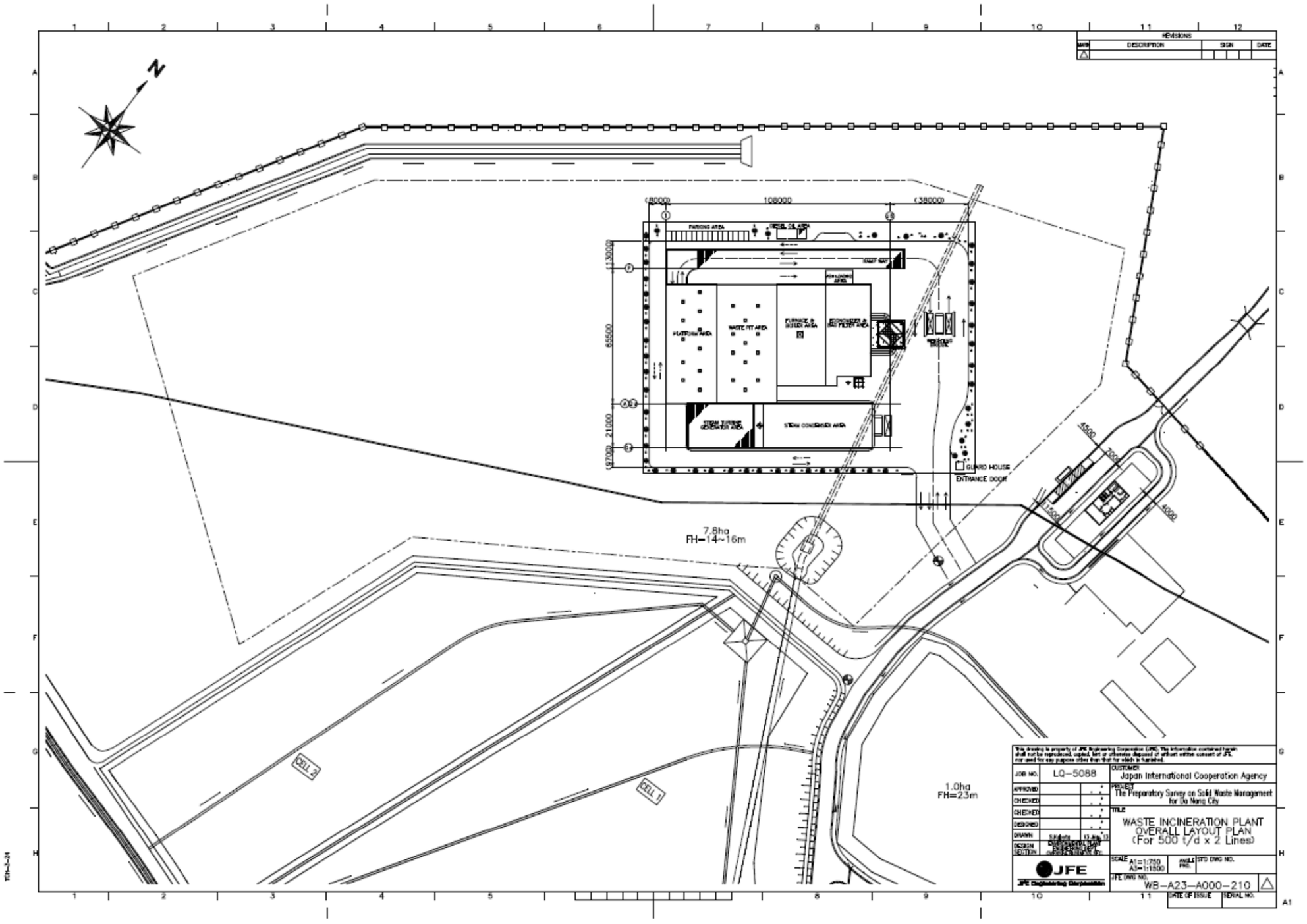

N
114000
220000
ASSUMED SORTING & MBT FACILITY AREA
7.8ha
FH=14~15m
1.0ha
FH=2.3m
CELL 2
CELL 1
WASTE INCINERATION PLANT
OVERALL LAYOUT PLAN
(For 500 t/d x 1 Line)
Japan International Cooperation Agency
The Preparatory Survey on Solid Waste Management for Da Nang City
LQ-5088
WB-A23-A000-710
JFE

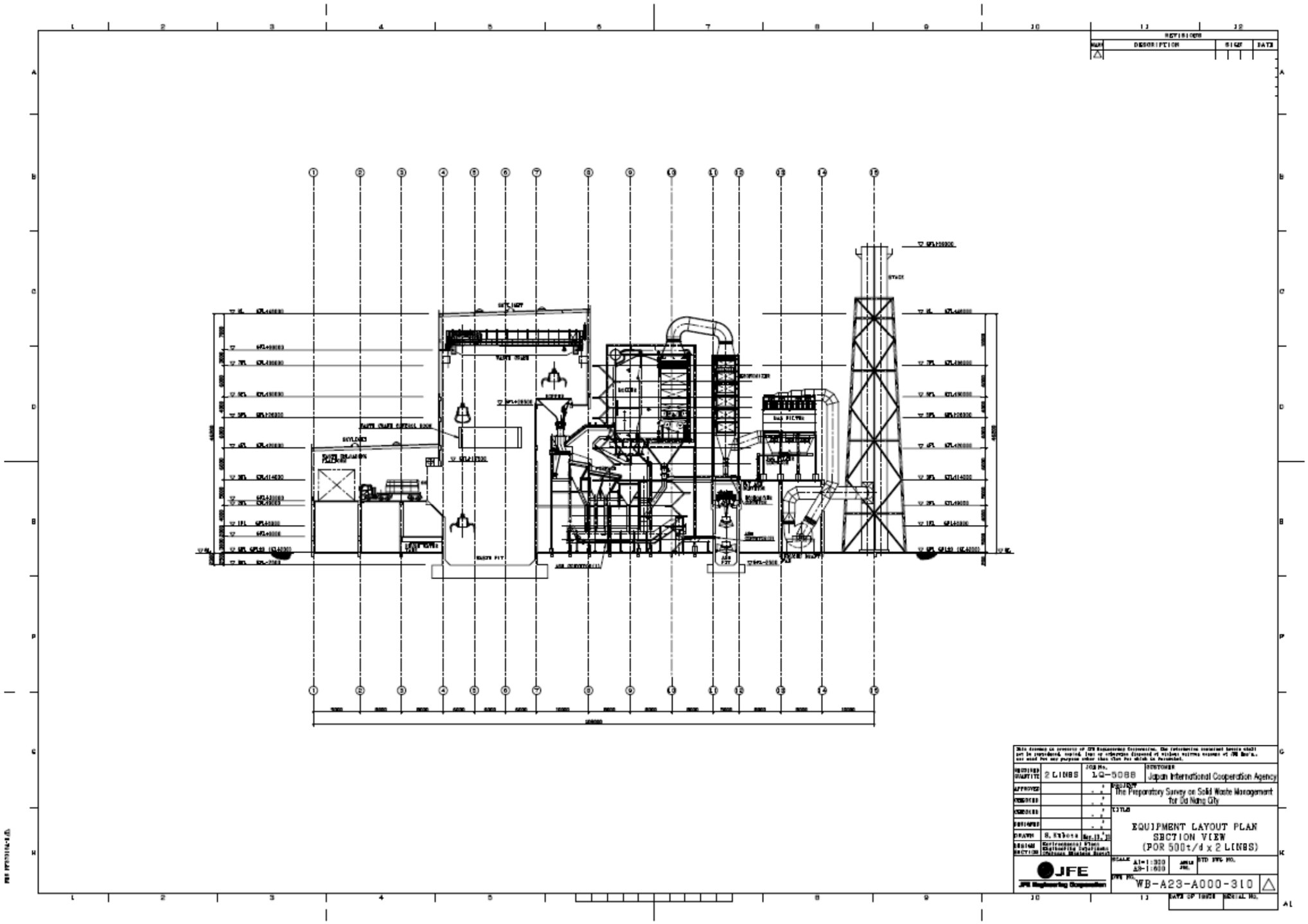

REVISIONS
MARK
DESCRIPTION
BY/CHK
DATE
CUSTOMER
Japan International Cooperation Agency
PROJECT
The Preparatory Survey on Solid Waste Management for Da Nang City
TITLE
EQUIPMENT LAYOUT PLAN
SECTION VIEW
(POR 500t/d x 1 L(NB)
JOB No.
LQ-5088
1 L(NB
JFE
JFE Engineering Corporation
SCALE
A1=1:300
A3=1:600
DWG NO.
WB-A23-A000-810


REVISIONS
DESCRIPTION
1 LINE
JOB No.
LQ-5088
CUSTOMER
Japan International Cooperation Agency
PROJECT
The Preparatory Survey on Solid Waste Management for Da Nang City
TITLE
EQUIPMENT LAYOUT PLAN
GROUND FLOOR(GFL±0, GL+200)
(FOR 500t/d x 1 LINE)
DRAWN
SCALE
A1=1:300
A3=1:600
STD DWG NO.
JFE
DWG NO.
WB-A23-A000-730
DATE OF ISSUE
SERIAL NO.


1 LINE
LQ-5088
Japan International Cooperation Agency
The Preparatory Survey on Solid Waste Management for Da Nang City
EQUIPMENT LAYOUT PLAN
THIRD FLOOR(GPL+14000)
(FOR 500t/d x 1 LINE)
JFE
WB-A23-A000-750

Option 2


N
REVISIONS
MARK
DESCRIPTION
SIGN
DATE
108000
PARKING AREA
DIESEL OIL AREA
WASTE PIT AREA
STEAM TURBINE GENERATOR AREA
STEAM CONDENSER AREA
GUARD HOUSE
ENTRANCE DOOR
4500
3000
4000
7.8ha
FH=14~16m
CELL 2
CELL 1
1.0ha
FH=2.3m
JOB NO. LQ-5088
CUSTOMER
Japan International Cooperation Agency
PROJECT
The Preparatory Survey on Solid Waste Management for Da Nang City
TITLE
WASTE INCINERATION PLANT
OVERALL LAYOUT PLAN
(For 500 t/d x 2 Lines)
APPROVED
CHECKED
CHECKED
DESIGNED
DRAWN
DESIGN SECTION
JFE
JFE Engineering Corporation
SCALE
A1=1:750
A3=1:1500
JFE DWG NO.
WB-A23-A000-210
DATE OF ISSUE
REVISAL NO.
A1


REVISIONS
DESCRIPTION
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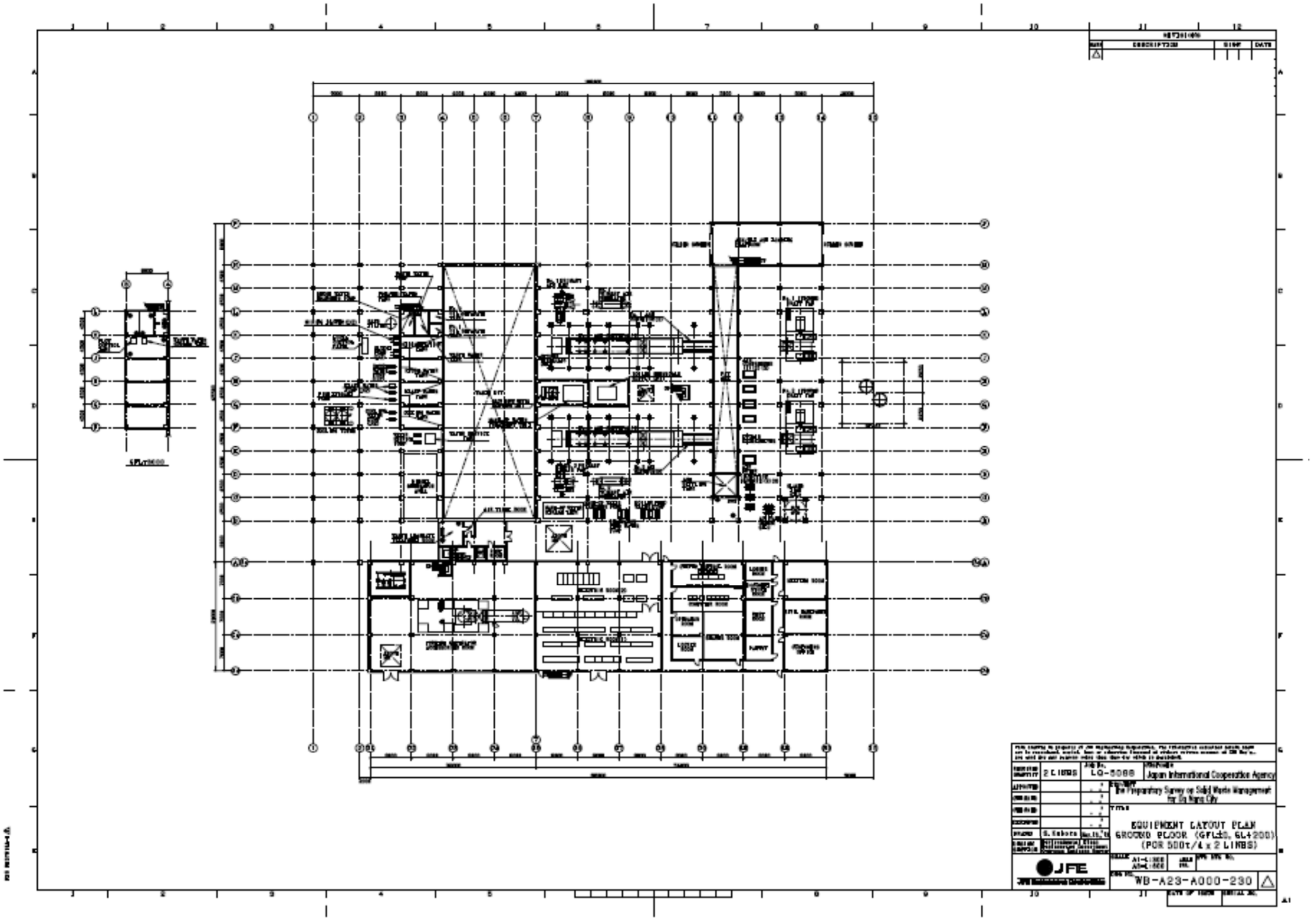
SECTION VIEW
(POR 500t/d x 2 LINES)
The Preparatory Survey on Solid Waste Management for Da Nang City
Japan International Cooperation Agency
JFE
WB-A23-A000-310


Japan International Cooperation Agency
The Preparatory Survey on Solid Waste Management for Da Nang City
EQUIPMENT LAYOUT PLAN
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JFE
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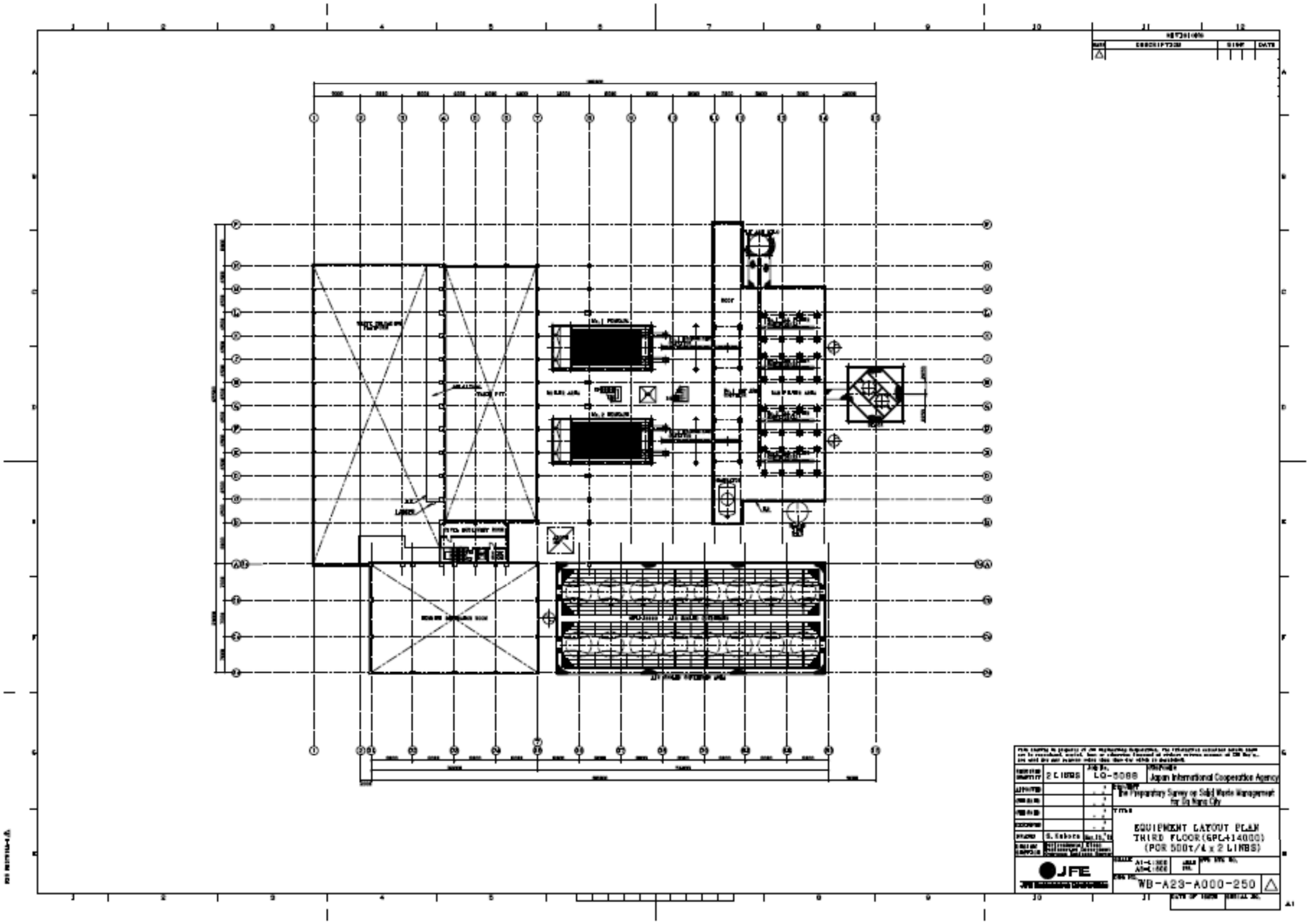
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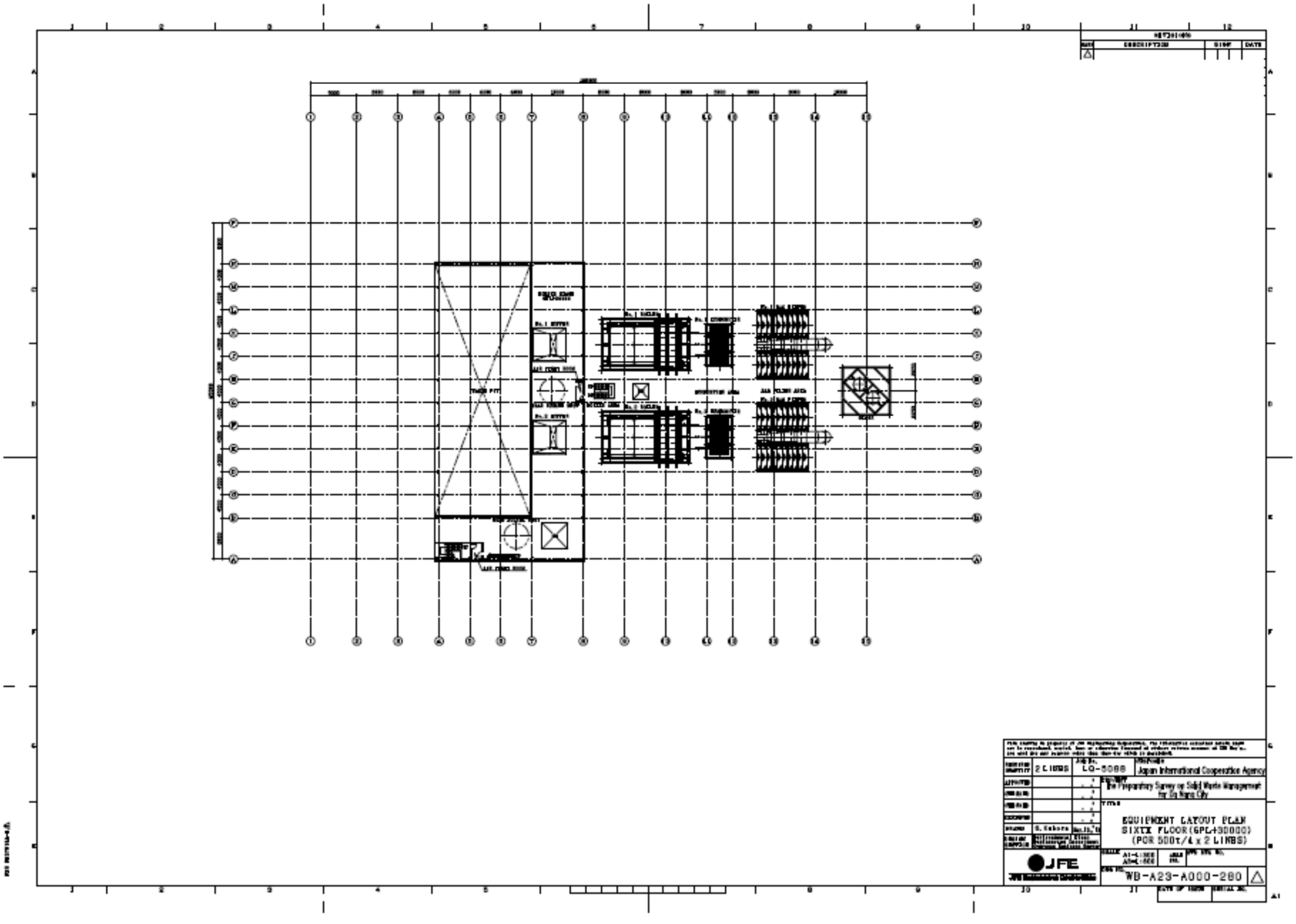
Japan International Cooperation Agency
The Preparatory Survey on Solid Waste Management for Da Nang City
JFE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SIXTH FLOOR(GPL+30000)
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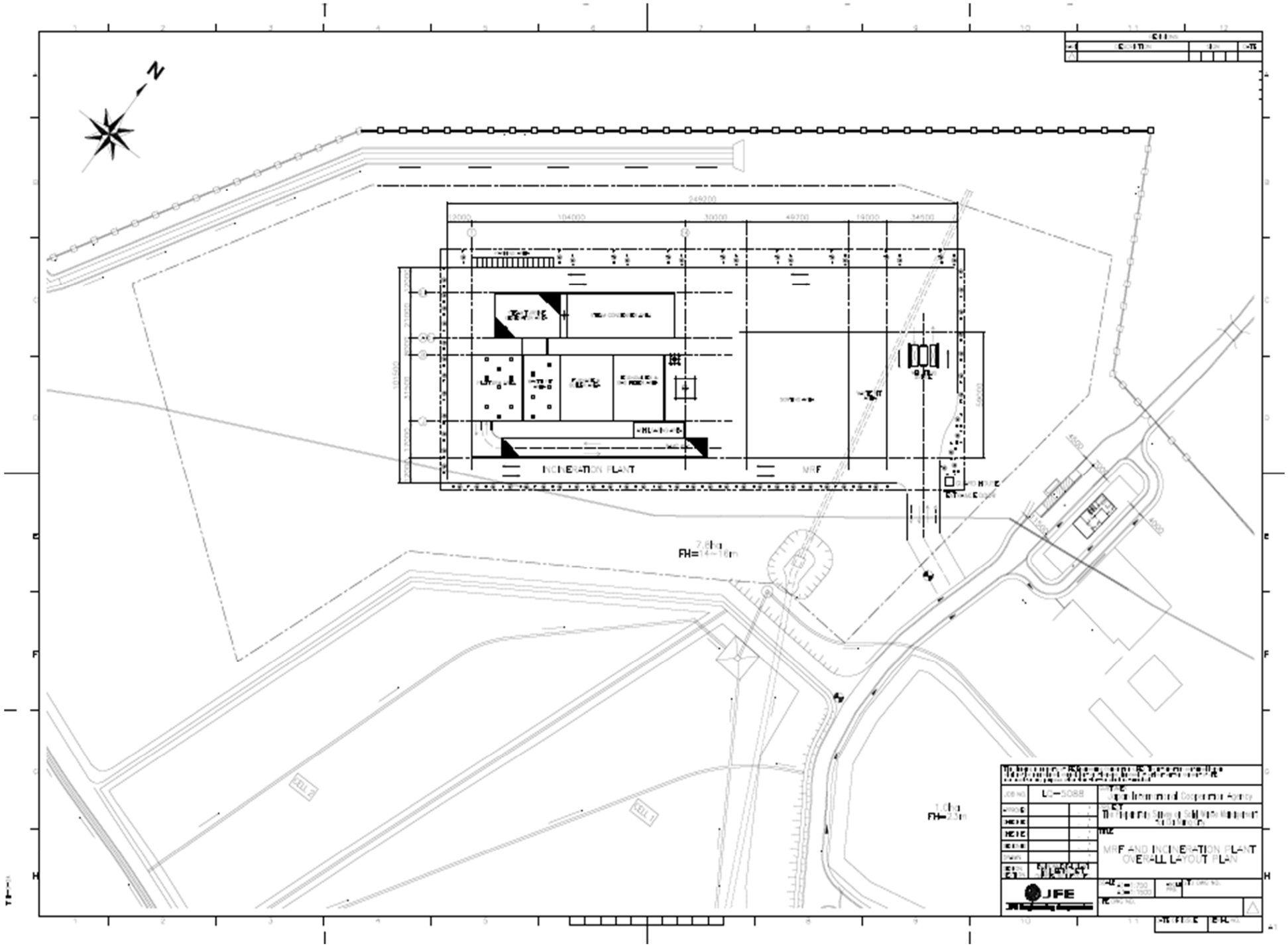
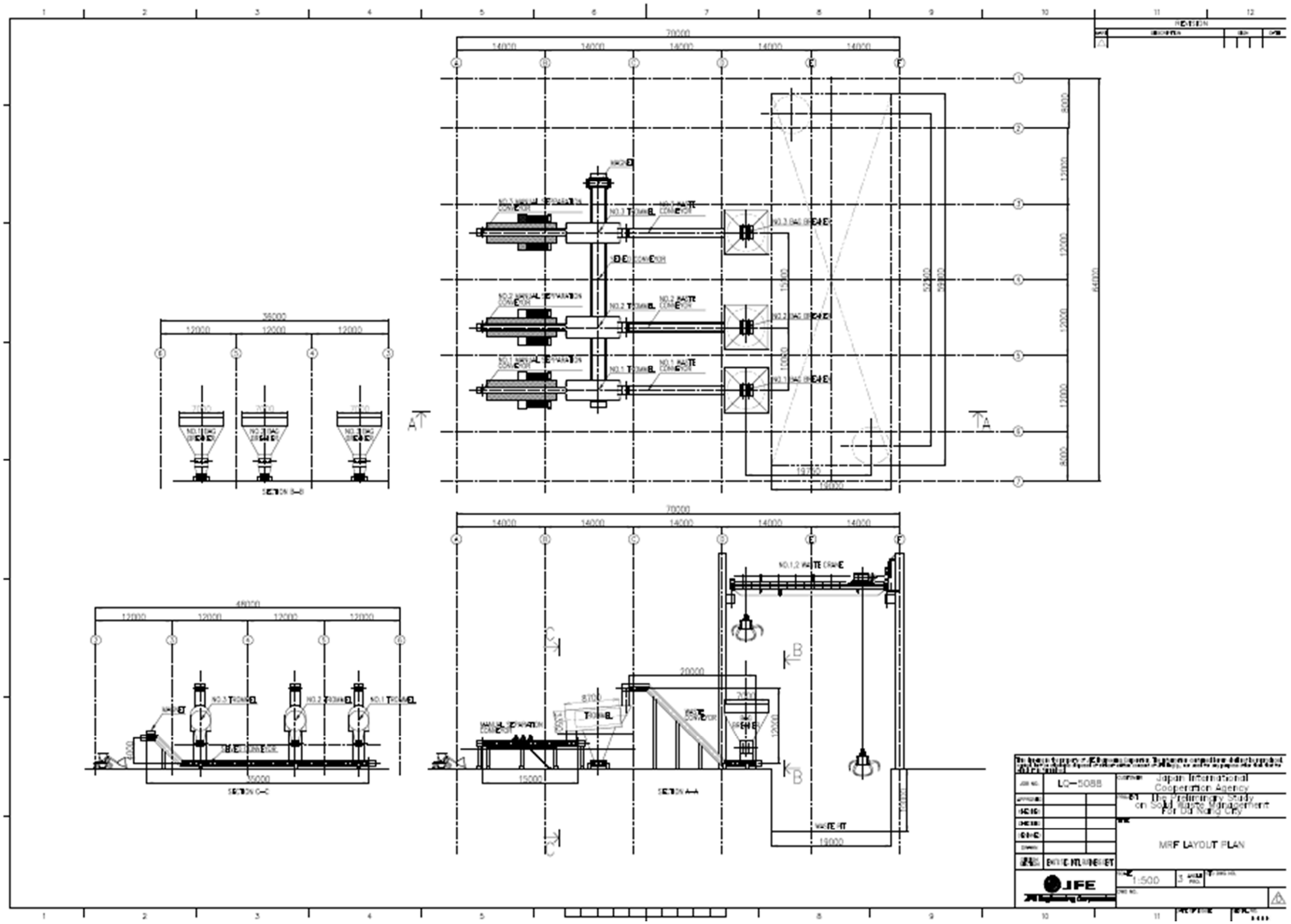
The Preparatory Survey on Solid Waste Management for Da Nang City
JFE

Option 3


N
INCINERATION PLANT
MRF
MRF AND INCINERATION PLANT
OVERALL LAYOUT PLAN
JFE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Japan International Cooperation Agency
The Preparatory Study on Solid Waste Management For Da Nang City
MRF LAYOUT PLAN
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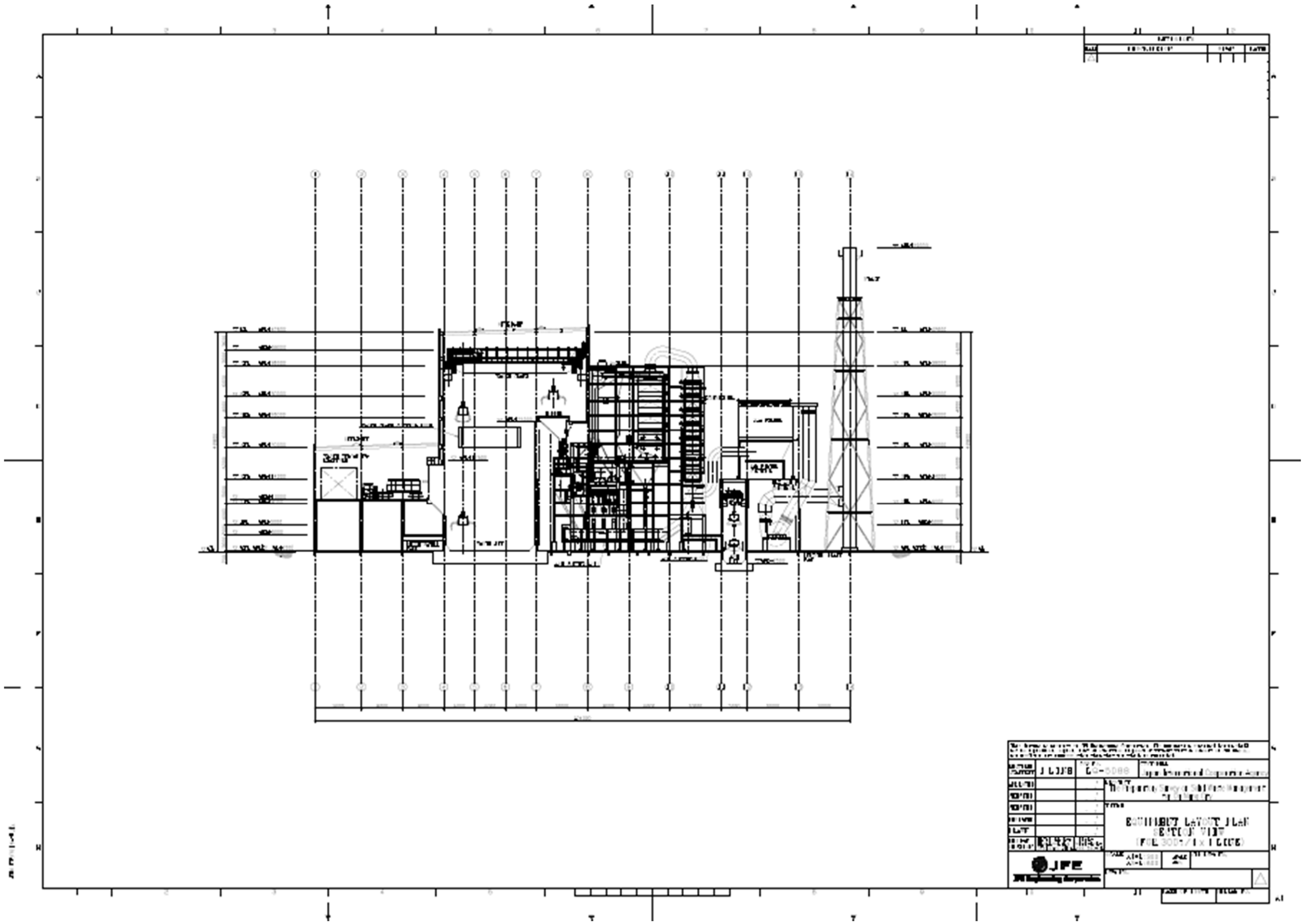

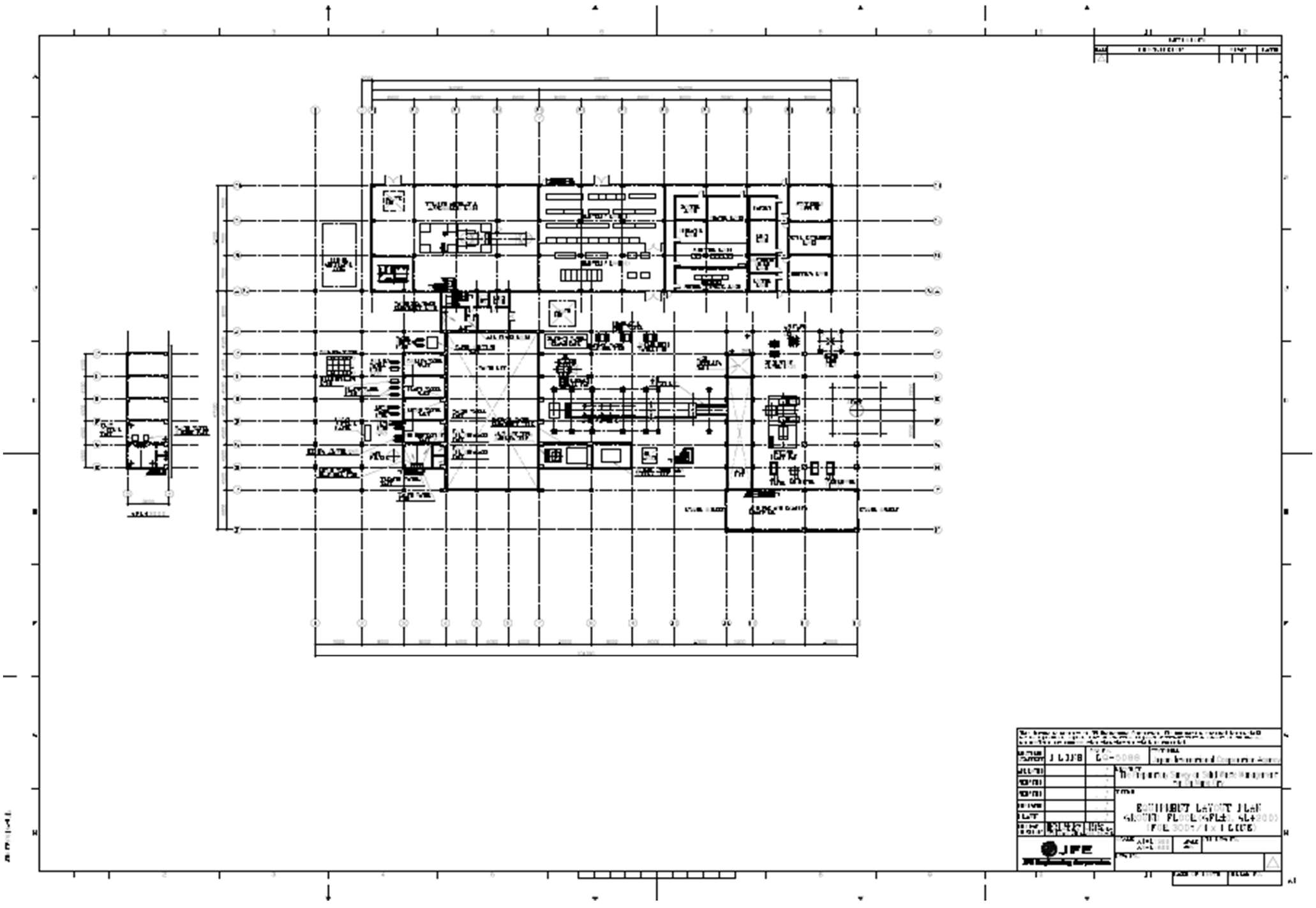

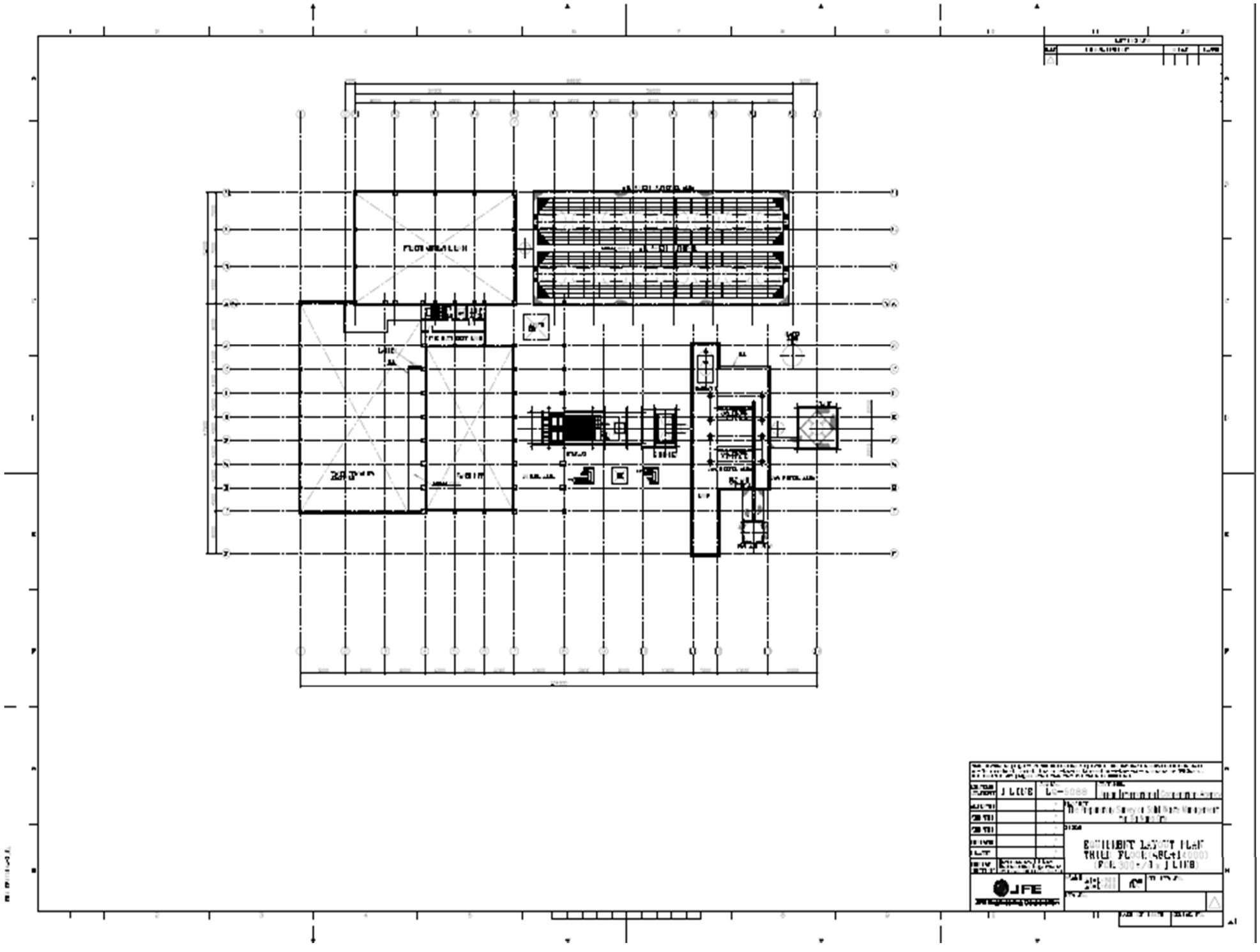

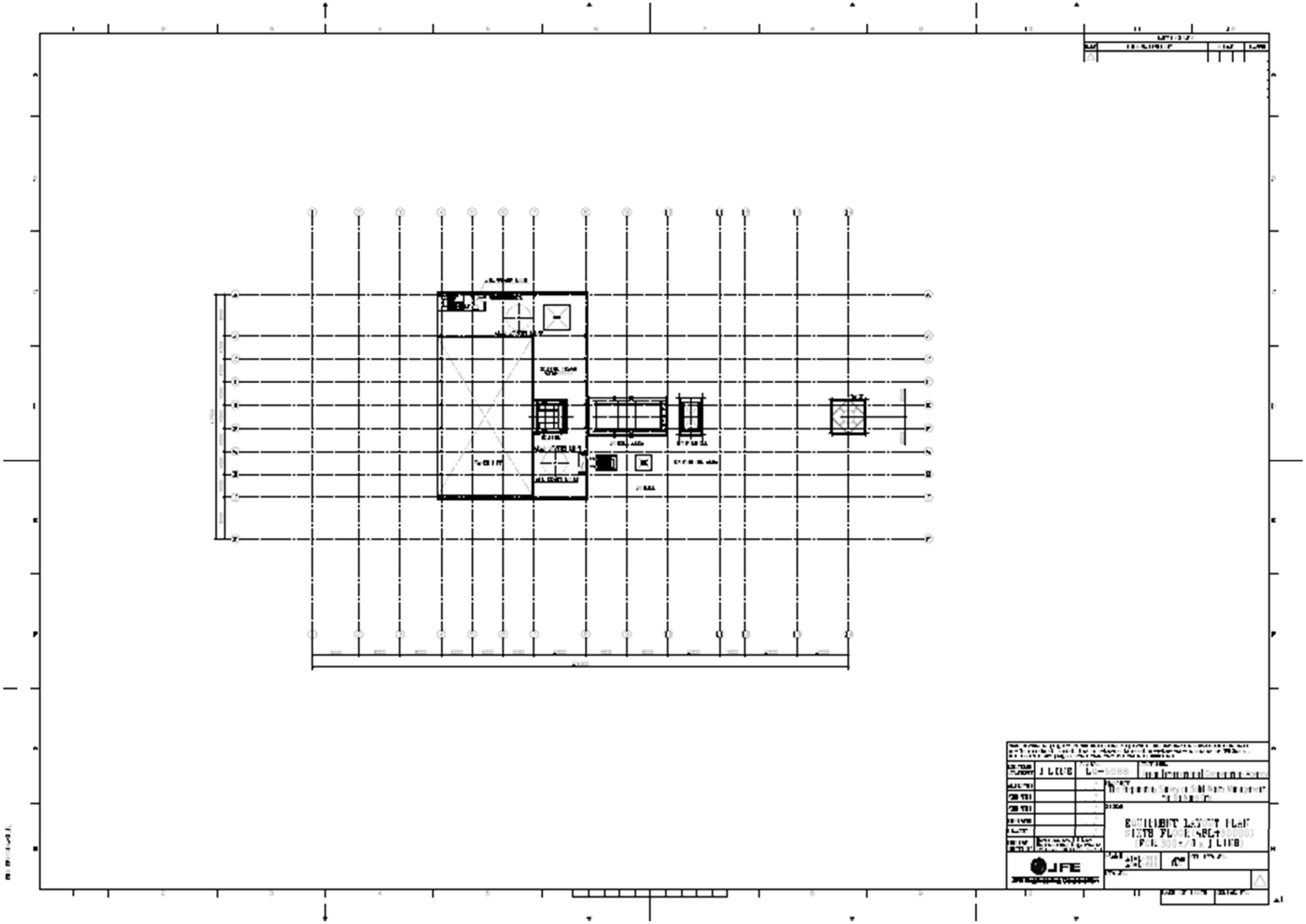

4.5 Estimated project expenditures regarding waste incineration facility

Estimated project expenditures for each option in this study are shown as below.

Table 4-2: Estimate of Cost for Each Option

Da Nang City : CAPEX & OPEX (Rough Estimate)					
		Case-2 (Incoming Waste)	Case-2-1 (Incoming Waste)	Case-3 (MRF + Incinerator)	Remarks
Condition	Facility Scale	500t/d x 2 Lines	500t/d x 1 Line (Future Addition)	350t/d x 3 Lines + 300 t/d x 1Line	
	Designated LHV	6.7 MJ/kg (1,600 kcal/kg)	6.7 MJ/kg (1,600 kcal/kg)	RDF: 9.2 MJ/kg (2,200 kcal/kg)	
CAPEX	Plant Equipment (Procurement & Fabrication)	¥5,040,000,000	¥2,690,280,000	¥2,429,000,000	Including transportation charge
	Construction (Civil and Building)	¥2,128,000,000	¥1,117,770,000	¥1,114,000,000	Excluding site development and ground preparation.
	Construction (Plant)	¥2,352,000,000	¥1,238,610,000	¥957,000,000	Including piping, wiring, painting and insulating
	Engineering (Design & Project Cost)	¥1,500,000,000	¥675,000,000	¥1,800,000,000	Including commissioning and supervising charge
	CAPEX Total	**¥11,020,000,000**	**¥5,721,660,000**	**¥6,300,000,000**	(1 JPY = 205 VND)
OPEX	Utility Cost	¥2,651,420,000	¥881,764,000	¥1,775,420,000	(※1)
	Maintenance Cost	¥6,379,000,000	¥1,802,700,000	¥4,074,580,000	Including labor Cost
	Labor Cost (For facility operation)	(※2)	(※2)	(※2)	
	OPEX Total (20 Years)	**¥9,030,420,000**	**¥2,684,464,000**	**¥5,850,000,000**	(1 JPY = 205 VND) (※3)
Others	**Assumed Income by Selling Electricity** (20 Years)	**¥19,064,546,341**	**¥6,381,980,488**	**¥6,639,028,293**	(1 JPY = 205 VND) (※1)
		<Above Case is for 13 years>			

Notes)
(※1) These are based on next table.
(※2) These have been considered in finance analysis.
(※3) SPC cost are not included in these price. (Those have been considered in finance analysis.)

Table 4-3: Utility Cost

Utility Consumption Detail

Conditions			
Operation	310 days/year	Mainetance	49 days/year	Start-up & Shutdown	6 days/year

Item	Unit Price		Unit	Case-2 : 500 t/d x 2 Lines		Case-2-1 : 500 t/d x 1 Line		Case-3 : MRF+300 t/d		Remarks
				Annual consumption	Annual Cost (kVND/year)	Annual consumption	Annual Cost (kVND/year)	Annual consumption	Annual Cost (kVND/year)	
Electric power										
Incinerator	1,500	VND/kWh	MWh	1,041	1,561,500	684	1,026,000	450	675,000	Maintenance, start-up & shutdown
MRF	1,500	VND/kWh	MWh	-		-		335	502,500	
Water consumption										
City water	6,214	VND/m3	m^3	50,907	316,336	38,875	241,569	32,057	199,202	
Waste water	-	VND/m3	m^3	10,560	-	6,710	-	5,530	-	QCVN40:2011/BTNMT Class B
Fuel oil (diesel)										
Start-up	20,650	VND/Litter	litter	147,600	3,047,940	73,800	1,523,970	44,300	914,795	3 times/year
Shutdown	20,650	VND/Litter	litter	73,800	1,523,970	36,900	761,985	22,100	456,365	3 times/year
MRF	20,650	VND/Litter	litter	-		-		334,800	6,913,620	
Flue gas treatment										
Slaked lime	4,200	VND/kg	kg	3,850,808	16,173,394	1,925,420	8,086,764	1,588,472	6,671,582	
Activated carbon	35,000	VND/kg	kg	77,468	2,711,380	38,749	1,356,215	31,968	1,118,880	
Waste water treatment										
Hydrochloric Acid (35%)	28,000	VND/kg	kg	2,867	80,276	1,283	35,924	1,058	29,624	
Caustic soda (24%)	4,000	VND/kg	kg	25,077	100,308	11,219	44,876	9,256	37,024	
Coagulant (FeCl3)	28,000	VND/kg	kg	15,839	443,492	7,085	198,380	5,845	163,660	
Boiler water treatment										
Boiler compounds	48,000	VND/kg	kg	2,212	106,176	1,106	53,088	912	43,776	
Deoxidizer	43,000	VND/kg	kg	727	31,261	379	16,297	313	13,459	
Demineralizer										
Hydrochloric acid (35%)	28,000	VND/kg	kg	16,508	462,224	8,506	238,168	7,017	196,476	
Caustic soda (24%)	4,000	VND/kg	kg	26,383	105,532	13,595	54,380	11,216	44,864	
Sulfite of soda (10%)	16,500	VND/kg	kg	868	14,322	447	7,376	369	6,089	
Cation-exchange resin	29,000	VND/Litter	litter	11	319	11	319	9	261	
Anion-exchange resin	85,000	VND/Litter	litter	32	2,720	32	2,720	26	2,210	
Oil, Grease										
Hydraulic oil	42,000	VND/Litter	litter	1,710	71,820	1,060	44,520	870	36,540	
Lubrication oil	63,000	VND/Litter	litter	5,400	340,200	2,700	170,100	2,200	138,600	
Grease	84,000	VND/kg	kg	1,000	84,000	500	42,000	400	33,600	
TOTAL					**27,177,170**		**13,904,651**		**18,198,127**	
					132,572 kJPY		67,828 kJPY		88,771 kJPY	

Item	Unit Price		Unit	Case-2 : 500 t/d x 2 Lines		Case-2-1 : 500 t/d x 1 Line		Case-3 : MRF+300 t/d		Remarks
				Annual surplus power	Annual income (kVND/year)	Annual surplus power	Annual income (kVND/year)	Annual surplus power	Annual income (kVND/year)	
Selling electric power	2,114	VND/kWh	MWh	94,860	**200,534,040**	31,755	**67,130,070**	33,034	**69,833,876**	
					978,215 kJPY		327,464 kJPY		340,653 kJPY	