Appendix A

Supplemental Information on Trend of Trade and Investment Between Asian Countries and Zambia

APPENDIX A

SUPPLEMENAL INFORMATION ON TREND OF TRADE AND INVESTMENT BETWEEN ASIAN COUNTRIES AND ZAMBIA

(1) MALAYSIA

1) Trade between Malaysia and Southern Africa

Malaysia's major trading partners in terms of exports are US, Singapore, Japan, China, Thailand, and Hong Kong. In 2007, US and Singapore shares of Malaysian export were 15.6% and 14.6% respectively. The table below shows the share of African countries in the total value of Malaysia's exports. In it, Africa's share is rather limited. Whereas South Africa and Egypt have larger shares than other countries with 0.45% and 0.23% respectively, the sum of eight southern African countries are still less than the amount of South Africa. South Africa's import value has steadily increased.

Table A.1 Exports from Malaysia to Southern Africa share in world total (%) and the annual growth rate (%)

	2001	2002	2003	2004	2005	2006		2002	2003	2004	2005	2006
							World	5.86	7.22	25.72	12.02	14.09
Egypt	0.238	0.317	0.454	0.290	0.324	0.213	Egypt	40.80	53.69	−19.57	25.11	−25.14
South Africa	0.290	0.269	0.332	0.378	0.405	0.415	South Africa	−2.03	32.56	43.05	20.15	16.91
Mauritius	0.044	0.047	0.050	0.044	0.043	0.049	Mauritius	11.48	15.16	9.60	9.78	31.27
Sudan	0.022	0.019	0.041	0.031	0.091	0.032	Sudan	−8.02	130.89	−5.32	226.90	−59.73
Tanzania	0.018	0.015	0.026	0.018	0.021	0.042	Tanzania	−14.06	91.82	−12.57	30.15	126.50
Kenya	0.023	0.014	0.018	0.034	0.037	0.049	Kenya	−33.99	35.49	135.34	20.86	51.13
Mozambique	0.005	0.066	0.017	0.013	0.011	0.015	Mozambique	1220.39	−71.88	−7.51	−5.01	56.55
Namibia	0.016	0.013	0.014	0.008	0.004	0.004	Namibia	−11.04	17.09	−27.34	−47.58	20.92
Angola	0.004	0.007	0.014	0.017	0.017	0.026	Angola	75.06	122.73	54.75	8.01	78.01
Djibouti	0.005	0.005	0.013	0.011	0.015	0.021	Djibouti	11.89	149.42	4.65	62.98	51.23
Madagascar	0.008	0.009	0.007	0.008	0.009	0.007	Madagascar	11.09	−12.64	33.96	40.15	−15.28
DRC	0.001	0.003	0.003	0.004	0.006	0.006	DRC	121.06	2.32	69.87	79.17	19.70
Zimbabwe	0.013	0.006	0.006	0.006	0.004	0.002	Zimbabwe	−49.80	10.46	16.52	−29.86	−32.67
Zambia	0.001	0.002	0.001	0.002	0.002	0.002	Zambia	76.13	−24.23	136.60	−2.23	6.06
Malawi	0.001	0.003	0.007	0.002	0.001	0.002	Malawi	322.60	154.20	−60.67	−28.53	63.91
Southern Africa*	0.059	0.115	0.090	0.071	0.066	0.100	Southern Africa*	104.11	−16.01	−0.62	4.14	72.74

Source: World Trade Atlas, Department of Statistics Malaysia

Note*: Southern Africa is the sum of the exports of Zambia and countries bordering with Zambia, i.e., Tanzania, Mozambique, Namibia, Angola, DRC, Zimbabwe and Malawi. Due to differences in the sources of data, the numbers shown in the tables are not consistent.

Among the main items exported to Southern African countries, fat and oil products form a large share[1]. Other exported items are diverse and many items do not have large share. Items such as electrical machinery, miscellaneous chemical products, furniture and bedding, and machinery have some significant values in exported goods to South Africa, Tanzania and Angola.

[1] Fat and Oil takes the largest share of the value of exported items toward South Africa, Tanzania, and Mozambique where the share in 2007 is 21.21%, 79.8% and 55%, respectively. (Calculated by the JICA Study Team based on the data of the Department of Statistics of Malaysia)

2) Trade between Malaysia and Zambia

Trade between Zambia and Malaysia has impressively developed over the last few years: Malaysia's import from Zambia increased dramatically from 2005. Exports from Malaysia exhibited some increase in 2006, but fluctuations were observed in the period. The major share of Malaysia's exports to the Southern African region were fat and oil (mainly palm oil products), and, in the case of Zambia, the share is also relatively large (16% of the export value in 2007.) [2] Another major exported product from Malaysia is rubber with 17% share in 2007. The major item imported by Malaysia is copper[3].

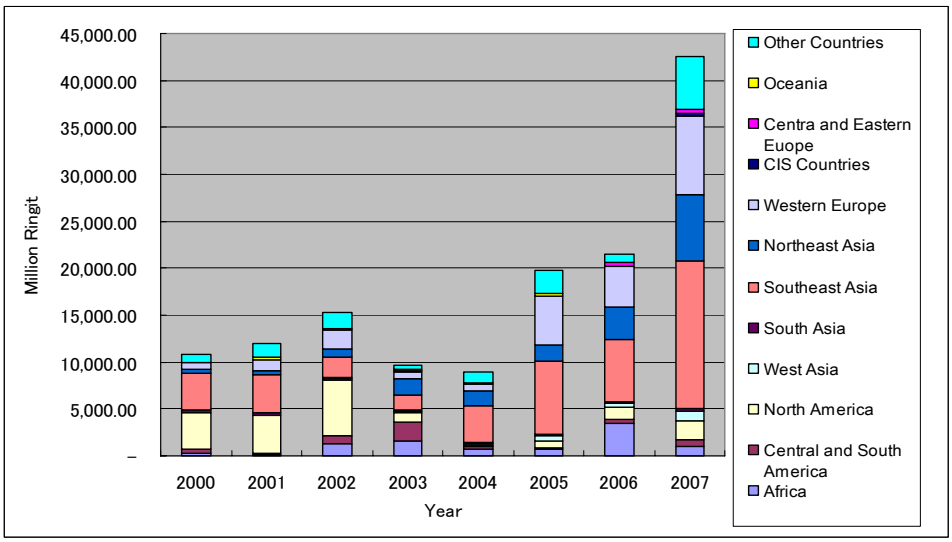
Table A.2 Malaysia trade balances with Zambia (Million US$)

	2003	2004	2005	2006
Export	2.8	1.9	1.9	3.2
Import	0	0	52.7	77.2

Source: Central Statistical Office of the Republic of Zambia (Million US$)

3) Malaysia's Outward Investment

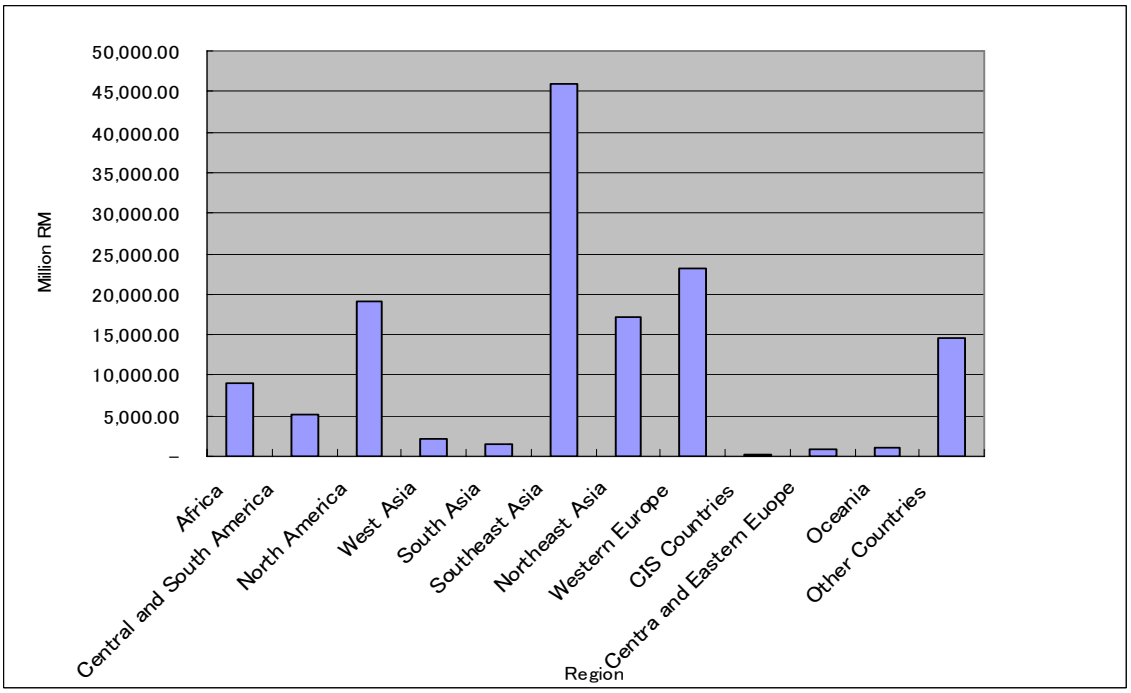
Malaysia's outward investment exhibited growth over the last few years. While Southeast Asian countries, notably Singapore, receive a large share of Malaysia's outward investment, the destinations are diversified to Northeast Asia and Western Europe.



Source: Bank Negara Malaysia (Million Ringit)

Figure A.1 Malaysia's foreign investment by year and destination

[2] World Trade Atlas based on the data of Department of Statistics of Malaysia.
[3] According to the data of the Department of Statistics of Malaysia, more than 95% of the import from Zambia is copper (World Trade Atlas).

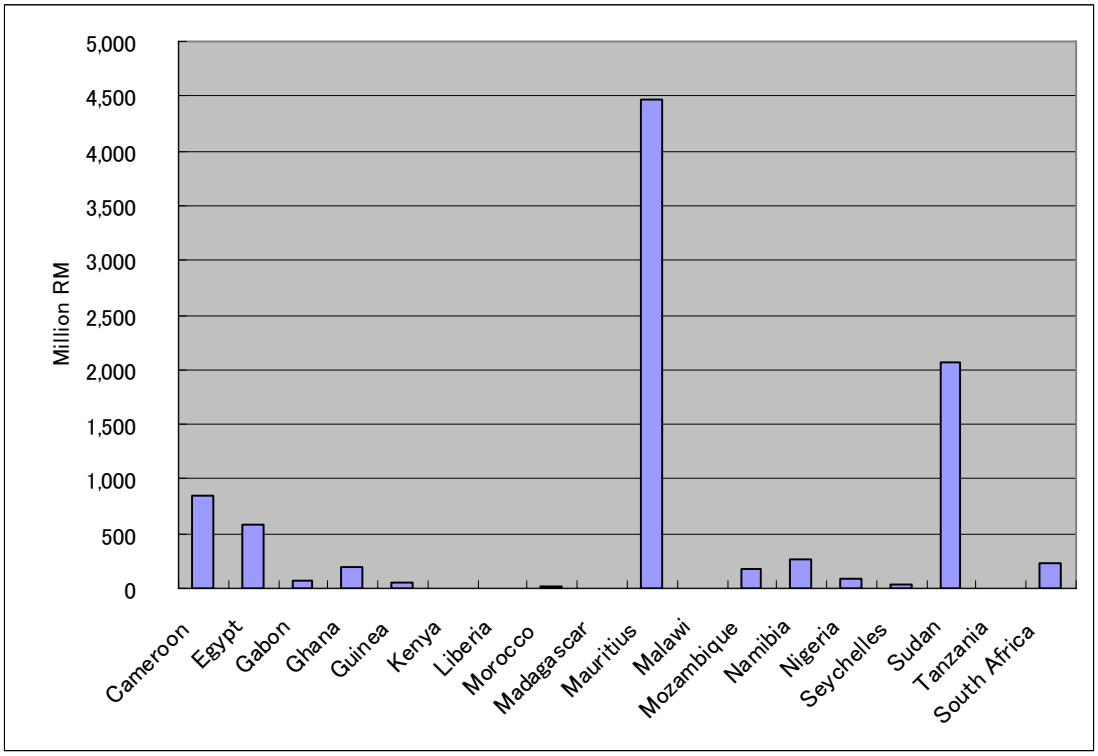


Source: Bank Negara Malaysia (Million Ringit)

Figure A.2 Malaysia's outward foreign investment [4](2000 – 2007)

Africa's share grew in 2002; however, as shown in the breakdown of total amount invested to African countries, the largest share was to Mauritius. Sudan also received a relatively large share of the investment from Malaysia. Data on the type and sector of investment could not be obtained.

[4] The offshore investment of Labuan IOFC received a large share of Malaysia's foreign investment. However, the data used here indicates the value without Labuan IOFC taking into the consideration of the fact of the unspecified nature of the financing as well as the inability of tracking the destination of the investment.



Source: Bank Negara Malaysia (Million Ringit)

Figure A.3 Malaysia's Outward Investment to Africa (2000-2007)

According to the report by the Bank Negara Malaysia, service industries forms 43% of Malaysia's outward foreign investment flow from 1999 to 2005, whereas 30% and 19% of the outflow were to manufacturing sector and oil and gas sector, respectively. Major part of the outward investment was from Malaysian-controlled companies comprising government-linked companies (GLCs) and resident-controlled companies (RCCs) (about 70% of the total flows)[5].

Transport, storage and communication sub-sector and utilities sub-sector, both form 20% each of the service sector investment of Malaysian-controlled companies, were done by joint venture or acquisition of the companies in Asia and Europe. Mining investment was to oil and natural gas exploitation. Some investment was done in Africa. The agriculture sector investment was mainly toward oil palm plantation[6].

The manufacturing sector with three major sub-sectors with fabricated metal product, machinery and equipment (48%), food, beverage and tobacco (14%) and chemical and petroleum-related industries (10%) invested in Asian countries and industrialized countries. The fabricated metals and equipment sub-sector comprises largely by electronics and electric appliances. The reasons of these industries choice in destination were analysed as follows:

- The industry invested abroad in order to reduce the cost of production.

[5] Bank Negara Malaysia, Quarterly Bulletin Third Quarter 2006, p.118.
[6] Ibid., p.120

- Some aimed at expanding the physical production capacity, higher technology and managerial capacity and expertise, brands and trademark rights. Therefore, the investment destination was mainly toward East Asian and industrialized countries.
- For the food and beverage industries, availability and proximity of sizable market were the determinants.

Africa received some investment from Malaysian-controlled companies in the area of construction.[7]

(2) Thailand

1) Trade between Thailand and Africa

The share of Southern and Eastern Africa in Thailand's total export value is limited although it is steadily growing. The shares of the total export to them shown in the below table in 2002 and 2006 were 0.95% and 1.47%, respectively. Moreover, about 50% to 60% of the exports of Southern and Eastern African countries were to South Africa. The share of South Africa grew from 50.6% in 2001 to 57% in 2006.

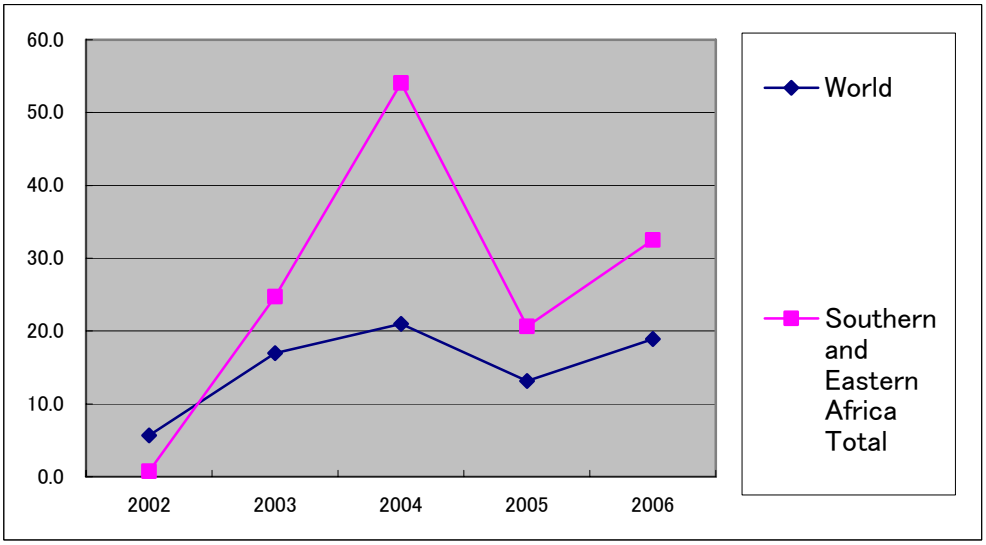
Table A.3 Thailand's Exports to Southern and Eastern Africa

	2001	2002	2003	2004	2005	2006
World	64908.67	68593.501	80252.572	97098.126	109848.41	130621.1
South Africa	314.222	331.524	414.988	654.469	840.578	1095.289
Egypt	141.952	125.313	172.287	213.401	264.351	379.674
Angola	16.68	20.832	25.148	73.045	36.205	50.25
Kenya	28.965	27.522	36.143	58.548	65.572	72.319
Sudan	18.206	20.603	18.217	26.199	44.773	86.25
Tanzania	33.864	33.318	29.886	38.856	37.278	49.213
Mozambique	10.845	8.816	10.928	41.279	42.841	33.862
Congo (Republic)	22.881	20.435	27.439	28.041	24.629	35.785
Ethiopia	7.602	14.957	10.069	11.747	21.746	29.735
Madagascar	4.721	3.698	11.506	26.471	33.735	20.375
Zimbabwe	3.625	2.379	5.444	5.653	6.904	14.056
Botswana	0.323	0.26	0.979	0.951	5.004	17.135
Djibouti	3.625	2.379	5.444	5.653	6.904	14.056
Uganda	11.043	10.104	8.859	10.764	10.667	12.739
Malawi	1.382	2.089	1.296	2.454	3.126	6.127
Zambia	1.36	1.83	2.204	5.447	7.075	6.364
Southern and Eastern Africa Total	621.296	626.059	780.837	1202.978	1451.388	1923.229

Source: The Custom Department of the Royal Kingdome of Thailand, World Trade Atlas (Million US$)

Despite the country level-fluctuation, the growth rate of exports from Thailand to Southern and Eastern Africa is larger than the growth rate of Thailand's exports to the world.

[7] Ibid., p.121



Source: JICA Study Team based on the date of the Custom Department of the Royal Kingdome of Thailand (Percentage)

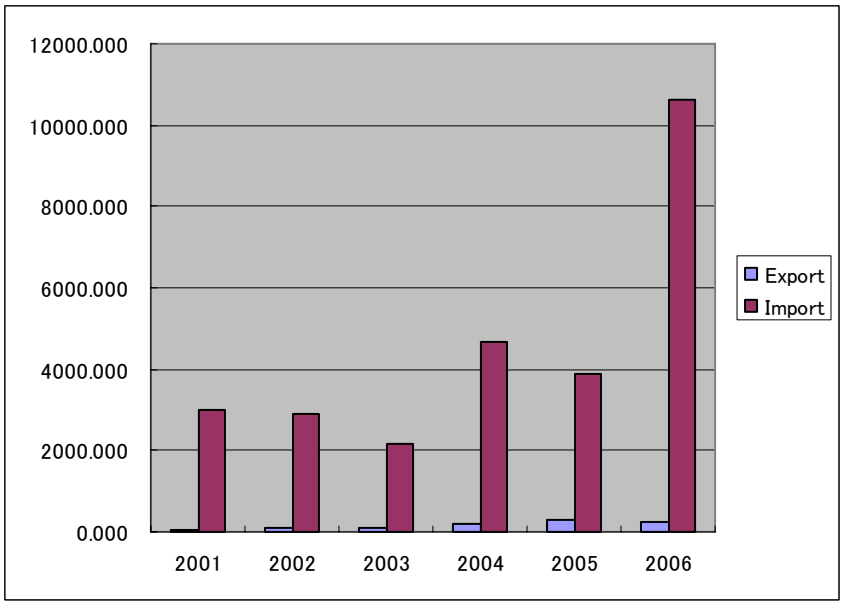
Figure A.4 Growth Rate of Thailand's Export

The items exported to Southern African countries show some variation to South Africa and other countries. However, cereals, vehicles, machinery, electrical machinery, and woven apparels are major commodities exported in general to countries in the region. Cereals (rice) is the major exported commodities both to South Africa and other countries[8]. Other main food items include sugar (especially Tanzania), prepared meat and fish, dairy, eggs, honey and others.

2) Trade between Thailand and Zambia

Thailand has a negative balance of trade with Zambia. Although Thailand's export to Zambia is very limited, its import is much larger.

[8] Cereals' share in total exported value to South Africa is from 11.% to 29.4% between 2004 to 2007. Cereals share to the export to Mozambique is around 70% of total value exported to the country.



Source: JICA Study Team based on the data of Custom Department of the Royal Kingdome of Thailand
(Baht)

Figure A.5 Thailand's Trade Balance with Zambia

Over 95% of the total value of import is from copper and articles. Cotton also has a modest share[9]. Although growth is observed, the share of copper can be largely attributed to the increase in the international copper price.

Table A.4 Import from Zambia: Share of Copper and Cotton

	Item	2001	2002	2003	2004	2005	2006
Value	COPPER & ARTICLE	2,988	2,871	2,140	4,495	3,691	10,520
	COTTON	11	0	42	143	176	79
Share	COPPER & ARTICLE	99.0	99.5	98.0	96.2	95.3	99.1
	COTTON	0.4	0.0	1.9	3.1	4.5	0.7

Source: JICA Study Team calculated based on the data of the Custom Department of the Royal Kingdom of Thailand
(Value: Million Baht, Share: Percentage)

3) Thailand outward investment destinations

Outward investment is increasing. The major destination is Asia especially China, Myanmar and Singapore. Although the data below from the Bank of Thailand does not mention Lao DPR, according to the research by the Office of the Board of Investment (BOI), Lao DPR is also one of the largest destination of Thai outward investment[10]. Mauritius is the only African country which appears in the

[9] The degree of processing of these items are low since copper is imported in the form of cathodes and cotton is not carded or combed.

[10] According to the data collected from Investment Promotion Agencies of host countries, Laos DPR received 330 projects which amount to US$2.4 billion in the period between 1988 and 2005 (Presentation material prepared by Mr. Mr. Pichit Dejneeranat, Senior Investment Promotion Officer, International Affairs Division, BOI).

statistics of the Bank of Thailand; Mauritius' share in the total outward investment of Thailand was between 1.5% to 3% in the period from 2003 to 2006.

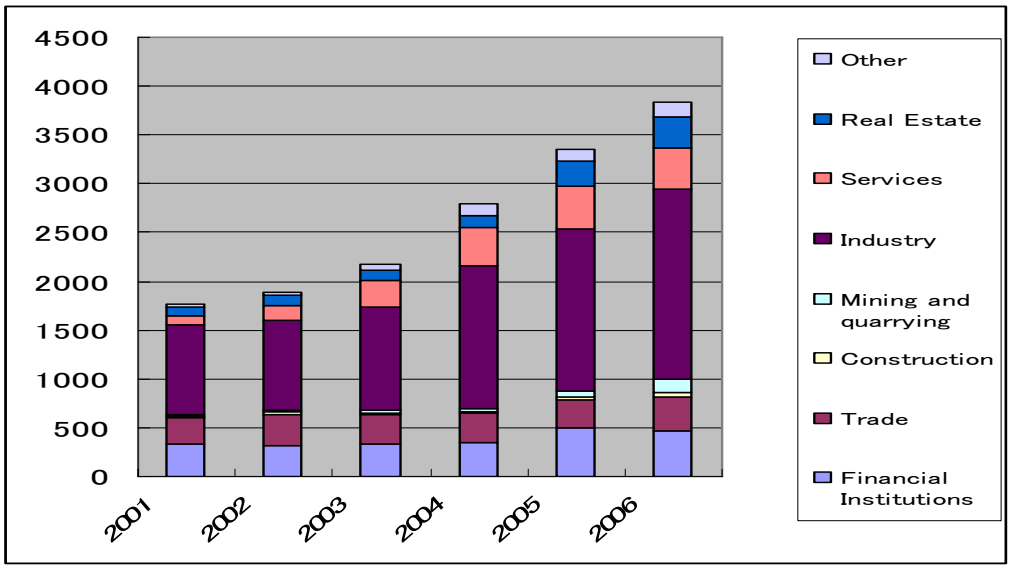
Table A.5 Thailand's Foreign Outward Investment

	2001	2002	2003	2004	2005	2006	Accumulated	Share(%)
Total	1,764	2,039	2,577	3,024	3,716	4,045	17,165	100.00
Mauritius	2	2	36	93	88	66	287	1.67
Cambodia	15	14	20	23	30	65	167	0.97
China	265	316	320	359	433	480	2173	12.66
India	7	23	33	44	82	74	263	1.53
Myanmar	188	279	386	462	564	522	2401	13.99
Singapore	262	283	429	532	682	879	3067	17.87
Vietnam	176	188	223	258	293	207	1345	7.84

Source: Bank of Thailand (Million US$)

According to interviews with Government agencies which have more information on overseas investment, some investment projects were planned to Africa in the past but no successful projects were reported so far to them.[11].

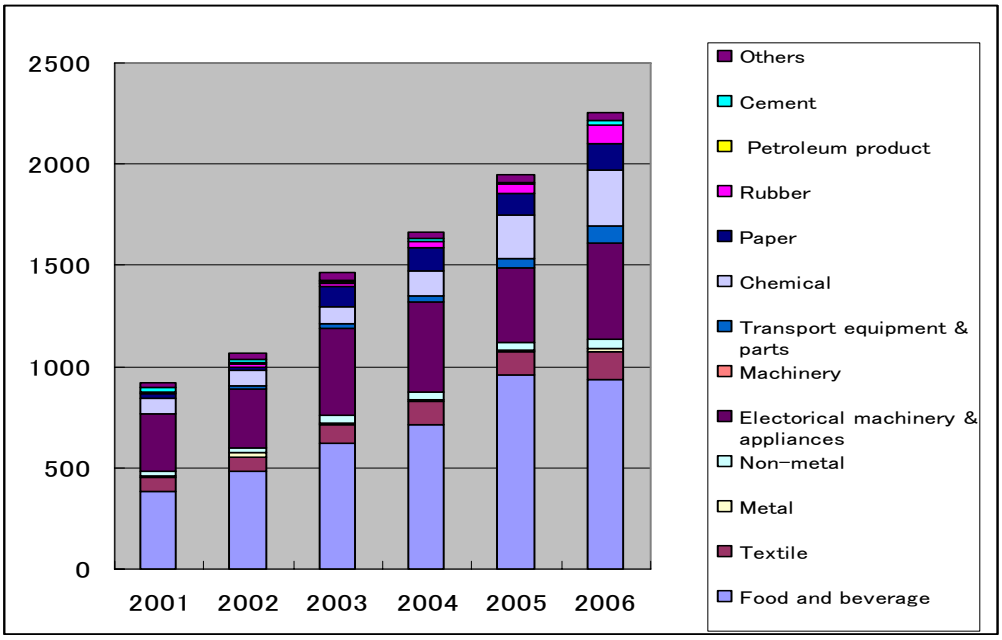
Thai outward investment is more active in industrial sectors than service sectors; the share of industry was 41% to 52% in the recent years. The most active sectors of Thai outward investment have been food and beverages. The share to the total outward investment in the period between 2001 and 2006 is 20% to 25%.



Source: JICA Study Team based on the data of Bank of Thailand (Million US$)

Figure A.6 Thailand Outward Investment by Sector

[11] Based on the interviews with the official of Exim Bank in June 2007 and one enterprise in food sector in July 2008.



Source: JICA Study Team based on the data of the Bank of Thailand (Million US$)

Figure A.7 Thailand Outward Investment to Industrial Sectors: Share by Industries

The investment determinants are further to be analysed by the questionnaire survey. However, a previous study based on the survey with enterprises analysed the factors which drive Thai enterprises for overseas investment as follows:

- Market-seeking is a significant motive for Thai FDI. Enterprises has been more active in establishing and expanding distribution channels through setting up own representations and facilities or through joint-venture arrangements.
- Efficiency-seeking investment has been increasing relatively recently especially in the labour-intensive industries such as garments.
- Resource-seeking investment can be found in sectors such as oil and gas and cement, though limited to large companies and conglomerates.[12]

4) Incentive scheme

In 2004, Thailand approved its overseas investment strategy. Its objectives were as follows:

- Find and ensure sources of resources such as agricultural, mining, and fisheries resources, jewelry, and energy.
- Market expansion for the sectors such as automobile parts, animal feed, agro-industries, telecoms, hotels and construction.
- Lower the production cost for sectors such as garments and jewelry.
- Gain access to new technologies.

[12] Kee Hwee Wee, "Outward foreign direct investment by enterprises from Thailand", *Transnational Corporation*, Vol 16, No.1 (April 2007) UNCTAD , p.102-103

The focus is on sectors with competitiveness such as agriculture and agro-industries, mining, fisheries, jewelry, and ornaments, energy, automobile parts, textiles and garments, and industrial estates. Current target markets are Indochina and other Southeast Asia countries.

As a part of the incentives for overseas investment promotion, the Exim Bank of Thailand has services such as long-term credit for investment, loans for contractors for overseas construction, and overseas investment insurance[13]. However, to date, no project has been financed in Africa[14].

(3) Singapore

1) Singapore's trade with Africa

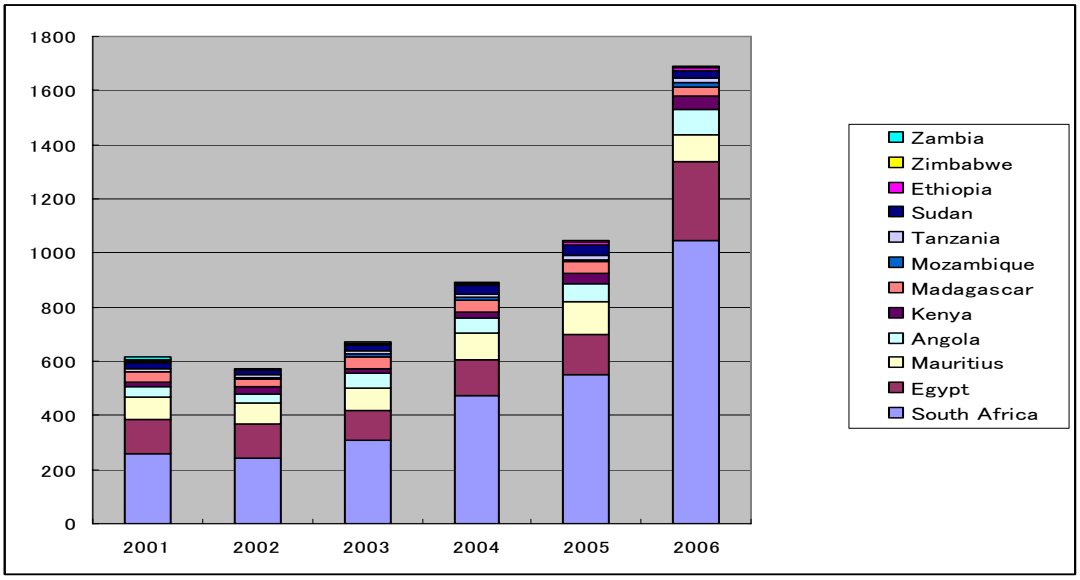
The trade between Singapore and Africa is very limited. As shown in the below table, the share of the Southern and Eastern African countries in the total export value of Singapore is less than 1%. South Africa's share in Singapore's exports to Southern and Eastern African countries is high and exhibits gradual increase in recent years.

Table A.6 Share of Southern and Eastern Africa in Singapore's Total Export Value and Share of Singapore's Exports to South Africa to Total Value to Southern and Eastern African Countries[15]

	2001	2002	2003	2004	2005	2006
Southern and Eastern Africa Total	0.50	0.46	0.42	0.45	0.46	0.62
South Africa's Share in Southern and Eastern Africa Total	42.27	41.87	45.62	53.28	52.38	61.90

Source: JICA Study Team based on the data of IE Singapore/World Trade Atlas (Percentage)

The country breakdown of exports from Singapore to Southern and Eastern African countries is shown below. As explained, the total amount is increasing, due mainly to increase of South Africa.



Source: JICA Study Team based on the data of IE Singapore (Million US$)

Figure A.8 Singapore's Exports to Southern and Eastern Africa

[13] *Export-Import Bank of Thailand* (Brochure of Exim Bank)
[14] Based on the interview with the official of Exim Bank in June 2008
[15] Southern and Eastern African countries in this figure include South Africa, Egypt, Mauritius, Angola, Kenya Madagascar, Mozambique, Tanzania, Sudan, Ethiopia, Zimbabwe, and Zambia

2) Singapore's outward investment and its characteristics

Singapore is active in investing outward. The major part of such investment is distributed to Asian countries (46% of FDI stocks)[16]. The outward investment to Africa is concentrated in Mauritius[17]. The value of Singapore outward investment by sector shows over 50% of the investment is toward financial and insurance sector[18]. In 2005, 73% of the outward investment was from service industries such as wholesale and retail trade, hotels and restaurants, transportation and storage, financial and insurance, information and communication, real estate, rental and leasing, and professional, technical services and administrative support[19].

Although statistical data indicating the share could not been obtained, the interviews with various stakeholders revealed that Singapore's overseas investment has been strongly led by the Government-linked companies (GLCs).[20] These GLCs' overseas investments started in 80s in manufacturing sectors: avoiding the increasing cost in Singapore, many companies off-shored the production facilities in Johor in Malaysia or Riau Islands such as Batam and Bintan in Indonesia. In 1990's, with the strong Government initiatives and supports, GLCs endeavored into the investment in countries such as Vietnam, China, and India.[21] The largest GLCs such as Temasek Holdings Co Ltd. and the Government Investment Corporation have expanded the geographical coverage of investment since then covering Europe, North America, Japan, and Middle East.[22] Due to the status of these companies being for-profit basis and publicly listed companies, they are keen on the profitability. Therefore, the investment decision is based on the strict deliberation.[23]

Africa is recent areas emerged for the investment destination. The International Enterprise Singapore (IE Singapore), the Government of Singapore's agency which provides various services to enterprises to promote trade and investment, started some promotion activities only recently. As IE Singapore's services are required to be cost-recovery basis with the fee paid by the beneficiary companies, the countries with high risk and high initial cost with poor infrastructure were rather avoided for its promotion focus. [24]

(4) India

1) India's trade with Africa

India's exports to Africa have been dramatically increasing in recent years. Although, the share of Africa in the total export value is still not high, as shown in the Table below, annual growth rate of the sum of major African countries have been 40% to 60% per annum in the period from 2004 to 2006

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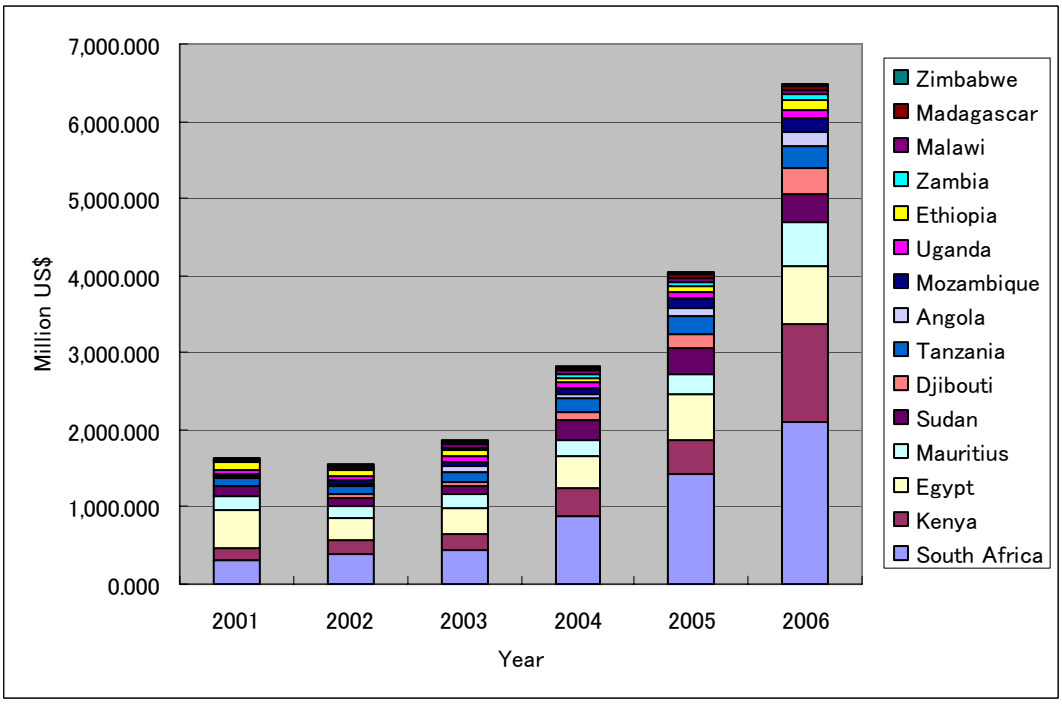
[16] UNCTAD, World Investment Report 2006, p.114
[17] UN, Asian Foreign Direct Investment in Africa: Towards a New Era of Cooperation among Developing Countries, p.33
[18] As of the end of 2004 and 2005, 56% and 48.8% of the outward investment was to financial and insurance sector where as 23% was to manufacturing sector. (Source: Singapore Department of Statistics).
[19] Singapore Department of Statistics, Yearbook of Statistics Singapore 2007
[20] The estimate of Temasek, one of the largest GLCs, an investment company, and its subsidiaries were announced to be 13% of GDP of Singapore (Source: Motion on Temasek Charter and EISC's Recommendations on Government in Business-Speaking Points for DPM's Round-Up Speech, 28th August 2002 on the Ministry of Finance of Singapore website: https://app.mof.gov.sg/news_speeches/speechdetails.asp?speechid=70).
[21] Gan Siang Kiong, p.62.
[22] Ibid., p.80-84.
[23] Ibid., p.85
[24] Based on the Interview with officials of IE Singapore in May 2008

Table A.7 Africa's Share to India's total export value
(Percentage to India's total export value)

	2001	2002	2003	2004	2005	2006
South Africa	0.741	0.802	0.780	1.167	1.425	1.724
Kenya	0.354	0.370	0.361	0.491	0.456	1.058
Egypt	1.149	0.572	0.586	0.549	0.584	0.610
Mauritius	0.388	0.323	0.314	0.271	0.257	0.473
Sudan	0.287	0.212	0.164	0.327	0.341	0.301
Djibouti	0.035	0.061	0.092	0.154	0.195	0.282
Tanzania	0.202	0.226	0.242	0.228	0.230	0.229
Angola	0.057	0.066	0.109	0.086	0.104	0.163
Mozambique	0.071	0.089	0.102	0.095	0.123	0.145
Uganda	0.126	0.125	0.142	0.100	0.085	0.091
Ethiopia	0.220	0.139	0.134	0.068	0.066	0.091
Zambia	0.057	0.058	0.062	0.059	0.068	0.080
Malawi	0.049	0.050	0.064	0.074	0.046	0.037
Madagascar	0.030	0.025	0.056	0.046	0.051	0.034
Zimbabwe	0.026	0.035	0.037	0.032	0.022	0.026
Southern Africa without SA*	0.462	0.522	0.616	0.572	0.592	0.679
Major African Countries*	3.792	3.152	3.245	3.745	4.053	5.342

Source: World Trade Atlas, DCGI&S, Ministry of Commerce of India (Percentage)



Source: World Trade Atlas, DCGI&S, Ministry of Commerce of India (Million US$)

Figure A.9 India's Exports to Africa

While South Africa's share of Indian exports is the largest, the breakdown of products imported by these countries indicates similarity. While largest traded commodities are minerals, fuel and oil, vehicles, various products pharmaceutical products, machinery, iron and steel, cereals, cotton yarn and textile, plastic and rubber are on the list of exported items to countries such as South Africa, Tanzania and Mozambique.

On the other hand, the major imported item from Africa was gold which formed 42.5% of the total

volume during the period of 2004 to 2005. South Africa is the major exporter with a share of 57% in the same period[25].

2) India's outward investment

India's outward investment is dramatically increasing in the recent years. The annual average between 1990 and 2000 was US$ 121million, and outward investment in total in 2003 and 2006 was US$1,879 million and US$9,676 million respectively[26]. While some examples of active Indian investment are observed, the data to show its strength could not be obtained yet. On the other hand, Indian firms are reported active in international mergers and acquisitions (M&A) in recent years. M&A during 1995 to August 2006 was observed with the North America-based companies (32%). Europe-based (29%) and Asian-based (22%). Africa's share is 6%. The sector breakdown of these M&A activities are diverse: the share of consumer goods and services is 22% largest in the period of 1995 to August 2006, whereas electronics and high technology 15%, IT services 11%, pharmaceuticals and healthcare 10%, metals and mining 7%, energy 6%, and automotive 5%[27].

3) Initiatives for promoting trade and investment with African countries

In 2002, the Government of India announced the new initiative of Focus Africa Programme which aims to promote exports toward SSA countries. After the launch of the programme with Nigeria, South Africa, Mauritius, Kenya Ethiopia, Tanzania, and Ghana, the target countries were further expanded to 17 countries including Southern African countries such as Zambia, Botswana, Mozambique, Angola, Namibia and Zimbabwe.

Focus Africa Programme especially eyes the expansion of trade in the following sectors: cotton yarn, fabrics and other textile items; drugs and pharmaceuticals; machinery & instruments; and transport equipment; and telecom and information technology[28].

As financial support, the Export and Import Bank of India (Exim Bank) set up Lines of Credit to a number of African countries which are accessible based on the agreement between the Government of India and the respective countries mainly for infrastructure development projects done by Indian contractors. However, the details of the loans provided (e.g., breakdown of the types of projects) is not publicised.

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[25] Exim Bank of India, Africa-An Overview of Recent Economic Developments and Challenge.
[26] UNCTAD, World Investment Report 2007
[27] India Goes Global-Accenture cited by Evalueserve, Indian Companies' Global Strategy, pp.1
[28] Ministry of Commerce, Press Release, Exim Bank Africa-An Overview of Recent Economic Developments and Challenges, www.ficii.com

Appendix B

Supplemental Information on Methodology of Investment Survey in Asian Countries

APPENDIX B

SUPPLEMENAL INFORMATION ON METHODOLOGY OF INVESTMENT SURVEY IN ASIAN COUNTRIES

(1) Enterprise questionnaire survey samples

The sample enterprises in key sectors were selected by following sources and informants:

Malaysia	• Kulara Lumpur Stock Exchange listed company database • Directory of companies participated in the Malaysian International Development Authority (MIDA) • Internet search of companies trade with Africa
Singapore	• Singapore Stock Exchange Directory • Internet search of companies in trade ventures in Africa and companies which are classified in the surveyed sector grouping • The list of the participants to the trade missions organised toward Lybia and Madagascar by IE Singapore*
Thailand	• Database of listed companies of the Thailand Stock Exchange (TSE website) • The Thai Chambers of Commerce Directrory 2008 • Board of Trade of Thailand Business directory 2008-2009 • Directory of the Thai Federation of Trade and Industry • The Federation of Thai Industries Directory 2007 • Factory Directory in Thailand 2008 (8th edition) • Database of member companies in FTI and TCC*
India	• The National Stock Exchange of India Limited (NSE) Directory • Internet search of companies classified in the abovementioned sector grouping • List of companies who participated in Zambia's trade missions in India obtained from ZDA • FICCI member database* • CII members*

(2) Structure of questionnaire

Questionnaires were distributed by e-mail and/or via fax attaching the short explanation of investment opportunities in Zambia and MFEZ. The questionnaire comprises the items indicated below.

Table: Items included in the Enterprise Survey

Researched Items by the Enterprise Questionnaire Survey	
Profile of the surveyed enterprise	Name of the company, address, contact person and the contacts
	Sub-sectors, core products or services*
	Year of establishment*
	Legal status*
	Amount of capital and asset*
	Annual turn over*
	Number of employees*
	Cost structure*
	Major markets*
	Other (size of production site etc)*
	Manufacturing: Utilisation rate of the production facility*
Investment demand to overseas	Medium term business forecast (next 3 years)
	Medium term business plan for overseas operation*
Recent investment * (Domestic and overseas)	Type of investment Amount invested
Overseas operation	Determinants and key issues for endeavouring overseas investment
	Planned or interested destination of investment*
	Possibility of the investment
	Determinants and key issues for deciding the site of investment
	Type of investment*
Problems and constraints faced for overseas investment and operation	
Required infrastructure and facilities for newly invested site	Necessary size of land*
	Necessary infrastructure/facilities for production and business operation Favourable investment incentives
Position of Southern Africa and Zambia as a potential destination of future investment	Reasons of selecting and not selecting Southern Africa Countries of selection Major concerns in investing in Southern Africa

* Items were only collected for the survey in Malaysia.

(3) Categorization of enterprises

Based on the experience of the survey in Malaysia which has started earlier than other three countries, the items were reduced and minimised in order to increase the number of response.

Categorisation and surveyed sub-sector

Category	Items included	Industries included (ISIC)	
Agriculture and agro-resource based	・Agricultural and forestry activities ("upstream") to processing industries of the agro-, fisheries, and wood resources "downstream" ・Service industries dealing with agro-, fisheries and wood products	A01 D15 D20 D21 D36 G51 -52 I63	Agriculture Food products and beverages Wood products Paper and paper products Furniture Wholesale and retail trade (specially for agro- and fisheries products) 6302 Storage and warehousing (specially for agro- and fisheries products)
Textile and garments	・Manufacturing of textile ・Manufacturing of wearing apparel	D17 D18	Textile Wearing apparel
Chemicals	・Manufacturing of pharmaceuticals ・Manufacturing of organic chemicals	D24	2411 Basic chemicals, 2412 Fertiliser and 2413 Plastics in primary form 2421 Pesticides and other agrochemicals 2423 Pharmaceuticals

Category	Items included	Industries included (ISIC)	
Rubber and Plastics	・Manufacturing of semi-processed plastic and rubber (such as plates, sheets)	D25	Rubber and plastics (Plastic parts used in the machinery and equipment and electronic components are included in "Machinery and equipment" and "Electric appliances and electronics", respectively) (Plastics as a form of raw materials for other products such as resin are included in "Chemical"
Metals	・Manufacturing of basic metals and metal fabrication	D27 D28	Basic metals Metal fabrication
Machinery and equipment	・Manufacturing of industrial equipment, machinery, and transportation equipment including vehicles. ・Manufacturing of parts for above-mentioned machinery and equipment.	D29 D34 D35	Machinery and equipment Vehicles and their parts Other transport equipment
Building materials	・Manufacturing of the products used for construction such as cements, ceramic products (tiles, roofing), and steel and fabricated metals ・Materials used for water, energy and telecom-related infrastructure development	D26 D27 D28	Non-metallic mineral products (2692~94 Cement, structural ceramic and clay products, re-factory ceramic products) Basic iron and steel (construction-related products such as steel bars) 2811 Structural metal products 2892 Metal treatment 2899 Manufacture of other fabricated metals (such as cables)
Electric appliances and electronics	・Manufacturing of electrical appliances ・Manufacturing of parts and components of electrical appliances and electronics ・Manufacturing of the components used in the above-mentioned products.	D30 D31 D32	Office, accounting and computing machinery Electrical machinery Radio, television and communication equipment
IT related services	・Services in information technologies or services using the information and communication technologies. ・Various activities are included such as software development, system development and management, outsourcing, programming, soft product development, data processing services and network development.	K72 K74	7221 and 7229 Software publishing, consultancy and supply 7230 Data processing 7414 System related business management consultancy
Construction and industrial estate development	・Construction ・Engineering consultants and other engineering related services ・Industrial estate development and operation	D45 K74 K70	Construction 7421 Architectural and engineering and related technical consultancy Real estate activities
Other services	・Education, health care, other	M80 N85	Education 8511~12 Hospital and medical activities
Others	・Shipping and forwarding of products ・Distributions and leasing of specific products ・Conglomerates operating various activities	I63 G51 -52 K71	6301~02 Cargo, storage and warehousing Wholesale and retail (Except agricultural and food products) 7121 and 7129 Renting of construction and other machinery

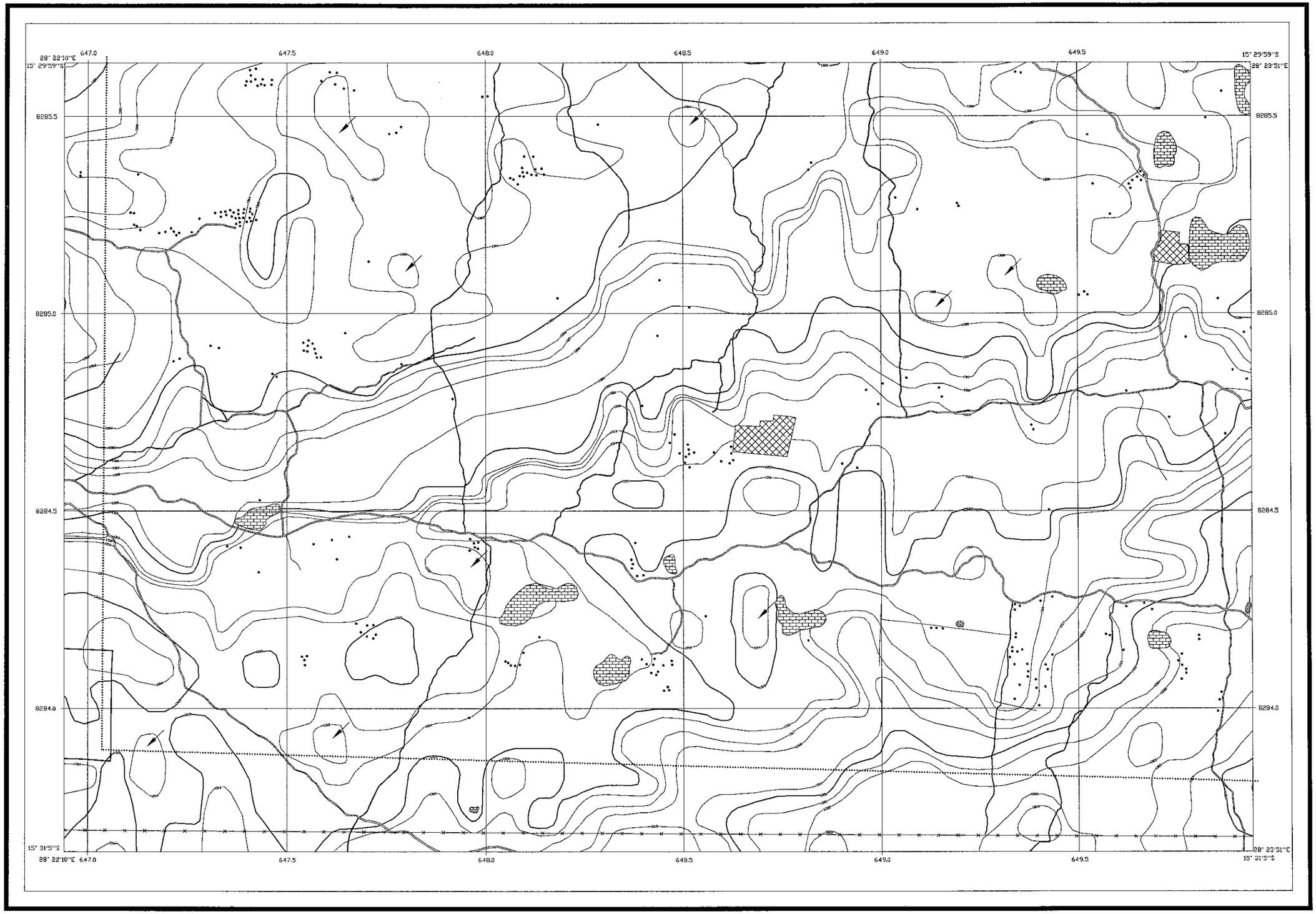
Appendix C

Topographical Map

REPUBLIC OF ZAMBIA

SCALE 1:5,000

001



INDEX TO ADJOINING SHEETS

002	004	006
001	003	005

SCALE 1:5,000

0 100 200 300 400 500 1000 METRES

House
Main Roads with Causeway
Motorable Tracks or Farm Roads
Concave
Power Line
Cultivated Land
Contours
Outcrop Rock
Fence

REPUBLIC OF ZAMBIA

SCALE 1:5,000

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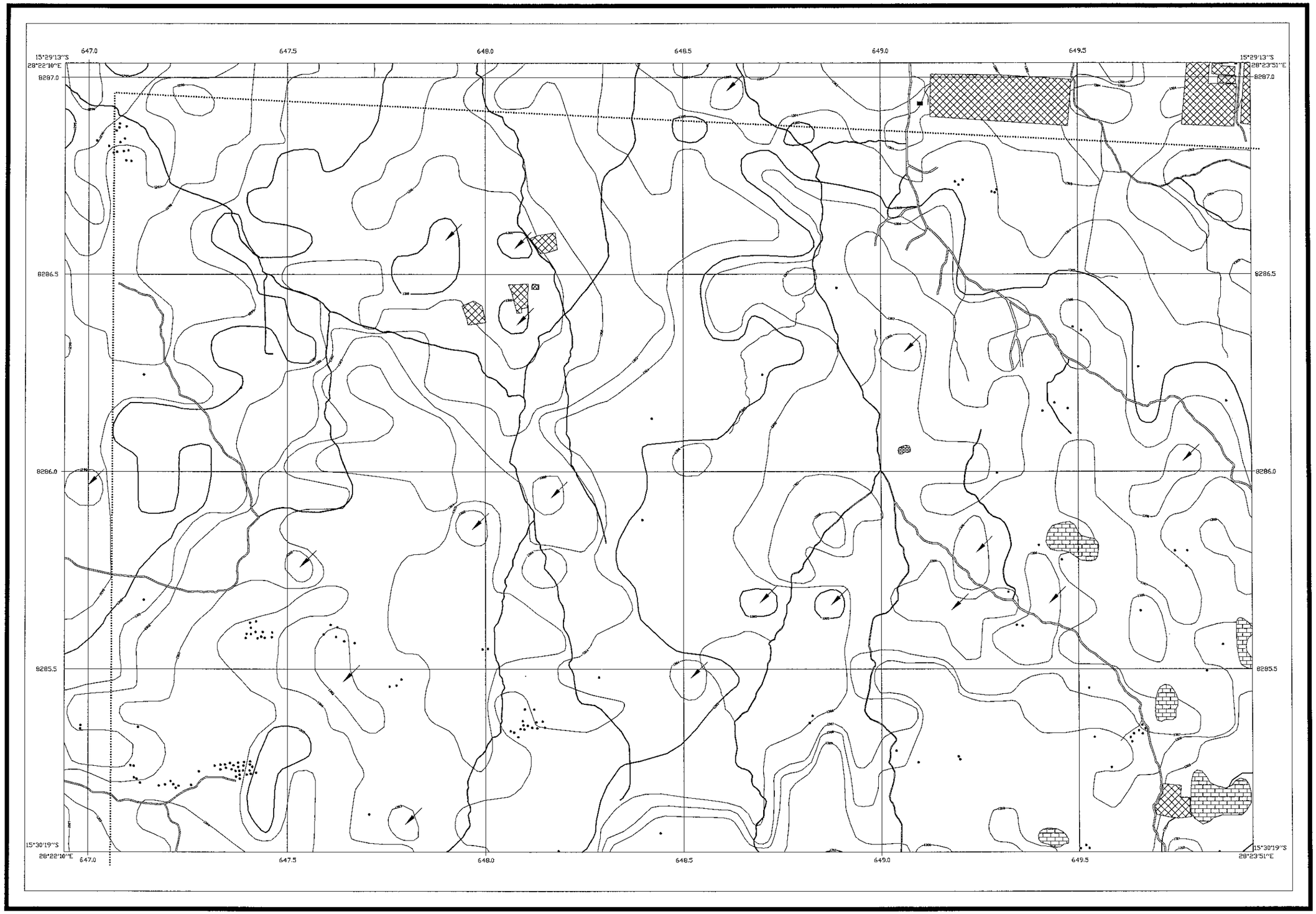

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Fence

REPUBLIC OF ZAMBIA

SCALE 1:5,000

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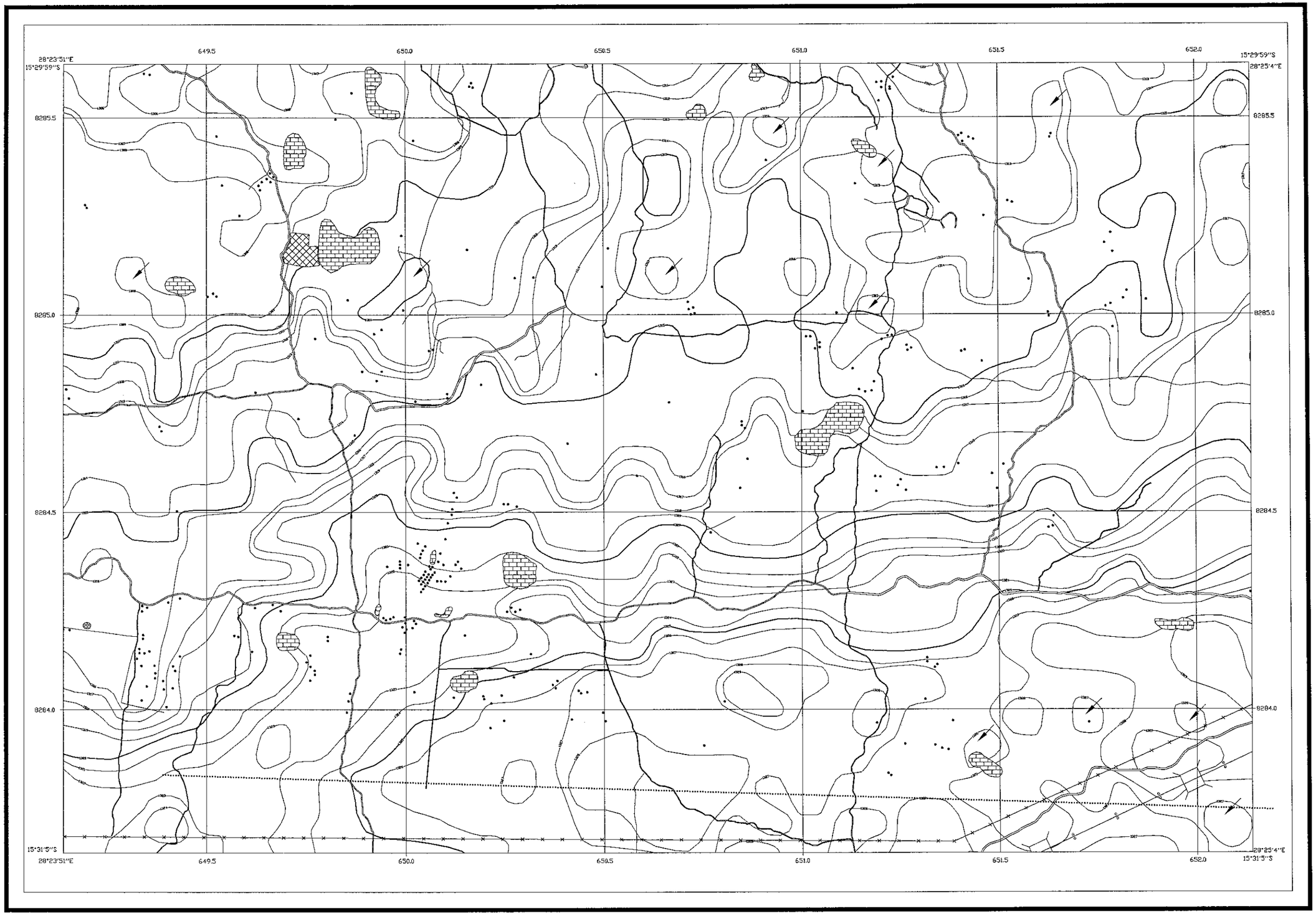

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SCALE 1:5,000

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Fence

C - 3

REPUBLIC OF ZAMBIA

SCALE 1:5,000

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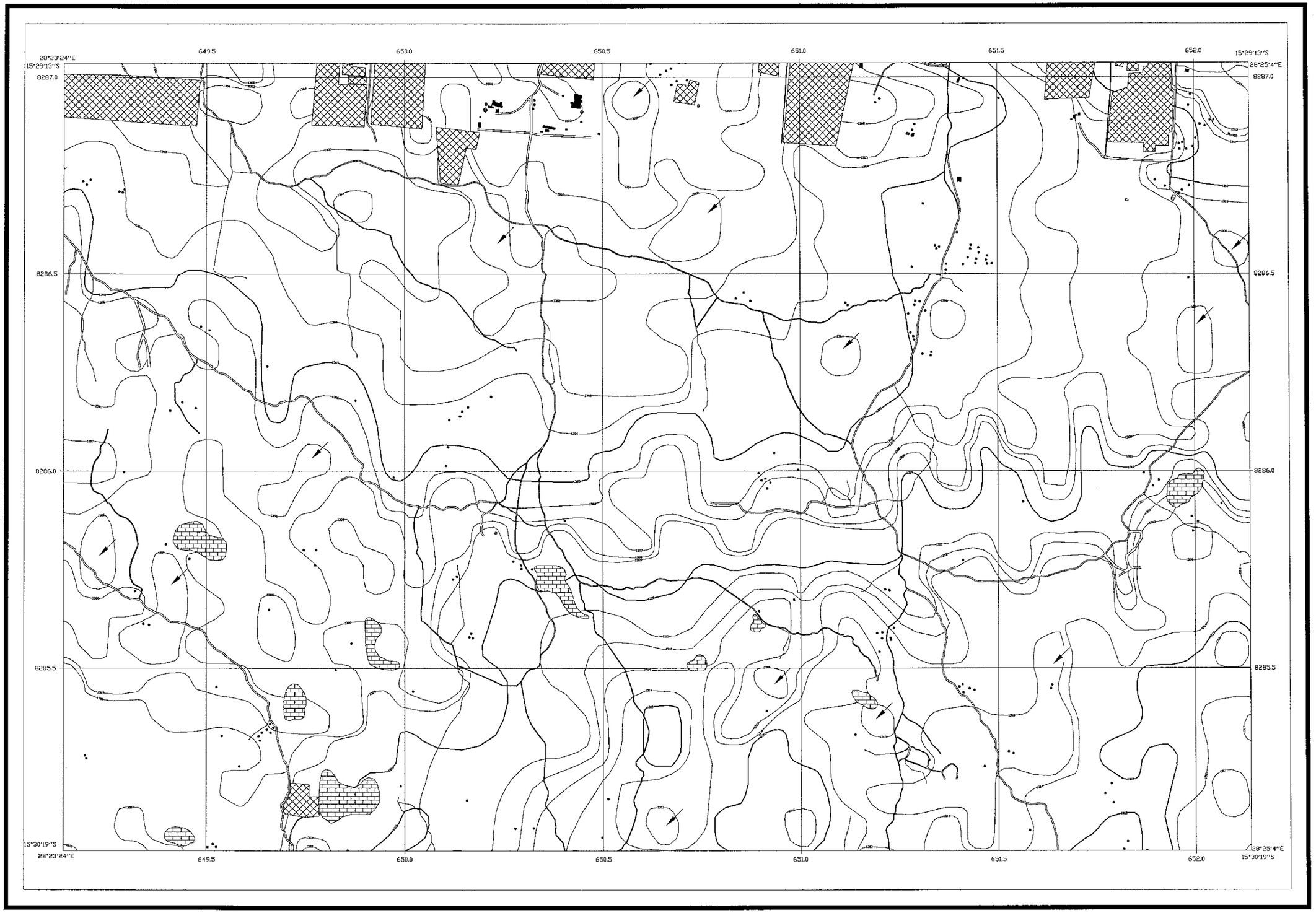

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001	003	005

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REPUBLIC OF ZAMBIA

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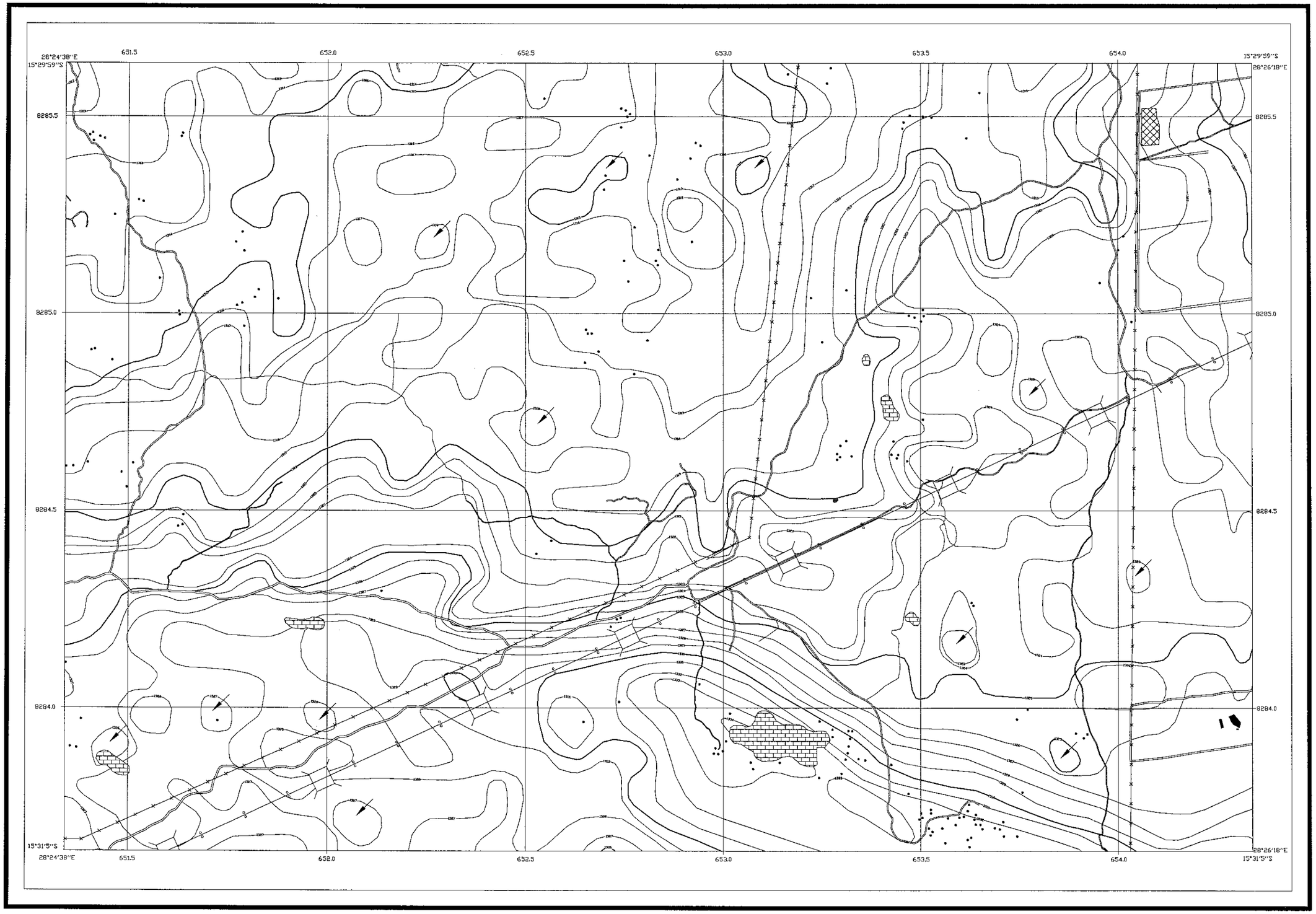

INDEX TO ADJOINING SHEETS

002	004	006
001	003	005

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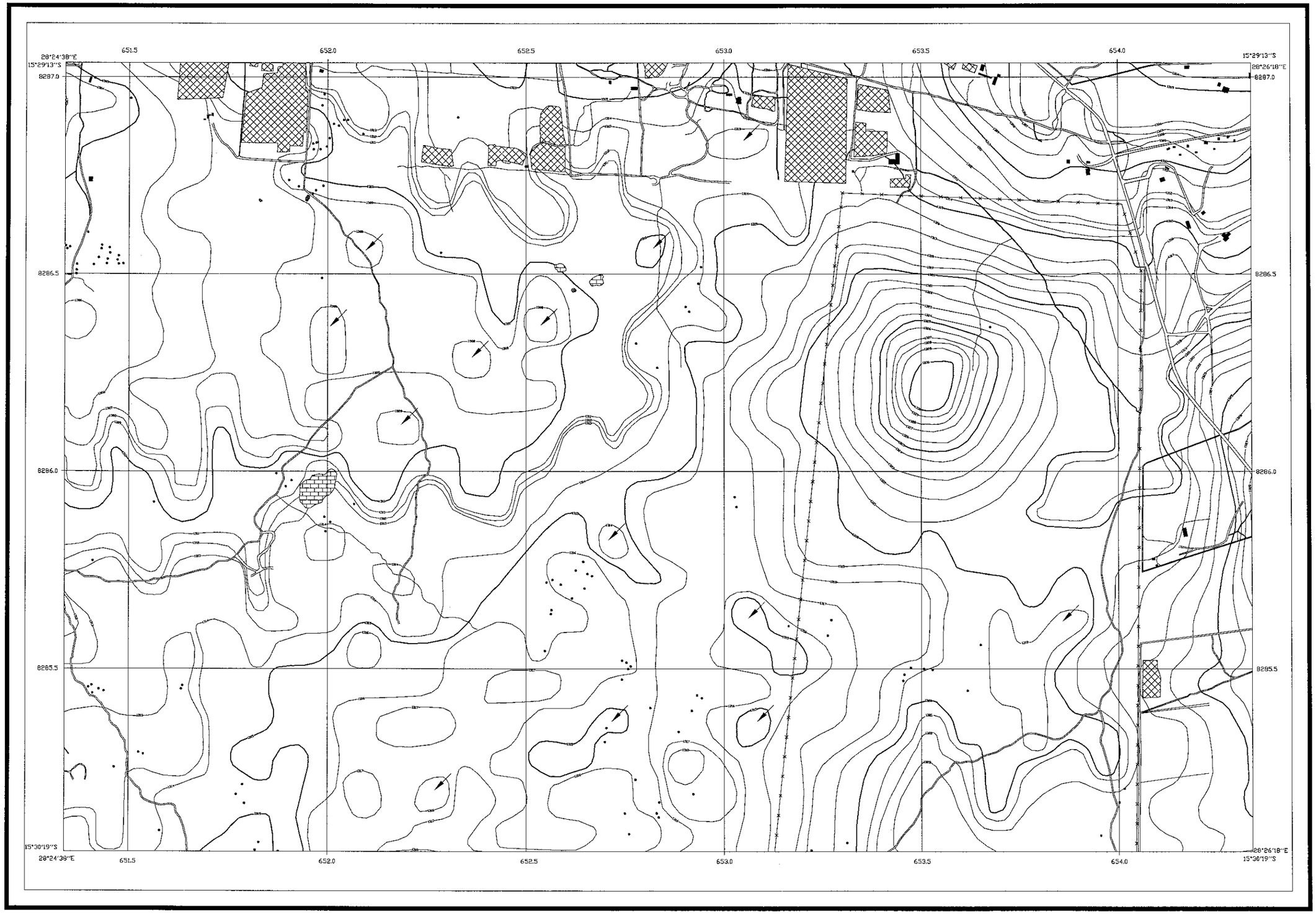
REPUBLIC OF ZAMBIA

SCALE 1:5,000

006



INDEX TO ADJOINING SHEETS

002	004	006
001	003	005

SCALE 1:5,000

0 100 200 300 400 500 1000 METRES

House
Mainroads,with Causeway
Motorable Tracks or Farm Roads
Concave
Power Line
Cultivated Land
Contours
Outcrop Rock
Fence

Appendix D

Hydrological Survey

APPENDIX D

HYDROLOGICAL SURVEY

To evaluate groundwater conditions including flow direction and groundwater amount, a hydrological survey was carried out by the JICA Study Team. Contents of the study included test well drilling, pumping tests, water quality analyses, groundwater level surveys, existing well inventory surveys and stream condition surveys. Part of the hydrological survey such as test well drilling and water quality analyses were undertaken by the local contractor.

D.1 TEST WELL DRILLING

(1) Location of the test wells

The sites for test well drilling were selected based on a physical relationship between existing well locations. Test well sites were specifically located on a straight line with existing wells. Test well drilling sites are shown in *Figure D.1*. In general, boreholes were drilled to a depth of 100 m. Based on the survey data, geological conditions, groundwater distribution and direction of groundwater flow were analyzed.

After each test well was drilled 100 m, geophysical logging was carried out for confirmation of aquifer and casing planning. Drilling Logs with geophysical logging results are shown in geological columnar section in this *Appendix*.

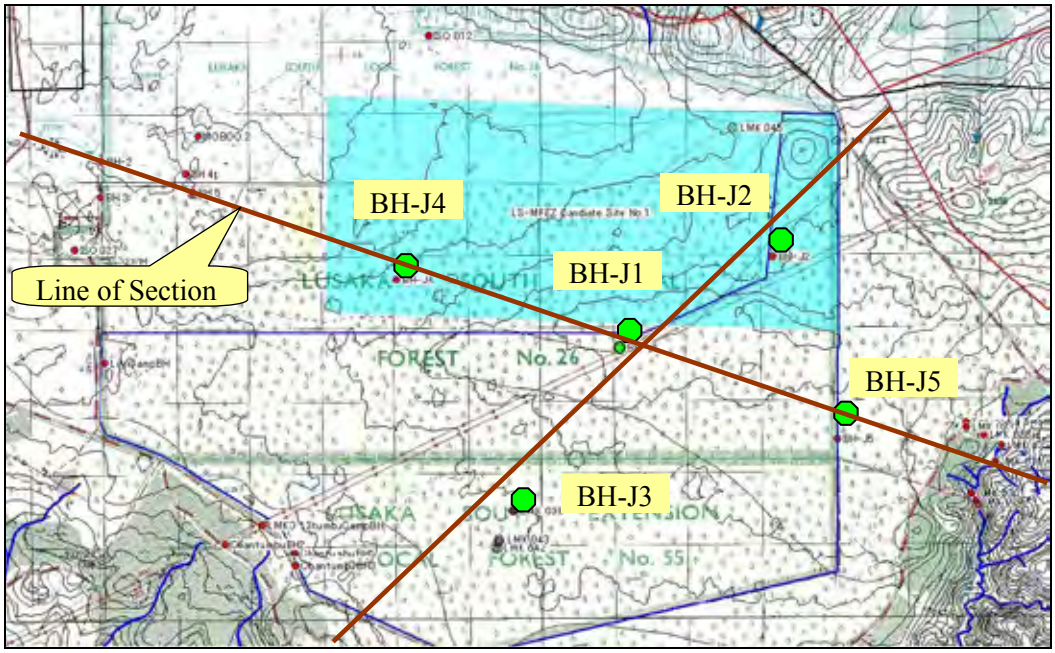


Figure D.1 Location Map of the Test Wells (BH-J1 to J5)

(2) Pumping Test

Pumping tests were carried out for each borehole after installation of the casing. This consisted of a step draw-down test, constant discharge test and recovery test. Hydraulic coefficients of the aquifer such as permeability, transmissibility and storage were calculated based on test results.

D.2 WATER QUALITY SURVEY

Groundwater quality and surface water quality have been analyzed to consider the classification of water, and also to establish baseline figures of present conditions around the LS-MFEZ area. 18 existing boreholes, 5 test wells constructed by the project and 5 streams around the Lusaka plateau were selected for water sampling points. Sampling points are shown in *Table D.*1 and *Figure D.2*.

Table D.1 List of the Sampling Points for Water Quality Testing

No	Name	Location	Type	Ownership	Project
1	Ngwerere Stream 1	Behind Elendele	Stream	Public	
2	Ngwerere Stream 2	Kasisi	Stream	Public	
3	Chailmbana Stream	Chalimbana	Stream	Public	
4	Kanyanja Stream	Knyanja	Stream	Public	
5	Shantumbu Stream	Shantumbu	Stream	Public	
6	ISO-6	Co-operative College	Borehole	College	Iso Project
7	ISO-12	New Kasama	Borehole	P.Mwamfuli	Iso Project
8	Leopard Hill 1	Woodland	Borehole	LWSC	
9	ISO-26(Shaft 5-2)	Lilayi	Borehole	LWSC	Iso Project
10	ISO-27	Lilayi	Borehole	Simoonga	Iso Project
11	ISO-30	Libala (Water Works 2)	Borehole	LWSC	Iso Project
12	ISO-36	Libala South (Libala Tippong Site (3))	Borehole	Libala	Iso Project
13	BH-2	Lilayi	Borehole	DWA	
14	BH-3	Lilayi	Borehole	DWA	
15	BH-6	Lilayi	Borehole	DWA	
16	BH-7	Shantumbu	Borehole	DWA	
17	BH-Z1	Lilayi Champ	Borehole	ZAWA	
18	BH-Z2	Chifwema(Leopard Hill Camp)	Borehole	ZAWA	
19	Sinkhole	West side of LS-MFEZ	Sinkhole	Non	
20	Pope Farm	Chifwema Road	Borehole	Pope	
21	Shantumbu 1	Shantumbu	Borehole	Rural Water	
22	Shantumbu 2	Shantumbu	Borehole	Rural Water	
23	Shantumbu 3	Shantumbu	Borehole	Rural Water	
24	BH-J1	South of MFEZ(Bside a Power Line)	Borehole	JST	
25	BH-J2	East area of MFEZ	Borehole	JST	
26	BH-J3	South of MFEZ(Centre of Lusaka Park)	Borehole	JST	
27	BH-J4	South West area of MFEZ	Borehole	JST	
28	BH-J5	South East of MFEZ	Borehole	JST	

＊Iso Project: Isotope Hydrology Project, June 2006

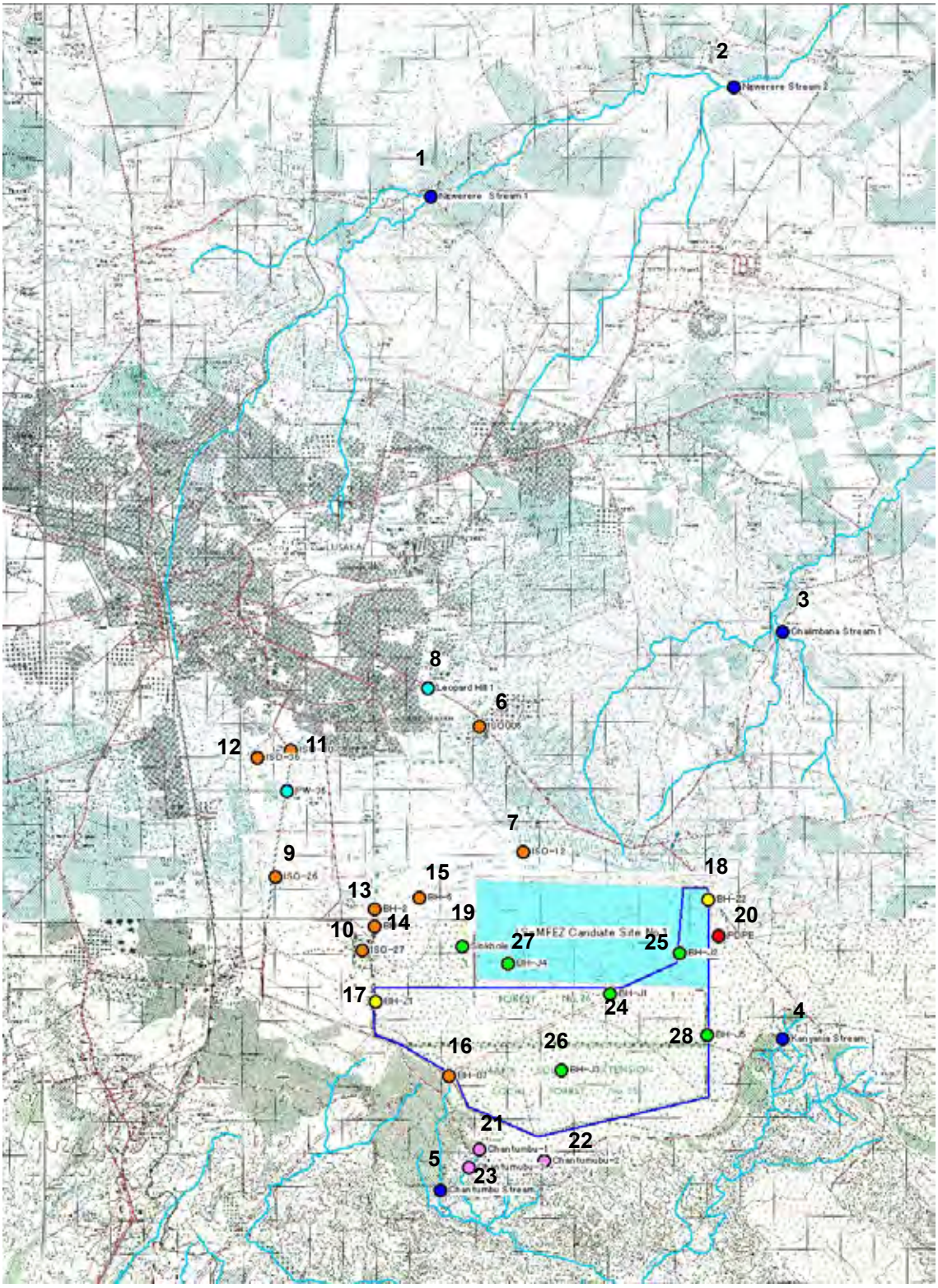


Figure D.2 Location Map of Water Sampling Points for Water Quality Survey

Analysis items of the water quality are as follows:

Analysis items for groundwater classification

Appearance, Temperature, Color, Odor, Taste, pH (Lab.), EC, Total Hardness (as $CaCO_3$), Total Alkalinity (as $CaCO_3$), Total Dissolved Solids (TDS), Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}), Magnesium (Mg^+), Chloride (Cl^-), Sulphate (SO_4^-), Bicarbonate (HCO_3^-) and Nitrate (NO_3^-)

Analysis items for contamination of water and planning of water treatment

DO, BOD, COD, Ammonium-nitrogen (NH_4-N), Nitrite-Nitrogen (NO_2-N), Nitrate-Nitrogen (NO_3-N), Total Iron (T-Fe), Fluoride (F^-), Coliform Group, Oil content, Arsenic (As), Lead (Pb), Cadmium (Cd), Mercury (Me), Chromium (Cr^{6+}) and Agricultural Chemical (according to the local availability)

D.3 GROUNDWATER LEVEL SURVEY

Groundwater level surveys are carried out on test well drilling, existing well ponds of quarry, sinkholes, locations of swamps and existent materials. Locations of survey points and results are shown in Table D.2 and Figure D.3.

Table D.2 List of the Locations for Groundwater Level Survey

No.	Place	Elevation of the Ground (m)	Location		G.W. Level (BGL-m)	Elevation Of G.W.L (m)	Date (2008)	Remarks
			Latitude (South)	Longitude (East)				
1	BH-J1	1326	15:31.288	28:24.540	12.64	1313.36	July 3	JICA
2	BH-J2	1319	15:30.544	28:25.713	20.51	1298.49	July 7	JICA
3	BH-J3	1315	15:32.630	28:23.647	4.10	1310.90	July 25	JICA
4	BH-J4	1311	15:30.798	28:22.803	19.00	1292.00	July 21	JICA
5	BH-J5	1323	15:31.908	28:26.160	6.98	1316.02	July 21	JICA
6	BH2	1300	15:29:54.5	28:20:32.1	9.36	1290.64	May 2	DWA
7	BH3	1301	15:30:10.9	28:20:31.5	13.90	1287.10	July 26	DWA
8	BH6	1300	15:29:42.5	28:21:17.8	12.80	1288.00	July 26	DWA
9	BH7	1307	15:32:37.6	28:21:47.2	3.24	1303.76	July 13	DWA
10	U9	1312	15:32.726	28:23.590	4.00	1308	July 1	DWA(?)
11	Shantumbu	1302	15:33:49.4	28:22:21.6	0.00	1302	June 28	Swamp
12	Kanyanja	1311	15:31:56.5	28:27:15.7	0.00	1311	June 28	Swamp
13	Shantumbu	1232	15:34:29.4	28:21:39.1	0.00	1232	June 28	Stream
14	Kanyanja	1304	15:32.025	28.27.420	0.00	1304	June 28	Stream
15	Sinkhole 1	1295	15:30.539	28:20.556	5.50	1289.5	June 7	Mahopo
16	Sinkhole 2	1298	15:30.460	28:22.028	5.00	1293	June 7	West mfez
17	Quarry 1	1292	15:28:24.1	28:20:33.1	6.5	1285.5	July 11	Eastern Que
18	Quarry 2	1278	15:26:45.7	28:16:16.1	2.5	1275.5	July 11	John Laing

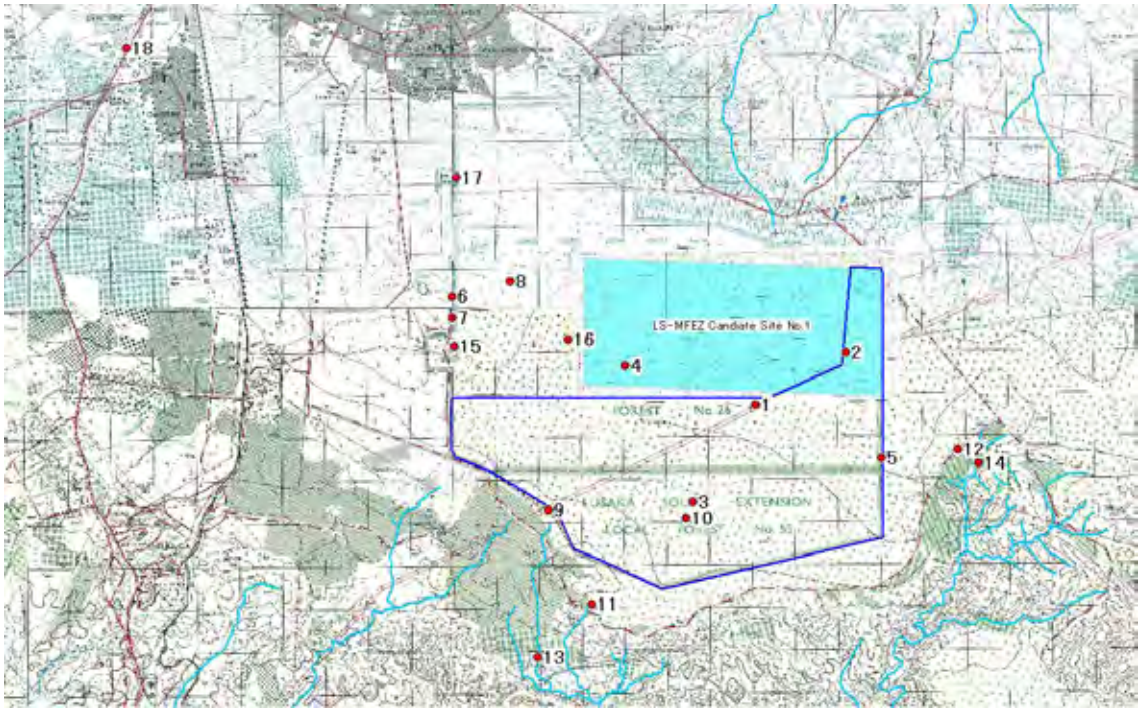


Figure D.3 Location Map of the Groundwater Level Survey Points

D.4 RESULTS OF HYDROLOGICAL SURVEY

(1) Result of the Test Wells

Two test wells which are inside of the LS-MFEZ site and three test wells which are outside were constructed in this project. According to the geological map, these five boreholes are located in the area of distribution of Lusaka dolomite. It was confirmed that the white carbonate massive rock (dolomite) is a main geological stratum and lies under approximately 30 m below the ground according to the drilling data and geophysical logging data . Few fissures are found in the dolomite and does not contain much water..

Shallow areas are not homogeneous since the area is comprised of karst in which gravel and unconsolidated earth are filled with voids of karst. Drilling in such areas tend to find a lot of water. An overview of the test well results is shown in Table D.3.

Table D.3 Overview of the Test Well Results

No.		BH-J1	BH-J2	BH-J3	BH-J4	BH-J5
Location	15:31.288S	15:30.544S	15:32.488S	15:30.739S	15:31.908S	15:31.908S
	28:24.540E	28:25.713E	28:23.670E	28:22.759E	28:26.160E	28:26.160E
Ground Elevation (m)		1326	1319	1315	1311	1323
Drilling Depth (m)		90	100	91	91	100
Static Water Level (GL-m)		12.54	20.51	4.10	19.00	6.98
First water Strike (GL-m)		21	31	16	24	7
Screen depth (GL- m)		1st : 18~30 2nd : 48~60	24~48	1st : 18~30 2nd : 36~42 3rd 48~54	1st : 18~36 2nd : 48~54	1st : 6~18 2nd : 30~42
Draft Estimation of Sustainable Discharge Rate (m^3/day)		415	220<	889<	737<	737<
Pumping Rate (m^3/h)		14.1	8.90	37.0	30.7	30.7
Draw Down (m)		4.08	11.00	2.43	2.69	6.77
Specific Capacity (m^3/h/m)		3.46	0.81	15.24	11.42	4.54
Transmissivity (m^2/day)		$6.64x10^1$	$1.89x10^1$	$3.25x10^2$	$2.19x10^2$	$9.64x10^1$
Permeability (m/day)		$3.85x10^{-3}$	$1.10x10^{-3}$	$1.88x10^{-2}$	$1.27x10^{-2}$	$5.58x10^{-3}$
Storage		0.28	0.02	0.29	11.3	2.58

* Elevation was estimated by USGS DEM

On the first drilling point of BH-J1, massive dolomite appeared from -9 to –100 m. There were two water strikes at 38 m and 84 m deep, respectively. Both had small water flows of 0.186 l/s (16 m^3/day). Also, at the first drilling point of BH-J5, massive dolomite started from 3m below the ground. There was completely no water. This means that the opening rate and permittivity of massive dolomite which lies below the karst zone is small even if the joint exists in the dolomite. And it can be said that the stable and dense rock distributed in this zone since the resistivity of dolomite indicates more than 10,000 (ohm-m) from the result of the geophysical logging. Depth of boundary between karst and massive dolomite is estimated from 25 to 35 m below the ground based on the test borehole drilling.

Provided that boreholes encounter the karst zone below the groundwater level, a production well with a discharge capacity of 400 m^3/day or more can be expected.

Although the critical discharge except BH-J1 could not be confirmed from the pumping test, a critical discharge of 700 m^3/day or more can be expected at BH-J3,J4,J5.

Meanwhile, for BH-J4, a zone with a resistivity of 5000(ohm-m) or less is distributed to the depth of approximately 70m from the ground surface. From drilling samples, this stratum can be regarded as a homogeneous dolomite, however, fissures can generally be seen and thus it is presumed that the said stratum retains small amounts of groundwater.

(2) Geological Condition of the LS-MFEZ Site

According to the results of test well drilling and field survey, the general geological structure is thought of as shown in *Figure D.4*.

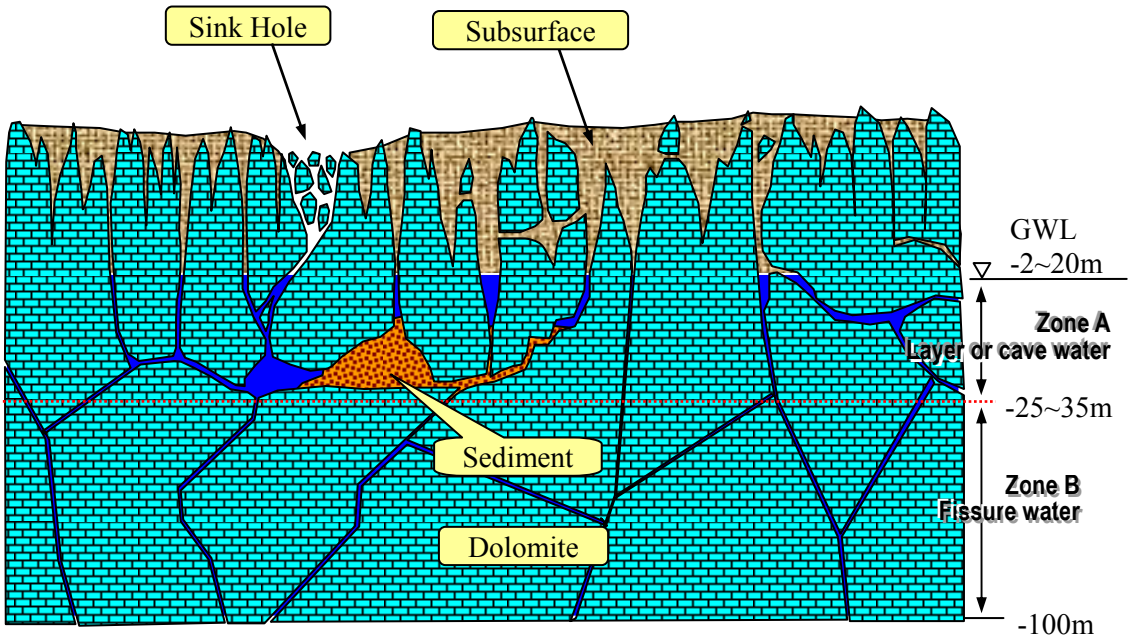


Figure D.4 General Geological Structure in LS-MFEZ area

As mentioned above, the high permeability zone (Zone A), where the karst is predominant, distributes to a depth of 25m to 35m from the ground surface. Massive and hard dolomite distributes in the area below the karst (Zone B). Most voids of karst are filled with subsurface soil and several sinkholes are distributed..

(3) Groundwater distribution

Groundwater levels and its horizontal distributions have been confirmed by boreholes, digging wells, ponds and streams. *TableD.2* indicates the surveyed locations of groundwater. Contour lines of groundwater levels for the concerned area was made as shown in *Figure D.5*, based on the results of survey.

From above, a difference of approx. 20m of groundwater level can be seen in the sections A-A', B-B' and C-C'. This difference (dotted line in *Figure D.4*) extends in the east-west direction at the southern part of LS-MFEZ. The groundwater level is 1310m in elevation at the south side of the line and 1290m in elevation, which is relatively deep, at the north side of the line, and thus the groundwater level changes sharply. A similar change can be seen in the geography and a magnitude of change of groundwater level exceeds that of the geography. This suggests that there may be the possibility that the south side of the groundwater is dammed up by an impermeable geological structure such as fault and shear-zones. And therefore, it can be said that the southern area of the line retains groundwater with a high potential independent from the catchment of Lusaka city.

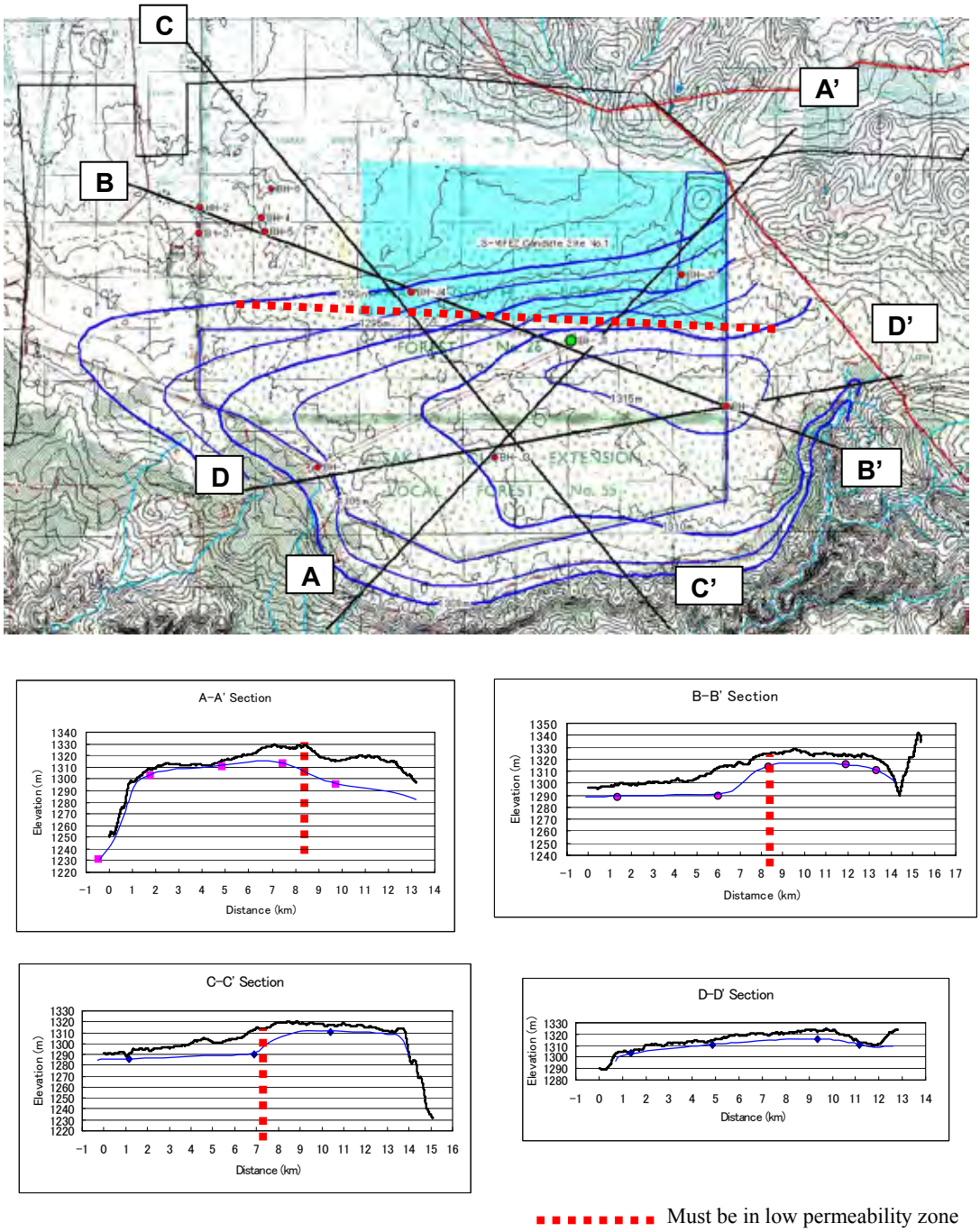
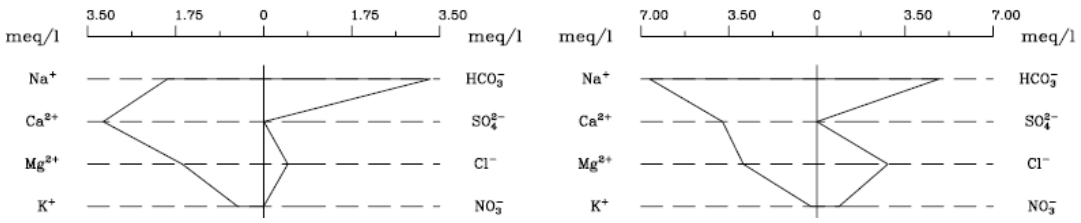


Figure D.5 Groundwater Contour Line

(4) Results of the Water Quality Test

Water quality tests were carried out using samples which were collected from test wells constructed by JICA, observation wells owned by DWA, production wells for LWSC, private wells and streams as shown in *Table D.1*. Test results are shown in *Table D.4*. Almost all groundwater in the survey area is acceptable for drinking except value of coliforms. Samples which are taken from ISO-6, ISO-12, Leopard Hill 1, ISO 26, ISO 27 and ISO 30 show a value of nitrate-nitrogen slightly higher than WHO drinking standards. Those boreholes are located in north-west area of LS-MFEZ, and therefore there is some possibility that the groundwater is contaminated by night soil. Groundwater qualities are organized into the Stiff Diagram as shown in *Figure D.7*.

Groundwater is widely classified into two(2) types such as (A) Carbonate Hardness Type, (B) Carbonate Alkali Type. Most groundwater is categorized as the Carbonate Hardness Type. This type of groundwater is typical surface water, which means that groundwater is fresh and discharges quickly(rainfall→surface water→groundwater→surface water→evaporation→). Some type A groundwater contains a lot of Mg2+, more than Ca2+ (A_{Mg}). It is considered that Mg2+ originated from dolomatic rock.



Type(A) Carbonate Hardness ($CaCO_3$) **Type(B) Carbonate Alkali (Na_2CO_3)**

Type B groundwater shows high levels of Alkali. It means that Type B groundwater is older than that of Type A. High alkali contained in old groundwater is induced by ion-exchange between Ca2+ or Mg+ and Na2+. Argillation of rock is stimulated by this ion exchange. Pope Farm and Shantumbu 3 which are Type B are located near the geological boundary between carbonate rock and schist. At the Pope Farm, groundwater comes from the north side where schist rock distributes. Also Shantumbu 3 is located outside of the carbonate rock area. It means that the groundwater in Shantumbu 3 does not directly come from surface of the Lusaka plateau but probably passes through the base rock of carbonate rock as shown in *Figure D.6*. The Result of the water quality test is shown in *Figure D.7, D.8*.

Water quality tests were carried out using samples which were corrected from three test wells constructed by JICA in rainy season. Test results are shown in *Table D.5*. COD values in dry season were higher than those in rainy season.

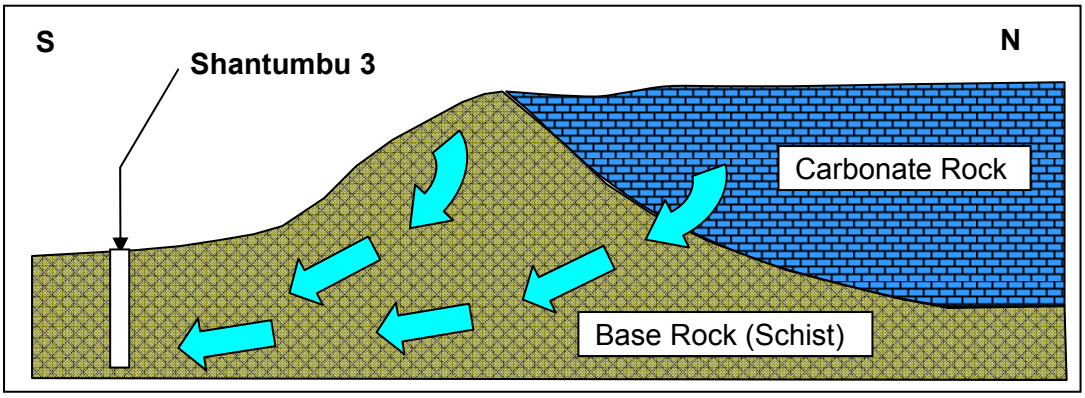


Figure D.6 Pattern Diagram of Groundwater Flow at Shantumbu 3

Table D.4 Results of the Water Quality Test

No	Name	pH (Lab.)	Total Dissolved Solids (TDS)	Temperature	Color	Odor	Total Hardness (as CaCO3)	Sulphate (SO4-)	Taste	Chloride (Cl-)	Total Alkalinity (as CaCO3)	Bicarbonate (HCO3-)	Nitrate (NO3-)	Magnesium (Mg+)	Calcium (Ca2+)	EC	Potassium (K+)	Sodium (Na+)
WHO Standard for Drinking Water		**6.5-8.5**	**1000**	**-**	**-**	**-**	**500**	**200.00**	**-**	**250.0**	**500**	**500**	**10.00**	**-**	**200.0**	**1500**	**-**	**-**
6	ISO-6	6.96	222	25.6	Not detected	Not detected	372	2.80	Not detected	38.0	348	312	**10.50**	28.80	100.8	356	7.18	79.60
7	ISO-12	7.31	211	25.1	Not detected	Not detected	402	1.40	Not detected	40.0	398.0	344	**24.44**	41.76	91.2	364	4.16	49.60
8	Leopard Hill 1	7.32	231	24.8	Not detected	Not detected	390	49.80	Not detected	26.0	356	316	**20.10**	19.68	123.2	375	15.30	49.90
9	ISO-26(Shaft 5-2)	6.88	216	25.6	Not detected	Not detected	384	<0.01	Not detected	20.0	322	296	**10.62**	33.60	97.6	345	10.66	27.70
10	ISO-27	6.55	310	23.9	Brownish Yellow	Earthy/Rust	258	6.15	Bitter/Rust	38.0	246	232	**23.38**	30.08	46.4	439	3.96	52.80
11	ISO-30	7.19	148	24.3	Not detected	Not detected	464	7.20	Not detected	12.0	448	409	**17.22**	46.48	124.80	365	7.19	48.30
12	ISO-36	6.94	208	24.4	Not detected	Not detected	476	108.40	Not detected	17.0	436	349	7.98	53.28	101.6	317	17.02	36.60
13	BH-2	6.52	188	23.6	Brownish Yellow	Earthy/Rust	130	4.70	Bitter/Rust	11.0	132	128	1.16	3.84	54.40	277	10.36	41.11
14	BH-3	6.81	198	23.8	Brownish Yellow	Earthy/Rust	360	8.00	Bitter/Rust	10.0	332	300	0.58	24.00	104.4	377	16.11	46.84
15	BH-6	7.02	196	23.6	Brownish Yellow	Earthy/Rust	276	8.85	Bitter/Rust	11.0	224	214	0.84	22.08	73.6	312	12.00	36.84
16	BH-7	7.58	166	24.1	Brownish Yellow	Earthy/Rust	308	4.50	Bitter/Rust	43.92	298	236	<0.01	43.92	50.0	292	6.81	49.60
17	BH-Z1(Leopard Hill)	6.77	312	23.9	Not detected	Not detected	**518**	72.70	Not detected	12.0	494	426	1.42	36.96	145.6	452	19.66	61.20
18	BH-Z2(Lilay)	7.36	198	22.8	Brownish Yellow	Earthy/Rust	306	1.90	Bitter/Rust	52.0	299	258	<0.01	11.52	103.20	304	7.44	28.80
19	Sinkhole	6.91	213	23.6	Not detected	Not detected	308	2.45	Not detected	15.0	376	322	1.42	24.96	83.2	355	9.62	28.80
20	Pope Farm	7.33	312	23.6	Not detected	Not detected	400	3.80	Not detected	14.0	448	412	1.33	7.28	31.2	432	14.40	51.20
21	Chantumbu 1	6.93	159	25.1	Not detected	Not detected	**652**	1.40	Not detected	18.0	**522**	484	1.86	77.76	131.2	272	5.62	26.90
22	Chantumbu 2	7.54	136	25.0	Brownish Yellow	Earthy/Rust	242	0.25	Rust	17.0	212	202	<0.01	19.68	64.0	248	20.19	44.10
23	Chantumbu 3	6.96	**3160**	25.6	Not detected	Not detected	336	<0.01	Not detected	100.0	308	296	**54.80**	35.52	75.20	4170	9.09	152.80
24	BH-J1	7.21	456	25.8	Not detected	Not detected	370	<0.01	Not detected	23.0	342	302	<0.01	49.92	64.8	681	15.98	33.30
25	BH-J2	7	527	25.1	Not detected	Not detected	420	<0.01	Not detected	25.0	408	394	<0.01	34.56	110.4	787	12.82	71.80
26	BH-J3	7.37	375	23.9	Not detected	Not detected	192	2.25	Not detected	12.0	188	168	0.73	3.84	70.6	560	14.62	39.33
27	BH-J4	7.25	510	24.6	Not detected	Not detected	236	1.05	Not detected	13.0	230	222	0.96	2.88	89.6	761	9.52	46.81
28	BH-J5	7.19	428	25.1	Brownish Yellow	Earthy/Rust	210	<0.01	Rust	28.0	208	179	<0.01	11.52	64.8	428	17.62	46.30

No	Name	DO	COD	BOD	Ammonium-nitrogen (NH4-N)	Nitrite-Nitrogen (NO2-N)	Nitrate-Nitrogen (NO3-N)	Total Iron (T-Fe)	Fluoride (F-)	Oil content	Arsenic (As)	Lead (Pb)	Cadmium (Cd)	Mercury (Me)	Chromium (Cr6+)	Total coliforms	Feacial Coliforms	
WHO Standard for Drinking Water		**–**	**–**	**–**	**1.50**	**0.10**	**10**	**0.30**	**1.50**	**–**	**0.10**	**0.10**	**0.003**	**0.001**	**0.05**	**0**	**0**	
1	Ngwerere Stream 1	7.02	84	28.0	**4.31**	**1.300**	**10.16**	**0.93**	0.09	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**4500**	3100	
2	Ngwerere Stream 2	5.02	76	14.0	<0.01	0.040	6.90	**0.42**	0.06	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**150**	70	
3	Chailmbana Stream	5.29	88	28.0	<0.01	0.008	<0.01	0.08	0.12	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**80**	50	
4	Kanyanja Stream	2.28	94	32.0	<0.01	0.019	<0.01	0.23	0.09	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**900**	700	
5	Chantumbu Stream	0.93	52	12.0	<0.01	0.005	<0.01	**0.33**	0.11	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**1200**	1000	
24	BH-J1	4.62	25	0.7	<0.01	<0.001	<0.5	<0.01	0.13	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**2**	0	
25	BH-J2	5.81	23	0.8	<0.01	<0.001	<0.5	<0.01	0.15	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**2**	0	
26	BH-J3	6.33	29	0.8	<0.01	<0.001	<0.5	<0.01	0.12	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**9**	0	
27	BH-J4	5.28	31	0.9	<0.01	<0.001	<0.5	<0.01	0.13	<0.005	<0.001	<0.01	<0.0002	<0.0002	<0.01	**4**	0	
28	BH-J5	5.62	25	0.9	<0.01	<0.001	<0.5	0.14	<0.005	<0.001	<0.001	<0.01	<0.0002	<0.0002	<0.01	**10**	0	

* Red figures are exceeding the value of WHO drinking standard

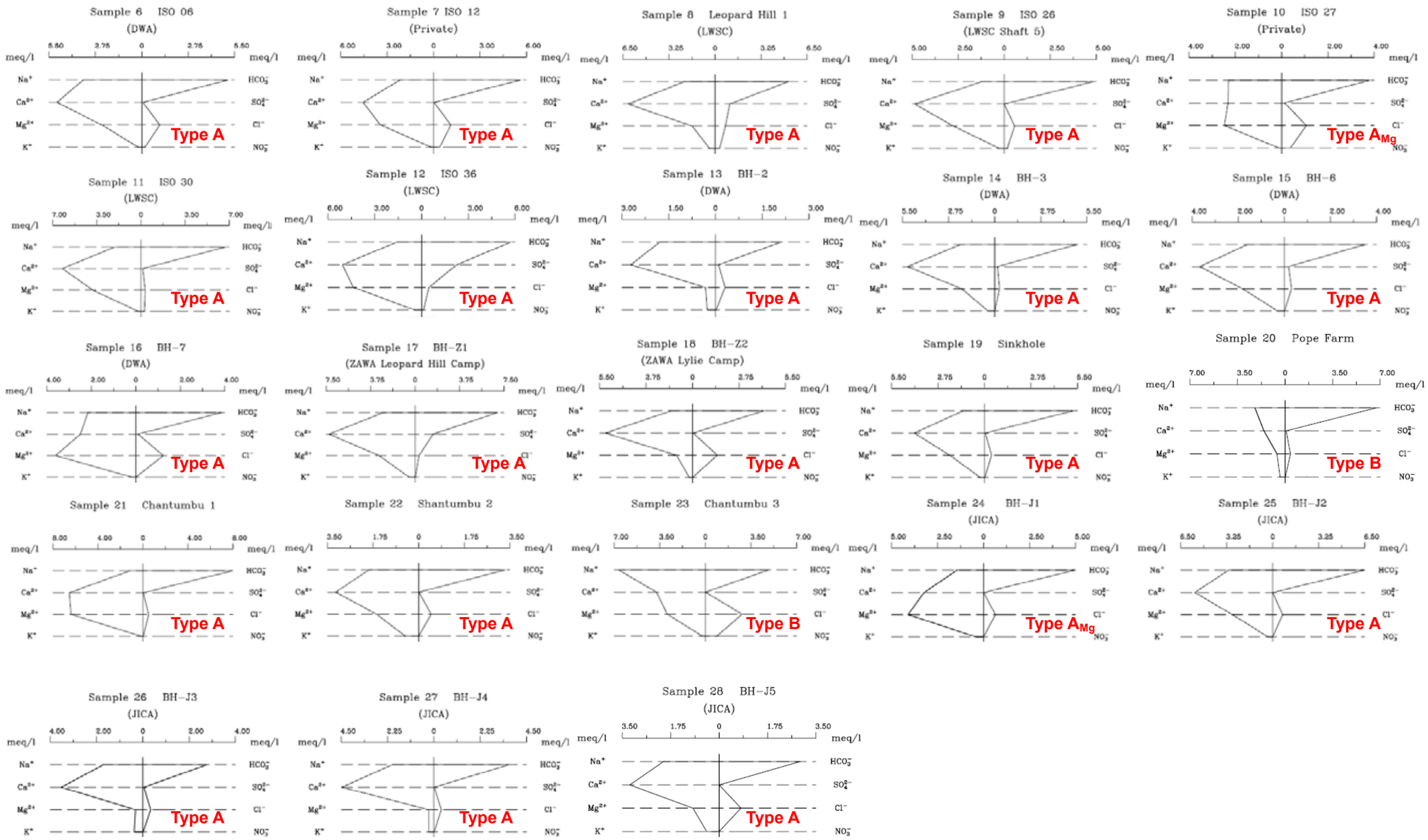
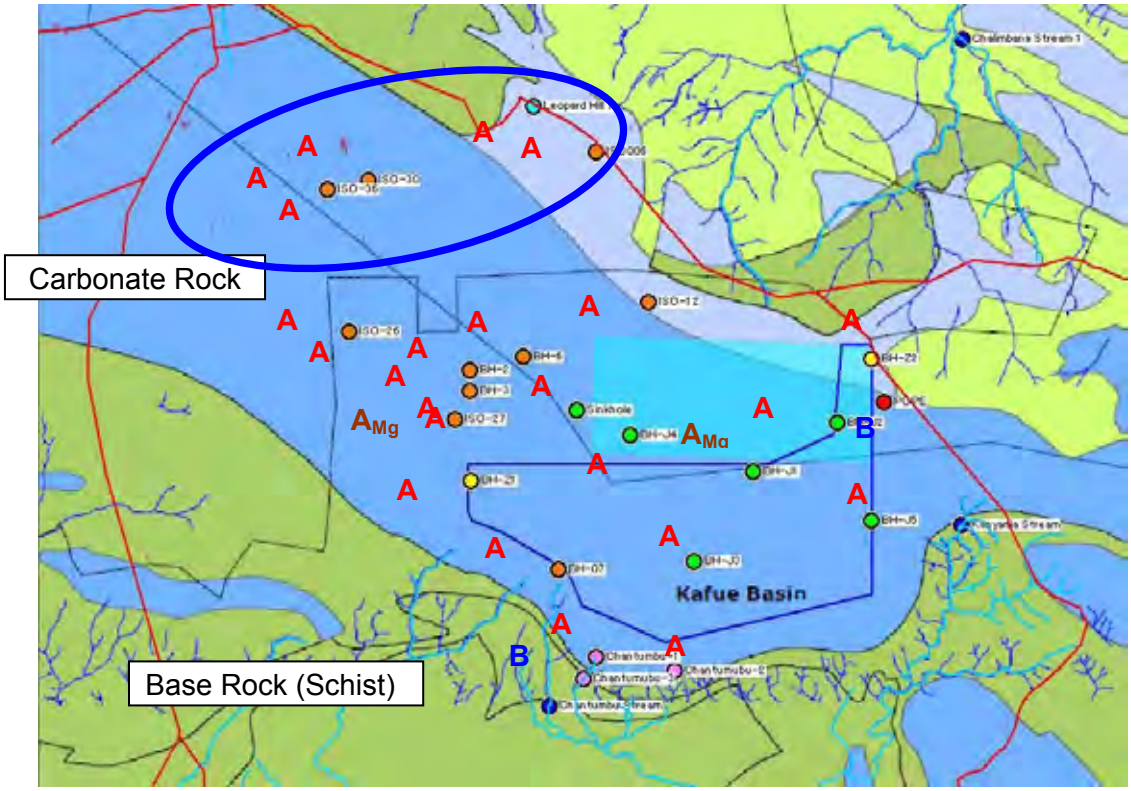


Figure D.7 Stiff Diagram

Table D.5 Results of the Water Quality Test in Rainy Season

Sampling Site	Parameter											
	Water Level (m)	pH	Temperature (^oC)	EC (microS/cm)	Eh (mV)	Odour	Taste	DO (mg/L)	BOD (mgO/L)	COD (mgO/L)	Ammonia-nitrogen (mgN/L)	Nitrite-nitrogen (mgN/L)
BH JN1	16.86	7.03	26.6	528	-46.7	ND	ND	2.37	1.4	6	<0.01	<0.001
BH JN3	6.85	6.85	26.3	433	-51.8	ND	ND	3.04	1.3	7	<0.01	<0.001
BH JN4	23.3	6.81	25.3	585	-33.8	ND	ND	1.91	1.1	5	<0.01	<0.001

Sampling Site	Parameter											
	Nitrate-nitrogen (mgN/L)	Orthophosphate (mg/L)	F (mg/L)	Fe (mg/L)	Cr (mg/L)	As (mg/L)	Pb (mg/L)	Cd (mg/L)	Hg (mg/L)	Oil/Greese (mg/L)	Total Coliform (No/100mL)	Fecal Coliform (No/100mL)
BH JN1	<0.01	<0.01	0.13	<0.01	<0.01	<0.001	<0.01	<0.0002	<0.0002	<0.005	0	0
BH JN3	2.5	<0.01	0.10	<0.01	<0.01	<0.001	<0.01	<0.0002	<0.0002	<0.005	0	0
BH JN4	<0.01	<0.01	0.18	<0.01	<0.01	<0.001	<0.01	<0.0002	<0.0002	<0.005	0	0



■ : Schist

■ : Carbonate Rock (Limestone, Dolomite)

: High Nitrate area

A: Carbonate Hardness Type

AMg: Carbonate Hardness with Mg dominant Type

B: Carbonate Alkali Type

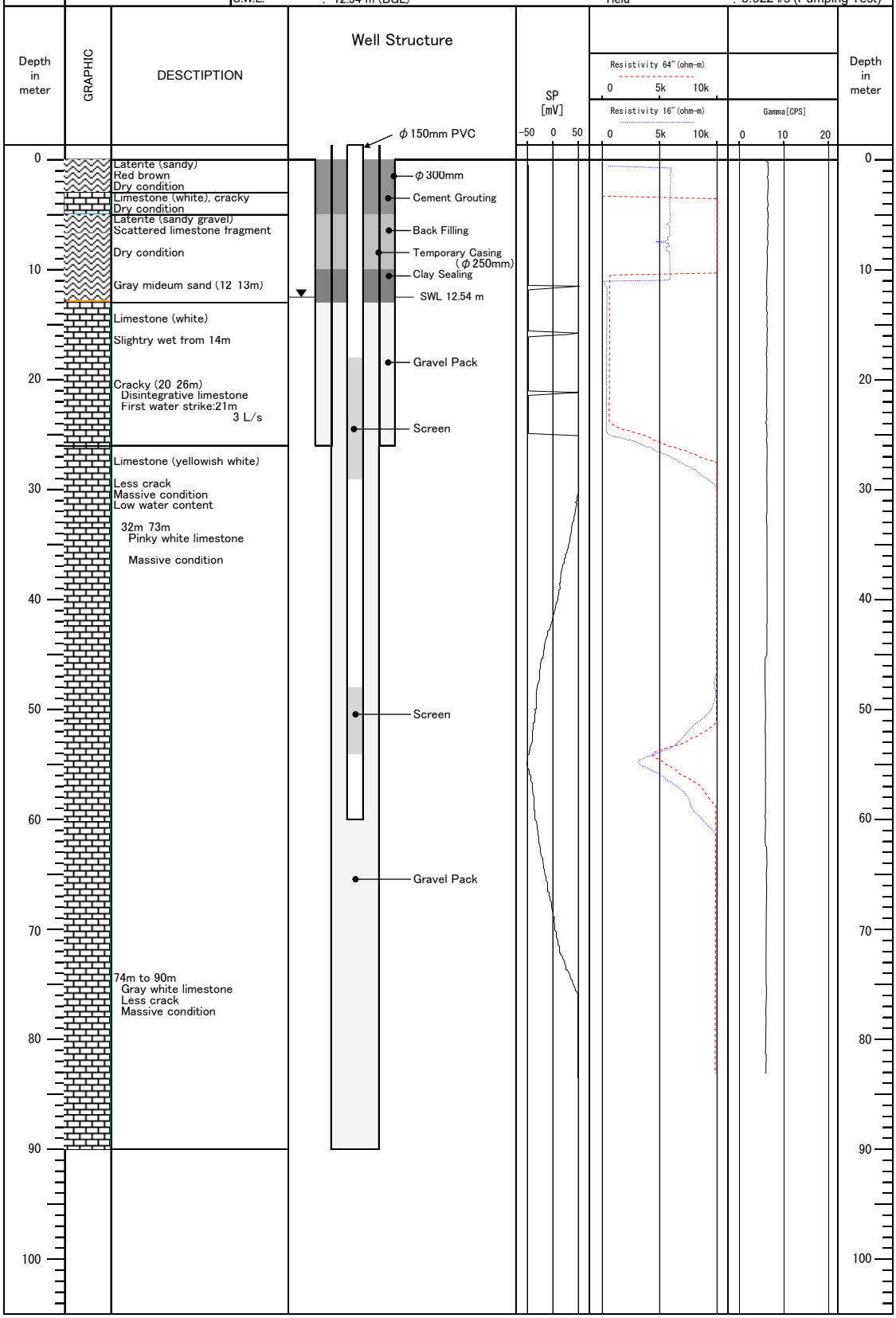
Figure D.8 Result of water quality test

JAPAN INTERNATIONAL COOPERATION AGENCY

The Study on Master Plan of Lusaka South Multi-Facility Economic Zone

No. BH-J1

Latitude	: -15:31.288'	Commenced	: 7-Jun-08
Longitude	: 28:24.540'	Completed	: 12-Jun-08
Drilling Depth	: 90 m	Pumping Test Date	: 3-Jul-08
S.W.L.	: 12.54 m (BGL)	Yield	: 3.922 l/s (Pumping Test)



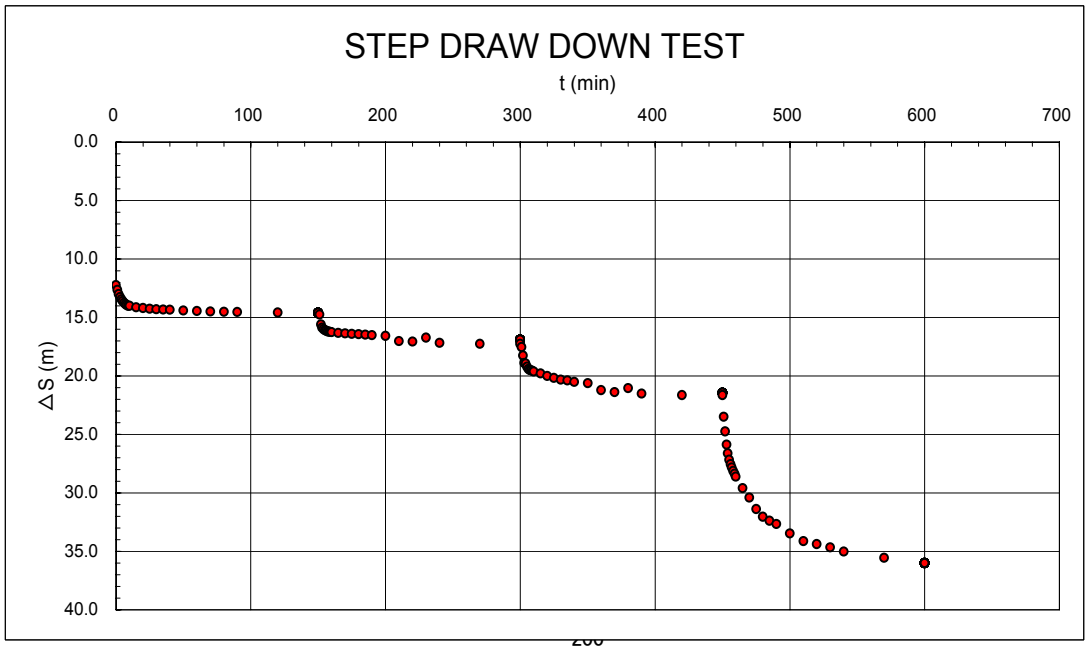
PROJECT TITLE:	The Study on Master Plan of Lusaka South Multi-Facility Economic Zone			
SITE No.:	BH-J1	DRILLED DEPTH:	90	(m)
REGION:	Lusaka Park	SWL: GL-	12.64	(m)
Starting DATE:	03/07/2008	CASING HEIGHT:	0.40	(m)

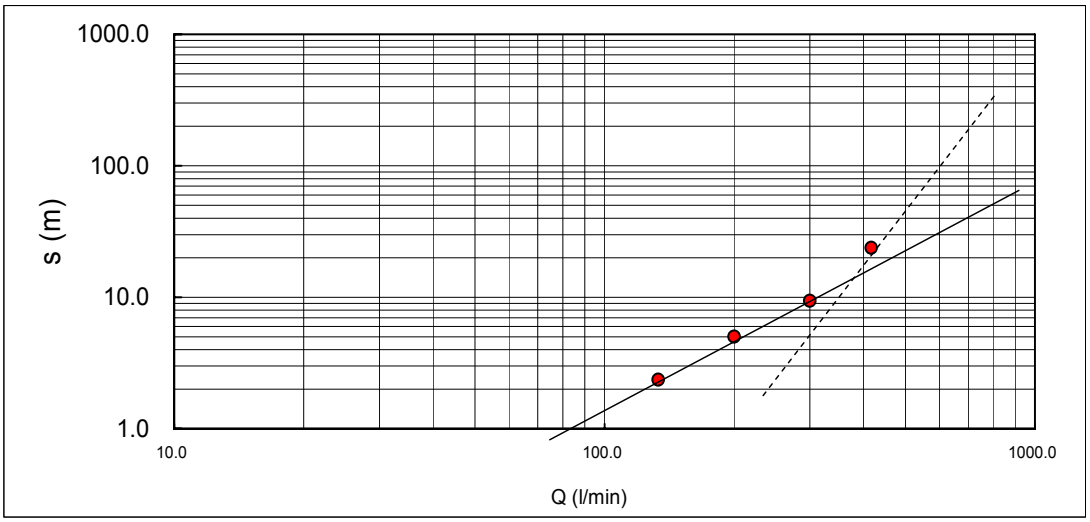
Time (min)	Measuring Data						
	1st Step	2nd Step	3rd Step	4th Step	5th Step	Constant	Recoveryly
1	13.04	15.15	17.93	23.48		14.89	14.54
2	13.40	16.00	18.66	24.74		15.36	13.98
3	13.65	16.28	19.29	25.88		15.63	13.72
4	13.85	16.39	19.34	26.62		15.74	13.55
5	13.99	16.49	19.61	27.17		15.81	13.48
6	14.14	16.52	19.81	27.55		15.87	13.46
7	14.26	16.59	19.89	27.83		15.94	13.40
8	14.34	16.61	19.92	28.12		15.96	13.37
9	14.39	16.63	19.97	28.37		15.98	13.37
10	14.41	16.65	20.01	28.62		16.00	13.34
15	14.52	16.71	20.19	29.60		16.06	13.31
20	14.59	16.77	20.41	30.40		16.12	13.29
25	14.65	16.81	20.56	31.39		16.16	13.28
30	14.69	16.83	20.71	32.05		16.18	13.26
35	14.72	16.86	20.78	32.38		16.21	13.26
40	14.74	16.90	20.90	32.67		16.25	13.24
50	14.81	16.98	21.02	33.46		16.32	13.24
60	14.85	17.02	21.22	34.12		16.37	13.23
70	14.89	17.07	21.39	34.38		16.42	13.21
80	14.92	17.13	21.45	34.65		16.49	
90	14.94	17.18	21.52	35.03		16.51	
120	14.98	17.25	21.63	35.55		16.60	
150	15.00	17.30	21.85	36.00		16.71	
180						16.82	
210						16.91	
240						16.98	
300						17.04	
360						17.06	
420						17.08	
480						17.09	
540						17.10	
600						17.10	
660						17.10	
720						17.11	
780						17.11	
840						17.12	
900						17.12	
960						17.12	
1020						17.12	
1080						17.12	
1140						17.12	
1200						17.12	
1260						17.12	
1320						17.12	
1380						17.12	
1440						17.12	
1500						17.12	

STEP DRAW DOWN TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone

Site No.: BH-J1





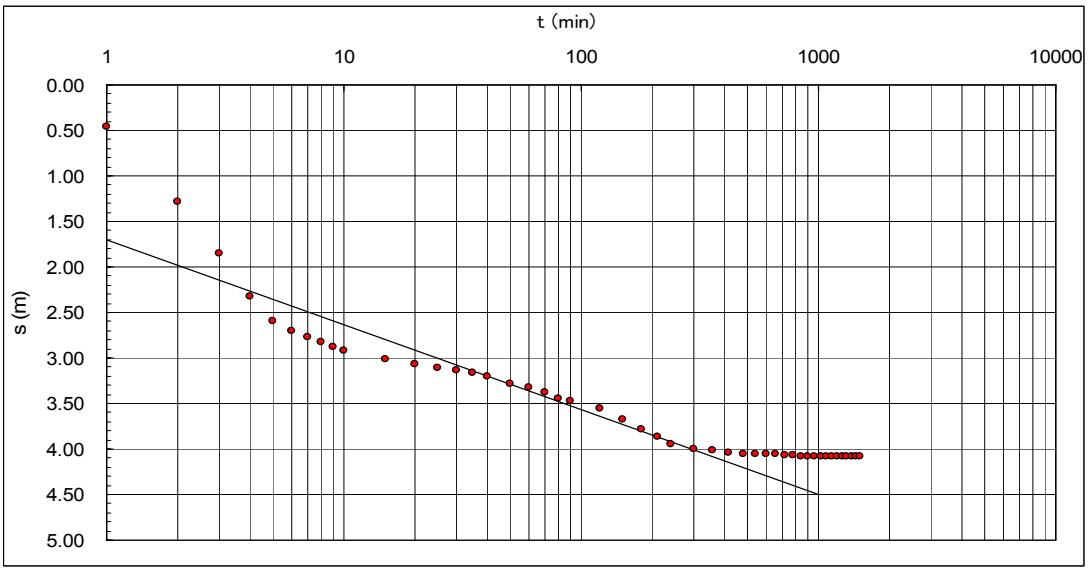
Step	Q (l/mim)	N.D. (m)	s (m)	Q/s (l/min/m)
1	133.30	14.60	2.36	56.48
2	200.00	17.25	5.01	39.92
3	300.00	21.63	9.39	31.95
4	416.70	36.00	23.76	17.54

LS-MFEZ JICA STUDY TEAM

CONTINUOUS PUMPING TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone
SITE No. : BH-J1 Date : 03/07/2008
Q : 235.32 (L/min) SWL : 12.64 (m)

HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)	HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)
11 : 55	0	12.64	0	16 : 55	300	16.64	4.00
11 : 56	1	13.1	0.46	17 : 55	360	16.66	4.02
11 : 57	2	13.92	1.28	18 : 55	420	16.68	4.04
11 : 58	3	14.49	1.85	19 : 55	480	16.69	4.05
11 : 59	4	14.96	2.32	20 : 55	540	16.7	4.06
12 : 0	5	15.23	2.59	21 : 55	600	16.7	4.06
12 : 1	6	15.34	2.7	22 : 55	660	16.7	4.06
12 : 2	7	15.41	2.77	23 : 55	720	16.71	4.07
12 : 3	8	15.47	2.83	24 : 55	780	16.71	4.07
12 : 4	9	15.52	2.88	25 : 55	840	16.72	4.08
12 : 5	10	15.56	2.92	26 : 55	900	16.72	4.08
12 : 10	15	15.65	3.01	27 : 55	960	16.72	4.08
12 : 15	20	15.71	3.07	28 : 55	1020	16.72	4.08
12 : 20	25	15.75	3.11	29 : 55	1080	16.72	4.08
12 : 25	30	15.77	3.13	30 : 55	1140	16.72	4.08
12 : 30	35	15.8	3.16	31 : 55	1200	16.72	4.08
12 : 35	40	15.84	3.2				
12 : 45	50	15.92	3.28				
12 : 55	60	15.97	3.33				
13 : 5	70	16.02	3.38				
13 : 15	80	16.09	3.45				
13 : 25	90	16.11	3.47				
13 : 55	120	16.2	3.56				
14 : 25	150	16.31	3.67				
14 : 55	180	16.42	3.78				
15 : 25	210	16.51	3.87				
15 : 55	240	16.58	3.94				



△s = 0.93 m △s1 = 1.70 △s2 = 2.63

SCREEN PIPE LENGH = 20.00 (m)

$$T = \frac{0.183Q}{\triangle s} = \frac{43.06}{0.93} = 46.14 \text{ (l/min/m)} = 0.04614 \text{ (m2/min)} \quad 66.4416 \text{ (m2/d)}$$

$$K = \frac{T}{m} = \frac{0.0461}{20.00} = 0.0023 \text{ (m/min)} = 3.85E\text{-}03 \text{ (cm/sec)}$$

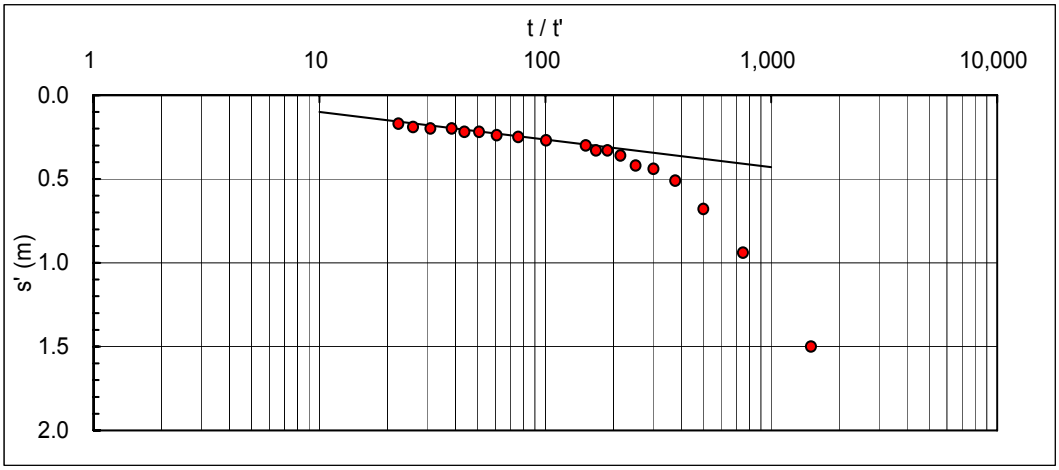
$$S = \frac{2.25Tt_0}{r^2} = \frac{0.0016}{0.0056} = 0.2784$$

LS-MFEZ JICA STUDY TEAM

RECOVERY TEST

PROJECT TITLE	:	The Study on Master Plan of Lusaka South Multi-Facility Economic Zone			
SITE No.	:	BH-J1	DRILLED DEPTH	:	90.00 (m)
COMMUNITUY	:		COMPLETED DEPTH	:	(m)
REGION	:	Lusaka Park	SWL	:	12.64 (m)
DATE	:	22/3/2002	CASING HEIGHT	:	0.40 (m)

HOUR	ACCUMU-LATED TIME t (min)	RECOVERY TIME t' (min)	t / t'	WATER LEVEL (m)	RECOVERY (m)	REMARKS
12 : 55	1,500	0		16.72	4.08	
12 : 56	1,501	1	1,501.0	14.14	1.50	
12 : 57	1,502	2	751.0	13.58	0.94	
12 : 58	1,503	3	501.0	13.32	0.68	
12 : 59	1,504	4	376.0	13.15	0.51	
13 : 0	1,505	5	301.0	13.08	0.44	
13 : 1	1,506	6	251.0	13.06	0.42	
13 : 2	1,507	7	215.3	13.00	0.36	
13 : 3	1,508	8	188.5	12.97	0.33	
13 : 4	1,509	9	167.7	12.97	0.33	
13 : 5	1,510	10	151.0	12.94	0.30	
13 : 10	1,515	15	101.0	12.91	0.27	
13 : 15	1,520	20	76.0	12.89	0.25	
13 : 20	1,525	25	61.0	12.88	0.24	
13 : 25	1,530	30	51.0	12.86	0.22	
13 : 30	1,535	35	43.9	12.86	0.22	
13 : 35	1,540	40	38.5	12.84	0.20	
13 : 45	1,550	50	31.0	12.84	0.20	
13 : 55	1,560	60	26.0	12.83	0.19	
14 : 5	1,570	70	22.4	12.81	0.17	



Q = 235.32 0 SWL = 12.64 (m)

△s = 0.17 △s1 = 0.10 △s2 = 0.27

SCREEN PIPE LENGH = 20.00 (m)

$$T = \frac{0.183Q}{\triangle s} = \frac{43.06}{0.17} = 260.9915 \text{ (l/min/m)} = 0.26099 \text{ (m2/min)}$$

$$K = \frac{T}{m} = \frac{0.26099}{20.00} = 0.01305 \text{ (m/min)} = 2.18E\text{-}02 \text{ (cm/sec)}$$

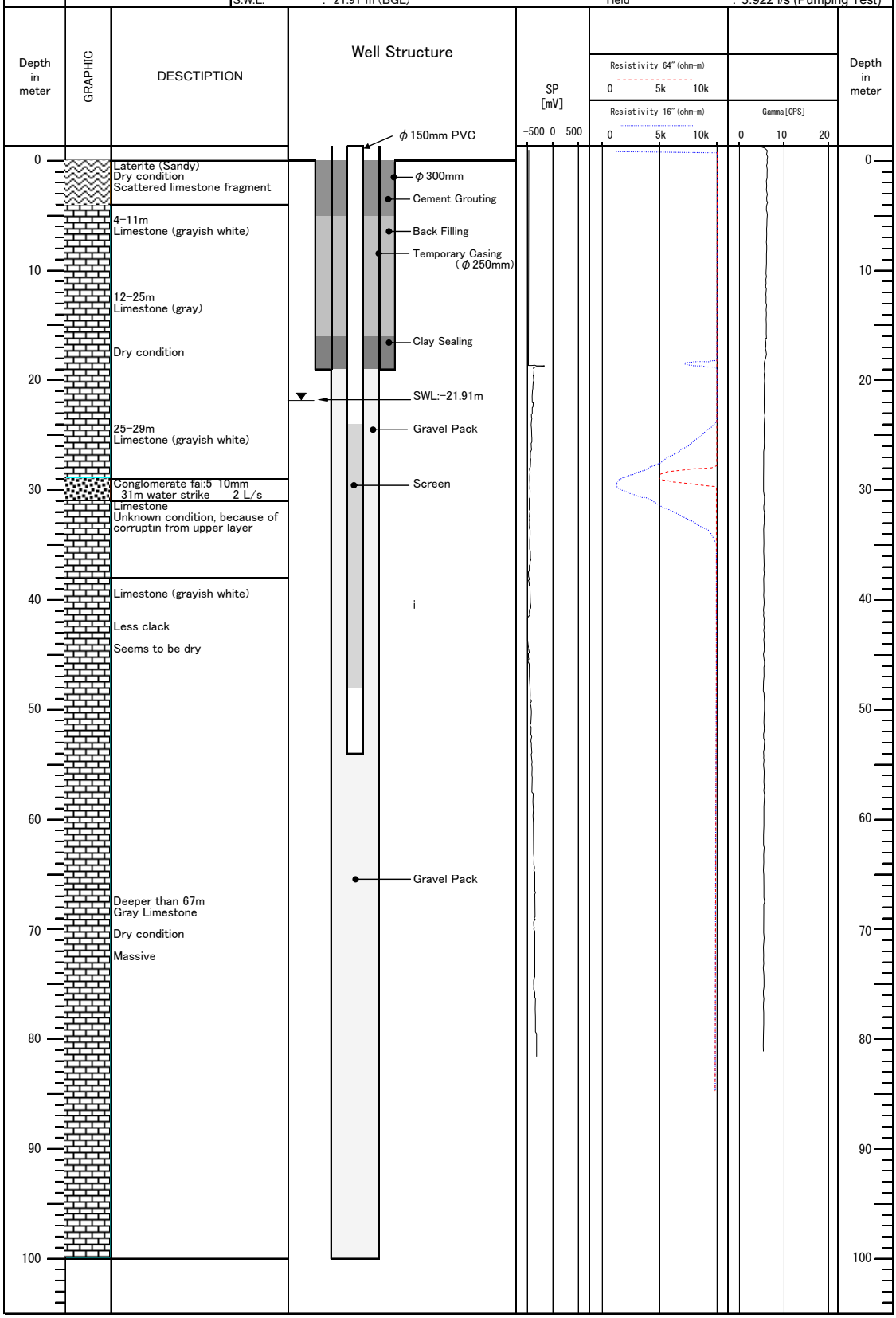
LS-MFEZ JICA STUDY TEAM

JAPAN INTERNATIONAL COOPERATION AGENCY

The Study on Master Plan of Lusaka South Multi-Facility Economic Zone

No. BH-J2

Latitude	: -15:30.554'	Commenced	: 13-Jun-08
Longitude	: 28:25,713'	Completed	: 18-Jun-08
Drilling Depth	: 100 m	Pumping Test Date	: 7-Jul-08
S.W.L.	: 21.91 m (BGL)	Yield	: 3.922 l/s (Pumping Test)



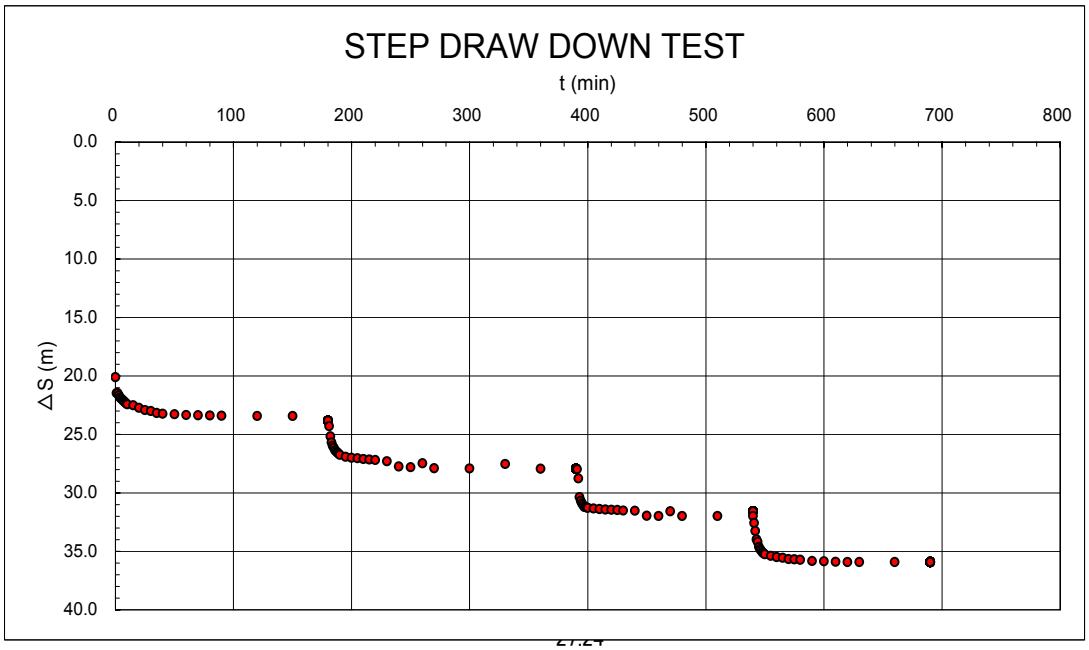
PROJECT TITLE:	The Study on Master Plan of Lusaka South Multi-Facility Economic Zone		
SITE No.:	BH-J2	DRILLED DEPTH:	100 (m)
REGION:	LS-MFEZ Site	SWL:	GL- 20.51 (m)
Starting DATE:	03/07/2008	CASING HEIGHT:	0.40 (m)

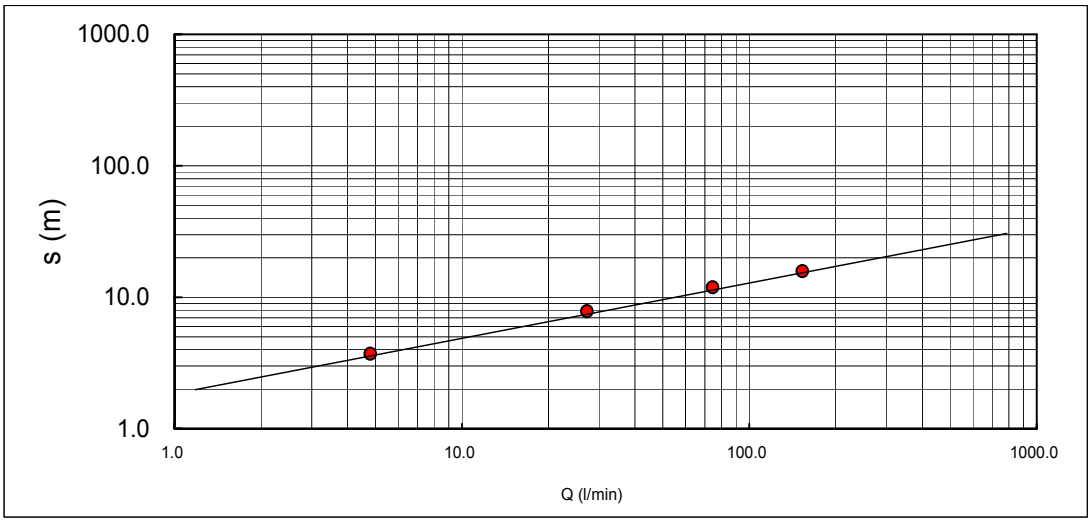
Time	Measuring Data						
(min)	1st Step	2nd Step	3rd Step	4th Step	5th Step	Constant	Recoveryly
1	21.86	24.69	28.37	32.58		23.79	31.01
2	21.86	25.58	29.16	33.26		24.67	29.56
3	22.06	26.08	30.77	33.97		25.91	27.98
4	22.26	26.38	31.09	34.20		26.15	26.01
5	22.36	26.54	31.29	34.61		26.95	25.87
6	22.45	26.77	31.44	34.80		27.15	25.34
7	22.55	26.87	31.59	34.94		27.45	24.89
8	22.64	26.96	31.62	35.09		27.65	24.52
9	22.73	27.07	31.65	35.17		27.74	24.14
10	22.82	27.15	31.68	35.25		27.84	23.99
15	22.92	27.31	31.74	35.38		28.23	23.20
20	23.12	27.39	31.78	35.48		28.54	22.83
25	23.32	27.44	31.82	35.56		28.75	22.56
30	23.41	27.50	31.84	35.65		28.95	22.31
35	23.58	27.55	31.86	35.69		29.05	22.16
40	23.64	27.59	31.90	35.73		29.14	21.98
50	23.68	27.69	31.94	35.83		29.32	21.52
60	23.74	27.75	31.96	35.86		29.52	21.25
70	23.77	27.80	31.97	35.89		29.70	21.10
80	23.78	27.86	31.97	35.91		29.89	21.03
90	23.81	27.89	31.98	35.92		29.99	21.01
120	23.83	27.91	31.98	35.92		30.19	20.98
150	23.83	27.93	31.98	35.92		30.31	20.95
180	23.83	27.94				30.42	20.94
210		27.94				30.50	20.93
240						30.71	20.93
300						30.93	20.92
360						31.10	20.92
420						31.25	
480						31.34	
540						31.44	
600						31.53	
660						31.60	
720						31.71	
780						31.79	
840						31.84	
900						31.88	
960						31.90	
1020						31.90	
1080						31.90	
1140						31.91	
1200						31.92	
1260						31.92	
1320						31.92	
1380						31.92	
1440						31.92	
1500						31.92	

STEP DRAW DOWN TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone

Site No.: BH-J2





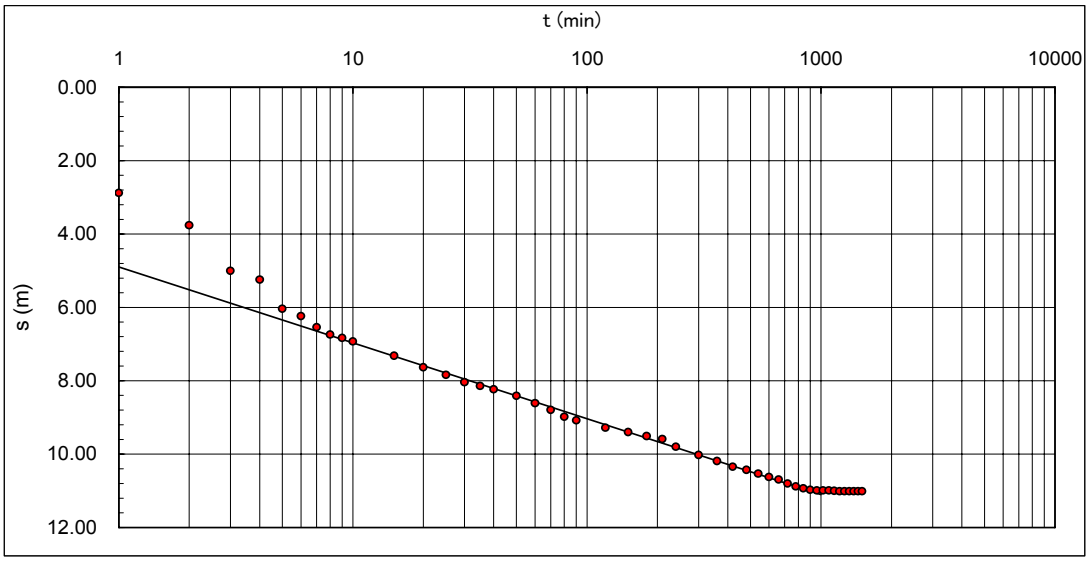
Step	Q (l/mim)	N.D. (m)	s (m)	Q/s (l/min/m)
1	4.80	23.83	3.72	1.29
2	27.24	27.94	7.83	3.48
3	74.58	31.98	11.87	6.28
4	153.12	35.92	15.81	9.69

LS-MFEZ JICA STUDY TEAM

CONTINUOUS PUMPING TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone
SITE No. : BH-J2 Discharge : 235.32 (L/min)
Q : 235.32 (l/mim) SWL : 20.51 (m) 03/07/2008

HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)	HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)
11 : 55	0	20.51	0	16 : 55 0	300	30.53	10.02
11 : 56	1	23.39	2.88	17 : 55 0	360	30.7	30.70
11 : 57	2	24.27	3.76	18 : 55 0	420	30.85	30.85
11 : 58	3	25.51	5	19 : 55 0	480	30.94	30.94
11 : 59	4	25.75	5.24	20 : 55 0	540	31.04	31.04
12 : 0	5	26.55	6.04	21 : 55 0	600	31.13	31.13
12 : 1	6	26.75	6.24	22 : 55 0	660	31.2	31.20
12 : 2	7	27.05	6.54	23 : 55 0	720	31.31	31.31
12 : 3	8	27.25	6.74	24 : 55 0	780	31.39	31.39
12 : 4	9	27.34	6.83	25 : 55 0	840	31.44	31.44
12 : 5	10	27.44	6.93	26 : 55 0	900	31.48	31.48
12 : 10	15	27.83	7.32	27 : 55 0	960	31.5	31.50
12 : 15	20	28.14	7.63	28 : 55 0	1020	31.5	31.50
12 : 20	25	28.35	7.84	29 : 55 0	1080	31.5	31.50
12 : 25	30	28.55	8.04	30 : 55 0	1140	31.51	31.51
12 : 30	35	28.65	8.14	31 : 55 0	1200	31.52	31.52
12 : 35	40	28.74	8.23				
12 : 45	50	28.92	8.41				
12 : 55	60	29.12	8.61				
13 : 5	70	29.3	8.79				
13 : 15	80	29.49	8.98				
13 : 25	90	29.59	9.08				
13 : 55	120	29.79	9.28				
14 : 25	150	29.91	9.4				
14 : 55	180	30.02	9.51				
15 : 25	210	30.1	9.59				
15 : 55	240	30.31	9.8				



Δs = 2.07 m $\Delta s1$ = 4.90 $\Delta s2$ = 6.97

SCREEN PIPE LENGH = 20.00 (m)

$$T = \frac{0.183Q}{\Delta s} = \frac{43.06}{2.07} = 20.837 \text{ (l/min/m)} = 0.02084 \text{ (m2/min)} \quad 30.0096 \text{ (m2/d)}$$

$$K = \frac{T}{m} = \frac{0.0208}{20.00} = 0.001 \text{ (m/min)} = 1.73E-03 \text{ (cm/sec)}$$

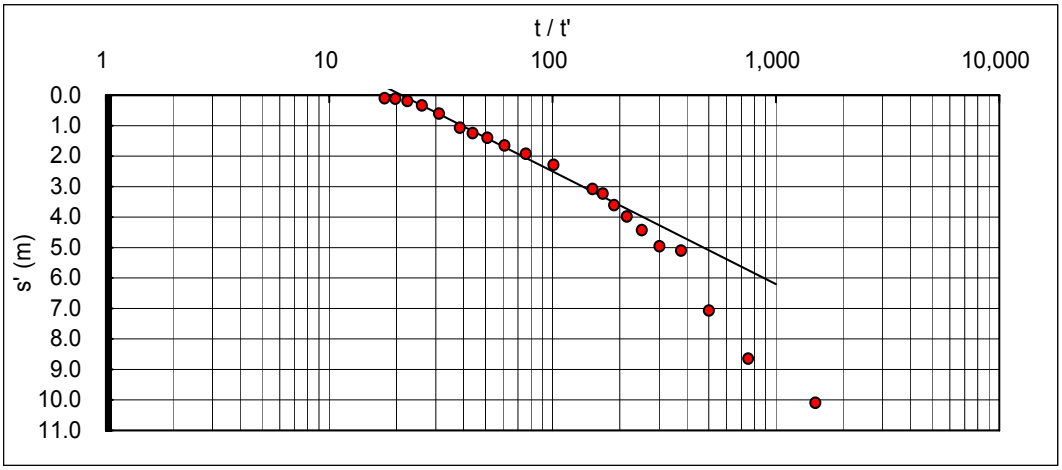
$$S = \frac{2.25Tt_0}{r^2} = \frac{0.0047}{0.08} = 0.0625$$

LS-MFEZ JICA STUDY TEAM

RECOVERY TEST

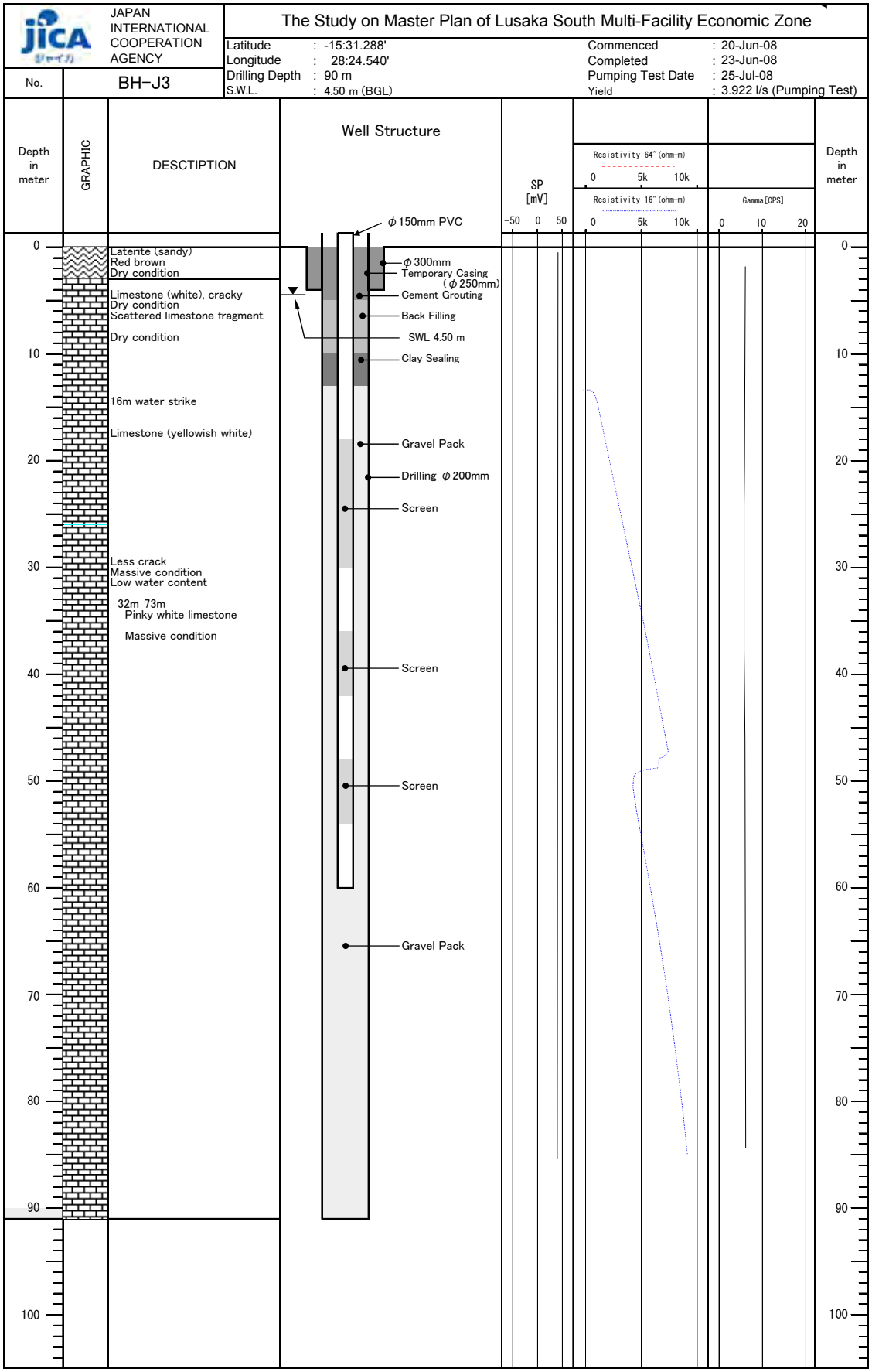
PROJECT TITLE	:	The Study on Master Plan of Lusaka South Multi-Facility Economic Zone			
SITE No.	:	BH-J2	DRILLED DEPTH	:	100.00 (m)
COMMUNITUY	:		COMPLETED DEPTH	:	(m)
REGION	:	LS-MFEZ Site	SWL	:	20.51 (m)
DATE	:	22/3/2002	CASING HEIGHT	:	0.40 (m)

HOUR	ACCUMU-LATED TIME t (min)	RECOVERY TIME t' (min)	t / t'	WATER LEVEL (m)	RECOVERY (m)	REMARKS
12 : 55	1,500	0		31.52	11.01	
12 : 56	1,501	1	1,501.0	30.61	10.10	
12 : 57	1,502	2	751.0	29.16	8.65	
12 : 58	1,503	3	501.0	27.58	7.07	
12 : 59	1,504	4	376.0	25.61	5.10	
13 : 0	1,505	5	301.0	25.47	4.96	
13 : 1	1,506	6	251.0	24.94	4.43	
13 : 2	1,507	7	215.3	24.49	3.98	
13 : 3	1,508	8	188.5	24.12	3.61	
13 : 4	1,509	9	167.7	23.74	3.23	
13 : 5	1,510	10	151.0	23.59	3.08	
13 : 10	1,515	15	101.0	22.80	2.29	
13 : 15	1,520	20	76.0	22.43	1.92	
13 : 20	1,525	25	61.0	22.16	1.65	
13 : 25	1,530	30	51.0	21.91	1.40	
13 : 30	1,535	35	43.9	21.76	1.25	
13 : 35	1,540	40	38.5	21.58	1.07	
13 : 45	1,550	50	31.0	21.12	0.61	
13 : 55	1,560	60	26.0	20.85	0.34	
14 : 5	1,570	70	22.4	20.70	0.19	
14 : 15	1,580	80	19.8	20.63	0.12	
14 : 25	1,590	90	17.7	20.61	0.10	



Q	=	235.32 0				SWL	=	20.51 (m)
△s	=	3.70	△s1	=	-1.20	△s2	=	2.50
		SCREEN PIPE LENGH		=	20.00 (m)			
T	=	$\frac{0.183Q}{\triangle s} = \frac{43.06}{3.70}$		=	11.63881 (l/min/m)		=	0.01164 (m2/min)
K	=	$\frac{T}{m} = \frac{0.01164}{20.00}$		=	0.00058 (m/min)		=	9.67E-04 (cm/sec)

LS-MFEZ JICA STUDY TEAM


JAPAN INTERNATIONAL COOPERATION AGENCY
The Study on Master Plan of Lusaka South Multi-Facility Economic Zone
No.
BH-J3
Latitude : -15:31.288'
Longitude : 28:24.540'
Drilling Depth : 90 m
S.W.L. : 4.50 m (BGL)
Commenced : 20-Jun-08
Completed : 23-Jun-08
Pumping Test Date : 25-Jul-08
Yield : 3.922 l/s (Pumping Test)
Depth in meter
GRAPHIC
DESCTIPTION
Well Structure
SP [mV]
Resistivity 64" (ohm-m)
Resistivity 16" (ohm-m)
Gamma [CPS]
φ150mm PVC
Laterite (sandy)
Red brown
Dry condition
Limestone (white), cracky
Dry condition
Scattered limestone fragment
Dry condition
16m water strike
Limestone (yellowish white)
Less crack
Massive condition
Low water content
32m 73m
Pinky white limestone
Massive condition
φ300mm
Temporary Casing (φ250mm)
Cement Grouting
Back Filling
SWL 4.50 m
Clay Sealing
Gravel Pack
Drilling φ200mm
Screen
Screen
Screen
Gravel Pack

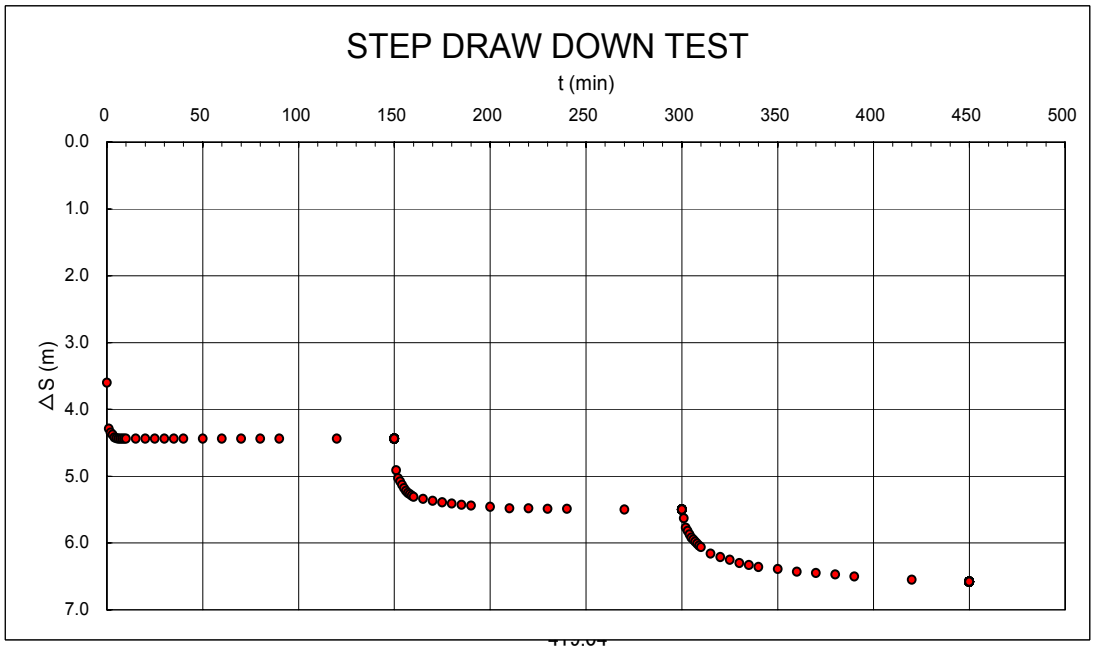
PROJECT TITLE:	The Study on Master Plan of Lusaka South Multi-Facility Economic Zone				
SITE No.:	BH-J3	DRILLED DEPTH:		90	(m)
REGION:	Lusaka Park	SWL:	GL-	4.10	(m)
Starting DATE:	24/07/2008	CASING HEIGHT:		0.50	(m)

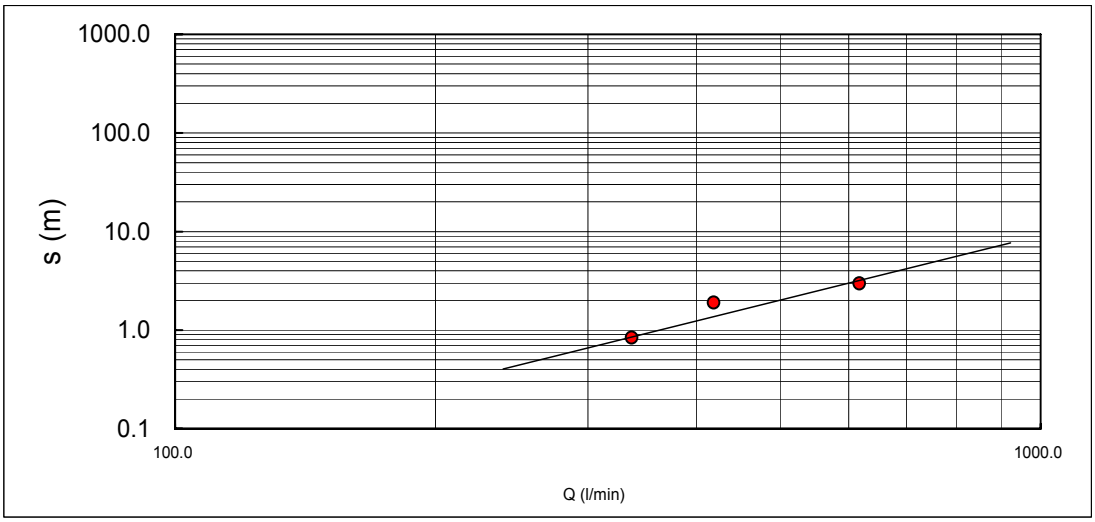
Time (min)	Measuring Data						
	1st Step	2nd Step	3rd Step	4th Step	5th Step	Constant	Recoveryly
1	4.79	5.41	6.13			6.12	6.43
2	4.85	5.53	6.27			6.20	6.15
3	4.88	5.58	6.32			6.27	5.64
4	4.92	5.63	6.37			6.32	5.33
5	4.93	5.68	6.42			6.37	5.09
6	4.94	5.72	6.45			6.40	4.87
7	4.94	5.75	6.48			6.43	4.78
8	4.94	5.77	6.51			6.46	4.72
9	4.94	5.79	6.54			6.49	4.67
10	4.94	5.81	6.56			6.51	4.65
15	4.94	5.84	6.66			6.55	4.62
20	4.94	5.87	6.71			6.58	4.62
25	4.94	5.89	6.75			6.61	4.62
30	4.94	5.91	6.80			6.64	4.61
35	4.94	5.93	6.83			6.66	4.61
40	4.94	5.94	6.86			6.68	4.61
50	4.94	5.96	6.89			6.72	4.61
60	4.94	5.98	6.93			6.76	4.61
70	4.94	5.98	6.95			6.79	4.61
80	4.94	5.99	6.97			6.84	
90	4.94	5.99	7.00			6.86	
120	4.94	6.00	7.05			6.88	
150	4.94	6.00	7.08			6.93	
180						6.95	
210						6.97	
240						6.98	
300						6.99	
360						7.01	
420						7.01	
480						7.02	
540						7.02	
600						7.03	
660						7.03	
720						7.03	
780						7.03	
840						7.03	
900						7.03	
960						7.03	
1020						7.03	
1080						7.03	
1140						7.03	
1200						7.03	
1260						7.03	
1320						7.03	
1380						7.03	
1440						7.03	
1500						7.03	

STEP DRAW DOWN TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone

Site No.: BH-J3





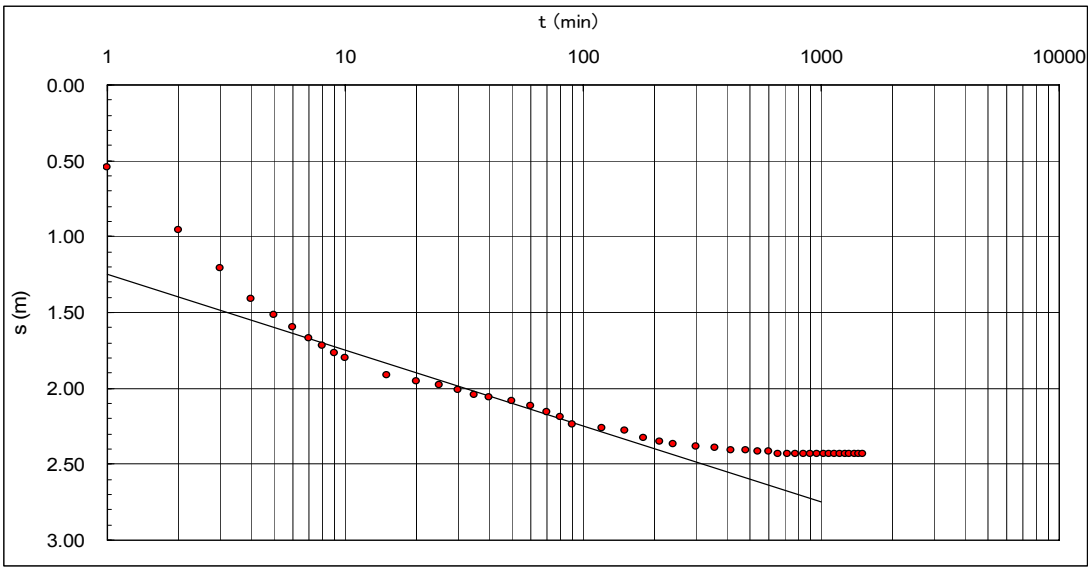
Step	Q (l/mim)	N.D. (m)	s (m)	Q/s (l/min/m)
1	336.78	4.44	0.84	400.93
2	419.04	5.50	1.90	220.55
3	617.22	6.58	2.98	207.12

LS-MFEZ JICA STUDY TEAM

CONTINUOUS PUMPING TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone
SITE No. : BH-J3 Date : 25/07/2008
Q : 617.22 (l/mim) SWL : 4.10 (m)

HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)	HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)
11 : 55	0	4.1	0	16 : 55	300	6.48	2.38
11 : 56	1	4.64	0.54	17 : 55	360	6.49	2.39
11 : 57	2	5.06	0.96	18 : 55	420	6.51	2.41
11 : 58	3	5.31	1.21	19 : 55	480	6.51	2.41
11 : 59	4	5.51	1.41	20 : 55	540	6.52	2.42
12 : 0	5	5.62	1.52	21 : 55	600	6.52	2.42
12 : 1	6	5.7	1.6	22 : 55	660	6.53	2.43
12 : 2	7	5.77	1.67	23 : 55	720	6.53	2.43
12 : 3	8	5.82	1.72	24 : 55	780	6.53	2.43
12 : 4	9	5.87	1.77	25 : 55	840	6.53	2.43
12 : 5	10	5.9	1.8	26 : 55	900	6.53	2.43
12 : 10	15	6.01	1.91	27 : 55	960	6.53	2.43
12 : 15	20	6.05	1.95	28 : 55	1020	6.53	2.43
12 : 20	25	6.08	1.98	29 : 55	1080	6.53	2.43
12 : 25	30	6.11	2.01	30 : 55	1140	6.53	2.43
12 : 30	35	6.14	2.04	31 : 55	1200	6.53	2.43
12 : 35	40	6.16	2.06				
12 : 45	50	6.18	2.08				
12 : 55	60	6.22	2.12				
13 : 5	70	6.26	2.16				
13 : 15	80	6.29	2.19				
13 : 25	90	6.34	2.24				
13 : 55	120	6.36	2.26				
14 : 25	150	6.38	2.28				
14 : 55	180	6.43	2.33				
15 : 25	210	6.45	2.35				
15 : 55	240	6.47	2.37				



Δs = 0.50 m $\Delta s1$ = 1.25 $\Delta s2$ = 1.75

SCREEN PIPE LENGH = 20.00 (m)

$$T = \frac{0.183Q}{\Delta s} = \frac{112.95}{0.50} = 225.9 \text{ (l/min/m)} = 0.2259 \text{ (m2/min)} = 325.296 \text{ (m2/d)}$$

$$K = \frac{T}{m} = \frac{0.2259}{20.00} = 0.0113 \text{ (m/min)} = 1.88E\text{-}02 \text{ (cm/sec)}$$

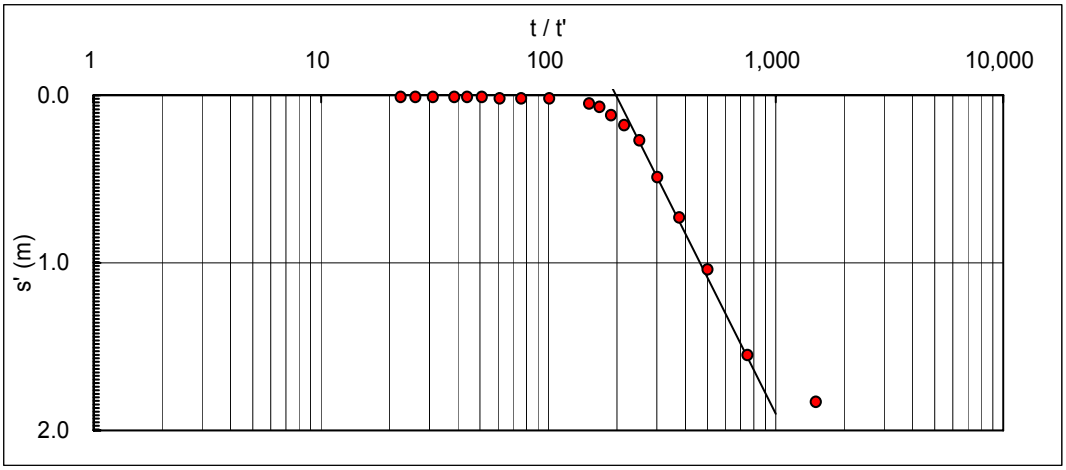
$$S = \frac{2.25Tt_0}{r^2} = \frac{0.0016}{0.0056} = 0.2857$$

LS-MFEZ JICA STUDY TEAM

RECOVERY TEST

PROJECT TITLE	:	The Study on Master Plan of Lusaka South Multi-Facility Economic Zone			
SITE No.	:	BH-J3	DRILLED DEPTH	:	90.00 (m)
COMMUNITUY	:		COMPLETED DEPTH	:	(m)
REGION	:	Lusaka Park	SWL	:	4.10 (m)
DATE	:	22/3/2002	CASING HEIGHT	:	0.50 (m)

HOUR	ACCUMU-LATED TIME t (min)	RECOVERY TIME t' (min)	t / t'	WATER LEVEL (m)	RECOVERY (m)	REMARKS
12 : 55	1,500	0		6.53	2.43	
12 : 56	1,501	1	1,501.0	5.93	1.83	
12 : 57	1,502	2	751.0	5.65	1.55	
12 : 58	1,503	3	501.0	5.14	1.04	
12 : 59	1,504	4	376.0	4.83	0.73	
13 : 0	1,505	5	301.0	4.59	0.49	
13 : 1	1,506	6	251.0	4.37	0.27	
13 : 2	1,507	7	215.3	4.28	0.18	
13 : 3	1,508	8	188.5	4.22	0.12	
13 : 4	1,509	9	167.7	4.17	0.07	
13 : 5	1,510	10	151.0	4.15	0.05	
13 : 10	1,515	15	101.0	4.12	0.02	
13 : 15	1,520	20	76.0	4.12	0.02	
13 : 20	1,525	25	61.0	4.12	0.02	
13 : 25	1,530	30	51.0	4.11	0.01	
13 : 30	1,535	35	43.9	4.11	0.01	
13 : 35	1,540	40	38.5	4.11	0.01	
13 : 45	1,550	50	31.0	4.11	0.01	
13 : 55	1,560	60	26.0	4.11	0.01	
14 : 5	1,570	70	22.4	4.11	0.01	



Q	=	617.22 0				SWL	=	4.10 (m)
△s	=	2.70	△s1	=	-0.80	△s2	=	1.90
		SCREEN PIPE LENGH		=	20.00 (m)			
T	=	$\frac{0.183Q}{\triangle s} = \frac{112.95}{2.70}$		=	41.83381 (l/min/m)		=	0.04183 (m2/min)
K	=	$\frac{T}{m} = \frac{0.04183}{20.00}$		=	0.00209 (m/min)		=	3.48E-03 (cm/sec)

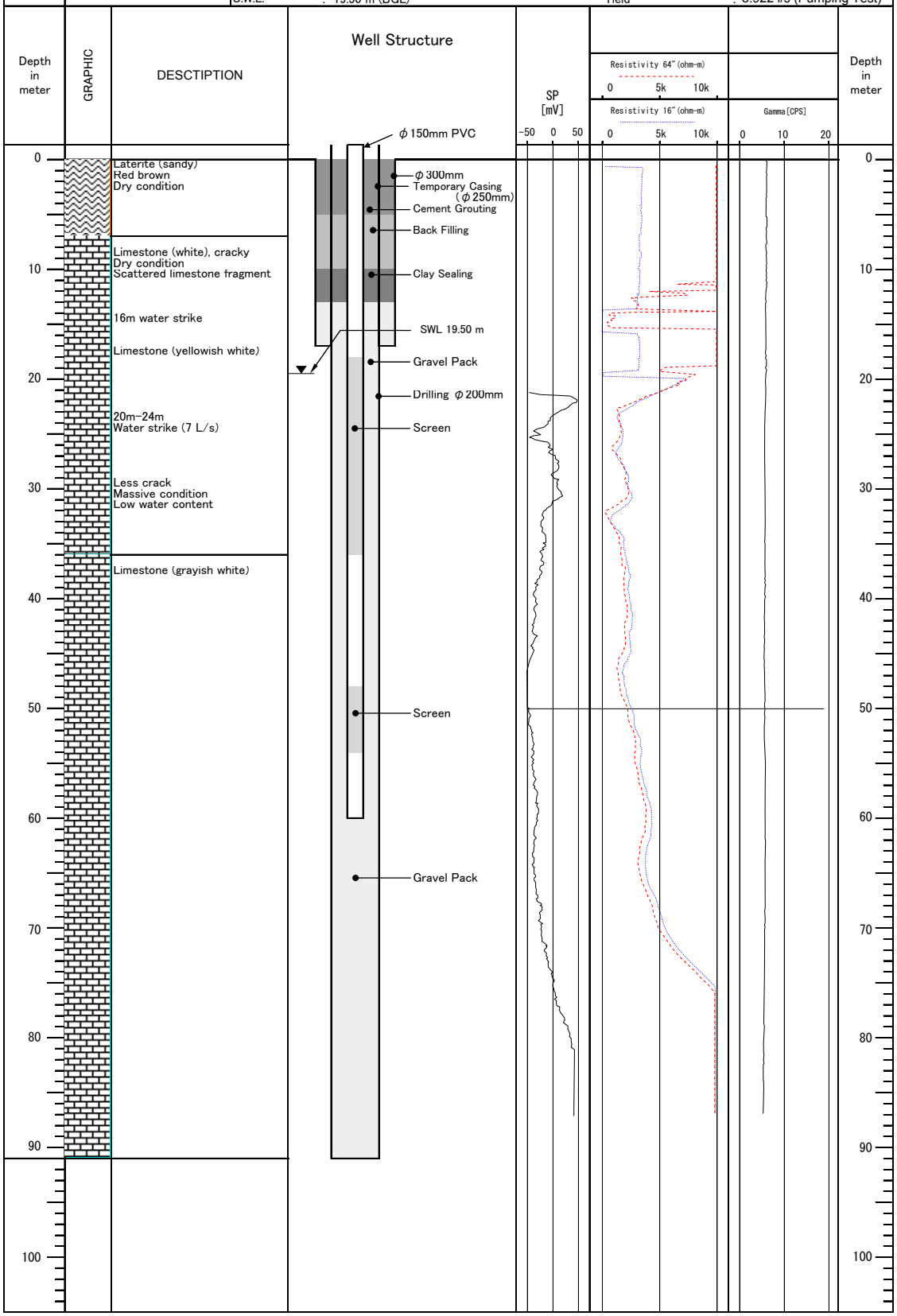
LS-MFEZ JICA STUDY TEAM

JAPAN INTERNATIONAL COOPERATION AGENCY

The Study on Master Plan of Lusaka South Multi-Facility Economic Zone

No. BH-J4

Latitude	: -15:30.739'	Commenced	: 17-Jul-08
Longitude	: 28:22.759'	Completed	: 19-Jul-08
Drilling Depth	: 91 m	Pumping Test Date	: 21-Jul-08
S.W.L.	: 19.50 m (BGL)	Yield	: 3.922 l/s (Pumping Test)



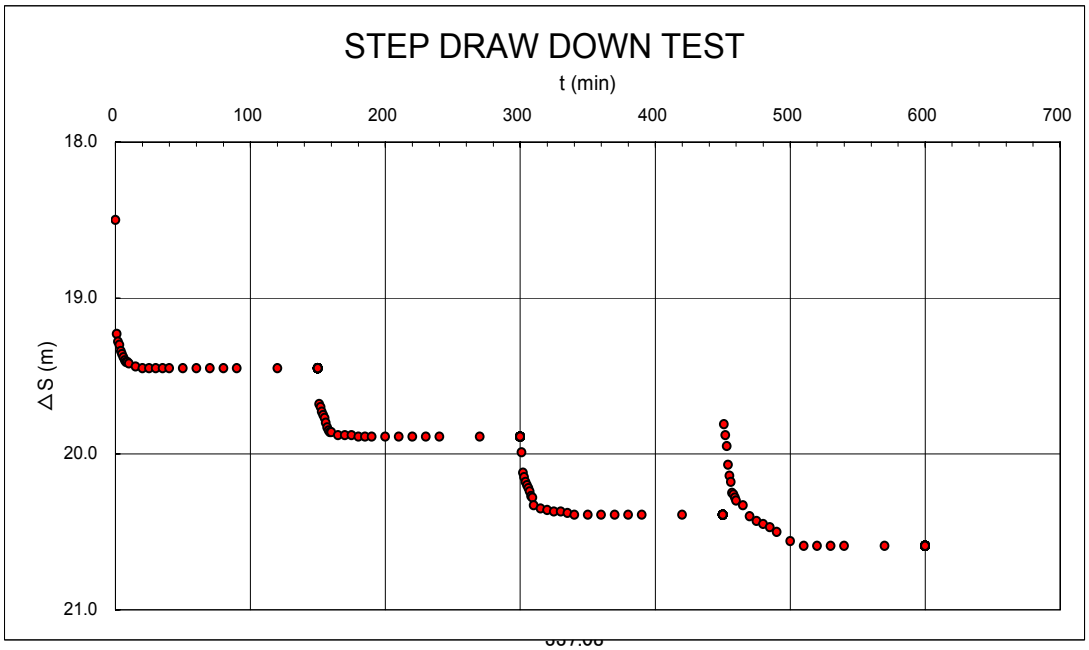
PROJECT TITLE:	The Study on Master Plan of Lusaka South Multi-Facility Economic Zone		
SITE No.:	BH-J4	DRILLED DEPTH:	91 (m)
REGION:	LS-MFEZ Site	SWL:	GL- 19.00 (m)
Starting DATE:	17/07/2008	CASING HEIGHT:	0.50 (m)

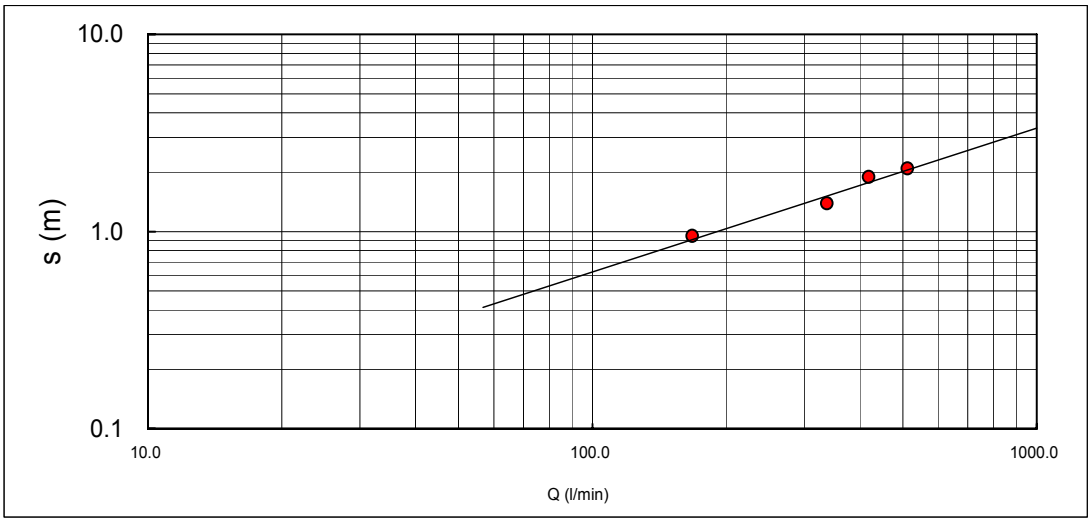
Time (min)	Measuring Data						
	1st Step	2nd Step	3rd Step	4th Step	5th Step	Constant	Recoveryly
1	19.73	20.18	20.49	20.31		19.80	21.79
2	19.78	20.20	20.62	20.38		20.10	21.05
3	19.80	20.23	20.65	20.45		20.23	20.78
4	19.84	20.25	20.68	20.57		20.33	20.60
5	19.86	20.27	20.70	20.64		20.39	20.49
6	19.88	20.30	20.72	20.68		20.45	20.43
7	19.90	20.33	20.74	20.75		20.50	20.38
8	19.91	20.35	20.77	20.76		20.54	20.34
9	19.91	20.36	20.78	20.78		20.58	20.31
10	19.92	20.36	20.83	20.80		20.61	20.29
15	19.94	20.38	20.85	20.83		20.72	20.10
20	19.95	20.38	20.86	20.90		20.78	19.98
25	19.95	20.38	20.87	20.93		20.84	19.90
30	19.95	20.39	20.87	20.95		20.89	19.84
35	19.95	20.39	20.88	20.97		20.93	19.78
40	19.95	20.39	20.89	21.00		20.96	19.74
50	19.95	20.39	20.89	21.06		21.02	19.67
60	19.95	20.39	20.89	21.09		21.06	19.62
70	19.95	20.39	20.89	21.09		21.10	19.58
80	19.95	20.39	20.89	21.09		21.14	19.55
90	19.95	20.39	20.89	21.09		21.18	19.53
120	19.95	20.39	20.89	21.09		21.28	19.50
150	19.95	20.39	20.89	21.09		21.35	19.50
180						21.37	
210						21.40	
240						21.44	
300						21.52	
360						21.72	
420						21.80	
480						21.87	
540						21.94	
600						21.99	
660						22.04	
720						22.07	
780						22.10	
840						22.13	
900						22.15	
960						22.17	
1020						22.18	
1080						22.18	
1140						22.18	
1200						22.19	
1260						22.19	
1320						22.19	
1380						22.19	
1440						22.19	
1500						22.19	

STEP DRAW DOWN TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone

Site No.: BH-J4





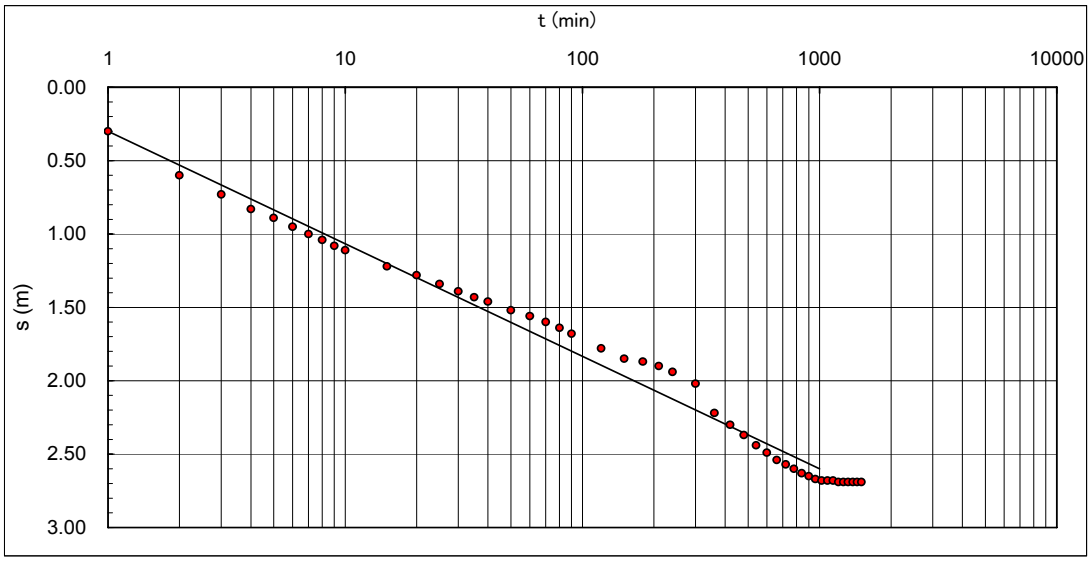
Step	Q (l/mim)	N.D. (m)	s (m)	Q/s (l/min/m)
1	167.88	19.45	0.95	176.72
2	337.08	19.89	1.39	242.50
3	419.04	20.39	1.89	221.71
4	511.86	20.59	2.09	244.91

LS-MFEZ JICA STUDY TEAM

CONTINUOUS PUMPING TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone
SITE No. : BH-J4 Discharge : 511.86 (L/min)
Q : 511.86 (l/mim) SWL : 19.00 (m) 03/07/2008

HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)	HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)
11 : 55	0	19	0	16 : 55 0	300	21.02	2.02
11 : 56	1	19.3	0.3	17 : 55 0	360	21.22	21.22
11 : 57	2	19.6	0.6	18 : 55 0	420	21.3	21.30
11 : 58	3	19.73	0.73	19 : 55 0	480	21.37	21.37
11 : 59	4	19.83	0.83	20 : 55 0	540	21.44	21.44
12 : 0	5	19.89	0.89	21 : 55 0	600	21.49	21.49
12 : 1	6	19.95	0.95	22 : 55 0	660	21.54	21.54
12 : 2	7	20	1	23 : 55 0	720	21.57	21.57
12 : 3	8	20.04	1.04	24 : 55 0	780	21.6	21.60
12 : 4	9	20.08	1.08	25 : 55 0	840	21.63	21.63
12 : 5	10	20.11	1.11	26 : 55 0	900	21.65	21.65
12 : 10	15	20.22	1.22	27 : 55 0	960	21.67	21.67
12 : 15	20	20.28	1.28	28 : 55 0	1020	21.68	21.68
12 : 20	25	20.34	1.34	29 : 55 0	1080	21.68	21.68
12 : 25	30	20.39	1.39	30 : 55 0	1140	21.68	21.68
12 : 30	35	20.43	1.43	31 : 55 0	1200	21.69	21.69
12 : 35	40	20.46	1.46				
12 : 45	50	20.52	1.52				
12 : 55	60	20.56	1.56				
13 : 5	70	20.6	1.6				
13 : 15	80	20.64	1.64				
13 : 25	90	20.68	1.68				
13 : 55	120	20.78	1.78				
14 : 25	150	20.85	1.85				
14 : 55	180	20.87	1.87				
15 : 25	210	20.9	1.9				
15 : 55	240	20.94	1.94				



△s = 0.77 m △s1 = 0.30 △s2 = 1.07
SCREEN PIPE LENGH = 20.00 (m)

$$T = \frac{0.183Q}{\triangle s} = \frac{93.67}{0.77} = 122.18 \text{ (l/min/m)} = 0.12218 \text{ (m2/min)} \quad 175.9392 \text{ (m2/d)}$$

$$K = \frac{T}{m} = \frac{0.1222}{20.00} = 0.0061 \text{ (m/min)} = 1.02E\text{-}02 \text{ (cm/sec)}$$

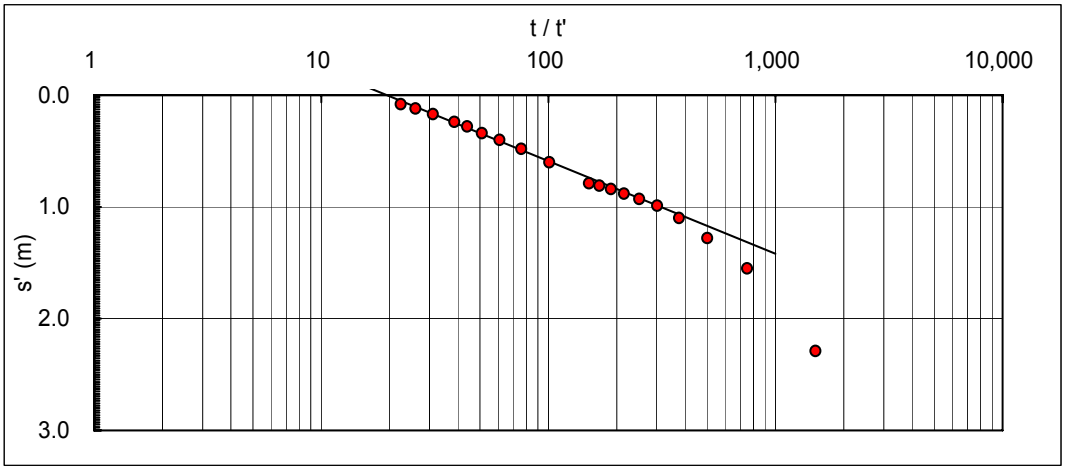
$$S = \frac{2.25Tt_0}{r^2} = \frac{0.0275}{0.08} = 0.3665$$

LS-MFEZ JICA STUDY TEAM

RECOVERY TEST

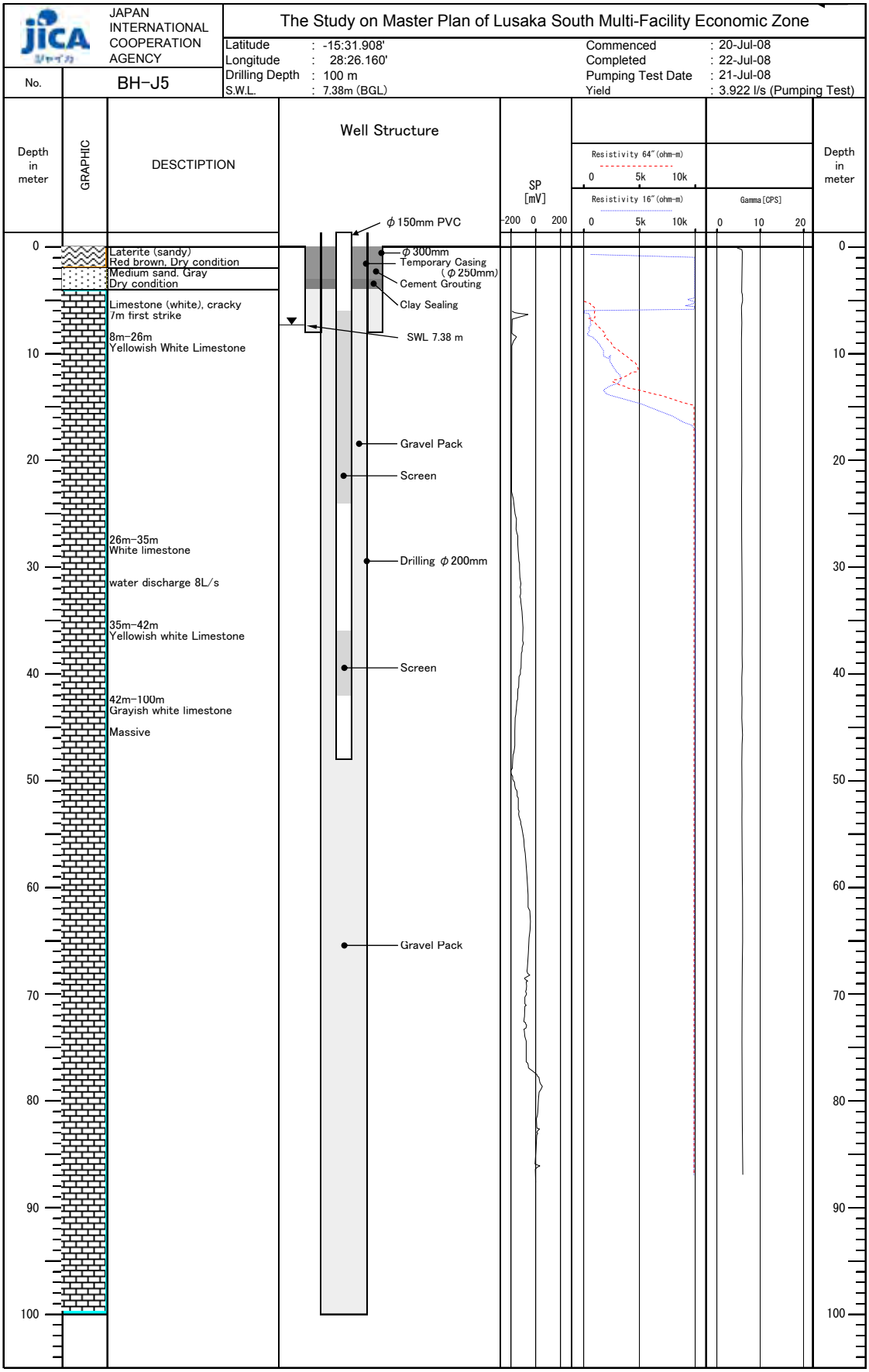
PROJECT TITLE	: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone				
SITE No.	: BH-J4	DRILLED DEPTH	:	91.00	(m)
COMMUNITUY	:	COMPLETED DEPTH	:		(m)
REGION	: LS-MFEZ Site	SWL	:	19.00	(m)
DATE	: 22/3/2002	CASING HEIGHT	:	0.50	(m)

HOUR	ACCUMU-LATED TIME t (min)	RECOVERY TIME t' (min)	t / t'	WATER LEVEL (m)	RECOVERY (m)	REMARKS
12 : 55	1,500	0		21.69	2.69	
12 : 56	1,501	1	1,501.0	21.29	2.29	
12 : 57	1,502	2	751.0	20.55	1.55	
12 : 58	1,503	3	501.0	20.28	1.28	
12 : 59	1,504	4	376.0	20.10	1.10	
13 : 0	1,505	5	301.0	19.99	0.99	
13 : 1	1,506	6	251.0	19.93	0.93	
13 : 2	1,507	7	215.3	19.88	0.88	
13 : 3	1,508	8	188.5	19.84	0.84	
13 : 4	1,509	9	167.7	19.81	0.81	
13 : 5	1,510	10	151.0	19.79	0.79	
13 : 10	1,515	15	101.0	19.60	0.60	
13 : 15	1,520	20	76.0	19.48	0.48	
13 : 20	1,525	25	61.0	19.40	0.40	
13 : 25	1,530	30	51.0	19.34	0.34	
13 : 30	1,535	35	43.9	19.28	0.28	
13 : 35	1,540	40	38.5	19.24	0.24	
13 : 45	1,550	50	31.0	19.17	0.17	
13 : 55	1,560	60	26.0	19.12	0.12	
14 : 5	1,570	70	22.4	19.08	0.08	



Q	=	511.86 0				SWL	=	19.00 (m)
△s	=	0.83	△s1	=	-0.24	△s2	=	0.59
		SCREEN PIPE LENGH		=	20.00 (m)			
T	=	$\frac{0.183Q}{\triangle s} = \frac{93.67}{0.83}$		=	112.8559 (l/min/m)		=	0.11286 (m2/min)
K	=	$\frac{T}{m} = \frac{0.11286}{20.00}$		=	0.00564 (m/min)		=	9.40E-03 (cm/sec)

LS-MFEZ JICA STUDY TEAM


JAPAN INTERNATIONAL COOPERATION AGENCY
The Study on Master Plan of Lusaka South Multi-Facility Economic Zone
No.
BH-J5
Latitude : -15:31.908'
Longitude : 28:26.160'
Drilling Depth : 100 m
S.W.L. : 7.38m (BGL)
Commenced : 20-Jul-08
Completed : 22-Jul-08
Pumping Test Date : 21-Jul-08
Yield : 3.922 l/s (Pumping Test)
Depth in meter
GRAPHIC
DESCTIPTION
Well Structure
SP [mV]
Resistivity 64" (ohm-m)
Resistivity 16" (ohm-m)
Gamma [CPS]
φ150mm PVC
φ300mm
Temporary Casing (φ250mm)
Cement Grouting
Clay Sealing
SWL 7.38 m
Gravel Pack
Screen
Drilling φ200mm
Screen
Gravel Pack
Laterite (sandy)
Red brown, Dry condition
Medium sand. Gray
Dry condition
Limestone (white), cracky
7m first strike
8m-26m
Yellowish White Limestone
26m-35m
White limestone
water discharge 8L/s
35m-42m
Yellowish white Limestone
42m-100m
Grayish white limestone
Massive

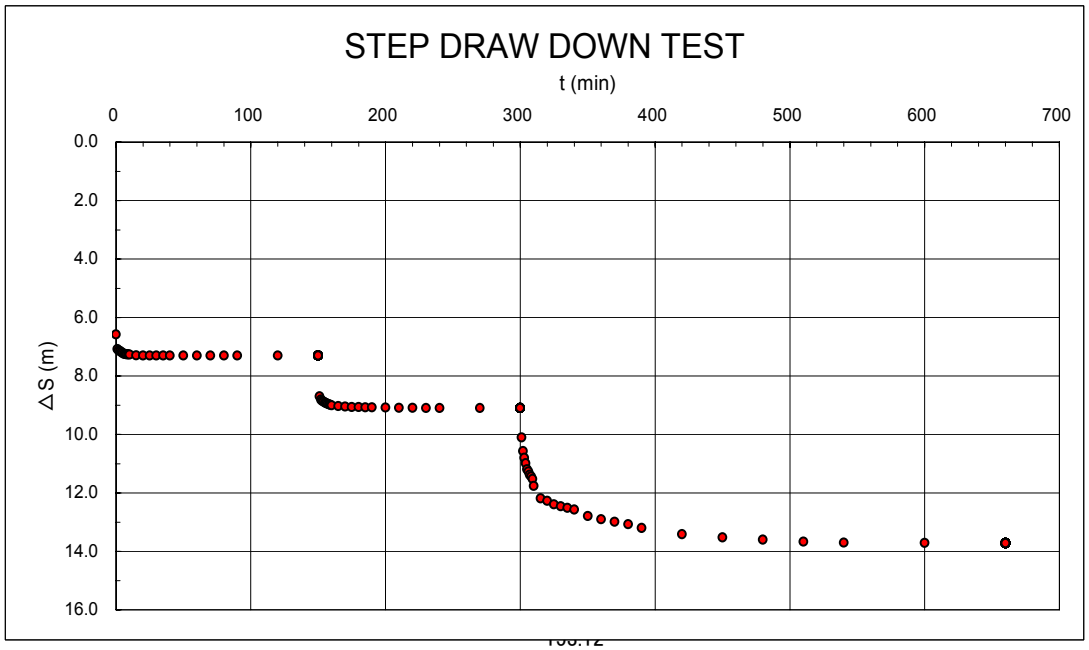
PROJECT TITLE:	The Study on Master Plan of Lusaka South Multi-Facility Economic Zone				
SITE No.:	BH-J5	DRILLED DEPTH:		100	(m)
REGION:	Lusaka Park	SWL:	GL-	6.98	(m)
Starting DATE:	07/07/2008	CASING HEIGHT:		0.40	(m)

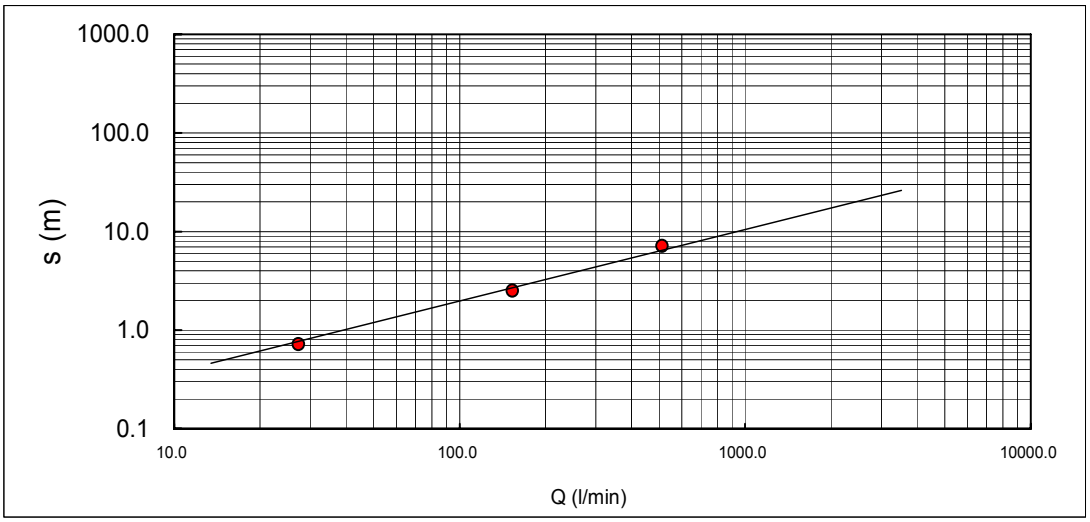
Time (min)	Measuring Data						
	1st Step	2nd Step	3rd Step	4th Step	5th Step	Constant	Recoveryly
1	7.48	9.10	10.50			8.60	11.98
2	7.52	9.21	10.97			9.00	10.00
3	7.55	9.25	11.20			9.15	8.96
4	7.58	9.28	11.39			9.23	8.34
5	7.62	9.31	11.59			9.35	8.07
6	7.64	9.33	11.67			9.65	7.76
7	7.65	9.35	11.78			9.75	7.64
8	7.66	9.37	11.84			9.80	7.59
9	7.66	9.39	11.92			9.90	7.52
10	7.67	9.40	12.16			10.11	7.48
15	7.69	9.43	12.59			10.30	7.46
20	7.70	9.45	12.67			10.49	7.44
25	7.70	9.46	12.79			10.61	7.43
30	7.70	9.46	12.86			10.88	7.42
35	7.70	9.47	12.91			11.24	7.42
40	7.70	9.47	12.97			11.28	7.41
50	7.70	9.48	13.19			11.44	7.41
60	7.70	9.49	13.30			11.56	7.40
70	7.70	9.49	13.39			11.72	7.39
80	7.70	9.50	13.47			11.82	7.39
90	7.70	9.50	13.60			11.96	7.39
120	7.70	9.50	13.81			12.34	7.39
150	7.70	9.50	13.92			12.60	
180			14.00			12.84	
210			14.07			13.05	
240			14.10			13.25	
300			14.11			13.50	
360			14.12			13.72	
420						13.87	
480						13.97	
540						14.07	
600						14.09	
660						14.11	
720						14.12	
780						14.13	
840						14.13	
900						14.13	
960						14.14	
1020						14.14	
1080						14.15	
1140						14.15	
1200						14.15	
1260						14.15	
1320						14.15	
1380						14.15	
1440						14.15	
1500						14.15	

STEP DRAW DOWN TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone

Site No.: BH-J5





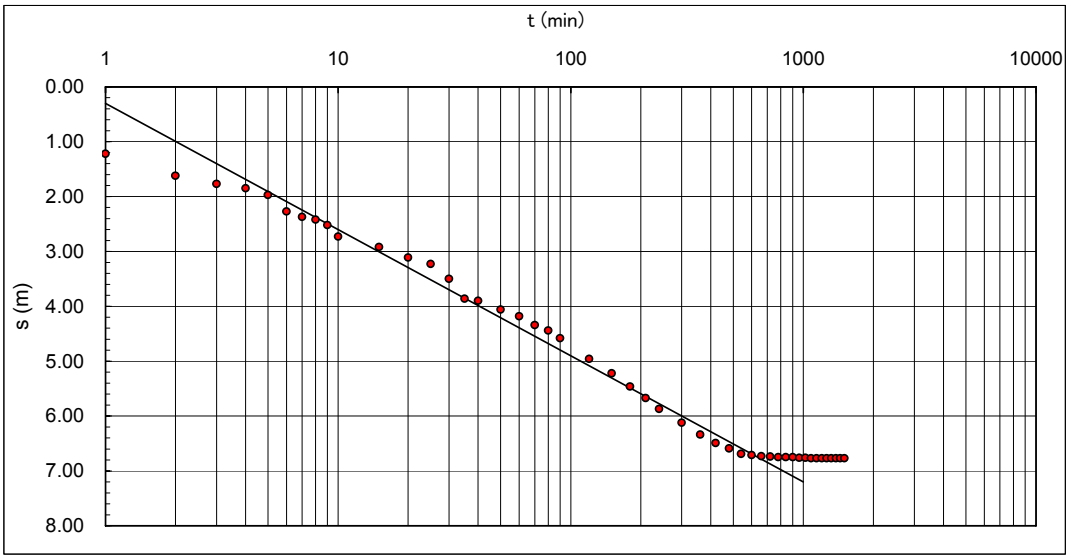
Step	Q (l/mim)	N.D. (m)	s (m)	Q/s (l/min/m)
1	27.24	7.30	0.72	37.83
2	153.12	9.10	2.52	60.76
3	511.86	13.72	7.14	71.69

LS-MFEZ JICA STUDY TEAM

CONTINUOUS PUMPING TEST

PROJECT TITLE: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone
SITE No. : BH-J5 Discharge : 235.32 (L/min)
Q : 235.32 (l/mim) SWL : 6.98 (m) 07/07/2008

HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)	HOUR	DURATION (min)	DWL (m)	DIFFERENCE (m)
7 : 38	0	6.98	0	12 : 38 0	300	13.1	6.12
7 : 39	1	8.2	1.22	13 : 38 0	360	13.32	13.32
7 : 40	2	8.6	1.62	14 : 38 0	420	13.47	13.47
7 : 41	3	8.75	1.77	15 : 38 0	480	13.57	13.57
7 : 42	4	8.83	1.85	16 : 38 0	540	13.67	13.67
7 : 43	5	8.95	1.97	17 : 38 0	600	13.69	13.69
7 : 44	6	9.25	2.27	18 : 38 0	660	13.71	13.71
7 : 45	7	9.35	2.37	19 : 38 0	720	13.72	13.72
7 : 46	8	9.4	2.42	20 : 38 0	780	13.73	13.73
7 : 47	9	9.5	2.52	21 : 38 0	840	13.73	13.73
7 : 48	10	9.71	2.73	22 : 38 0	900	13.73	13.73
7 : 53	15	9.9	2.92	23 : 38 0	960	13.74	13.74
7 : 58	20	10.09	3.11	24 : 38 0	1020	13.74	13.74
8 : 3	25	10.21	3.23	25 : 38 0	1080	13.75	13.75
8 : 8	30	10.48	3.5	26 : 38 0	1140	13.75	13.75
8 : 13	35	10.84	3.86	27 : 38 0	1200	13.75	13.75
8 : 18	40	10.88	3.9				
8 : 28	50	11.04	4.06				
8 : 38	60	11.16	4.18				
8 : 48	70	11.32	4.34				
8 : 58	80	11.42	4.44				
9 : 8	90	11.56	4.58				
9 : 38	120	11.94	4.96				
10 : 8	150	12.2	5.22				
10 : 38	180	12.44	5.46				
11 : 8	210	12.65	5.67				
11 : 38	240	12.85	5.87				



△s = 2.30 m △s1 = 0.30 △s2 = 2.60

SCREEN PIPE LENGH = 20.00 (m)

$$T = \frac{0.183Q}{\triangle s} = \frac{43.06}{2.30} = 18.723 \text{ (l/min/m)} = 0.01872 \text{ (m2/min)} \quad 26.9568 \text{ (m2/d)}$$

$$K = \frac{T}{m} = \frac{0.0187}{20.00} = 0.0009 \text{ (m/min)} = 1.57E\text{-}03 \text{ (cm/sec)}$$

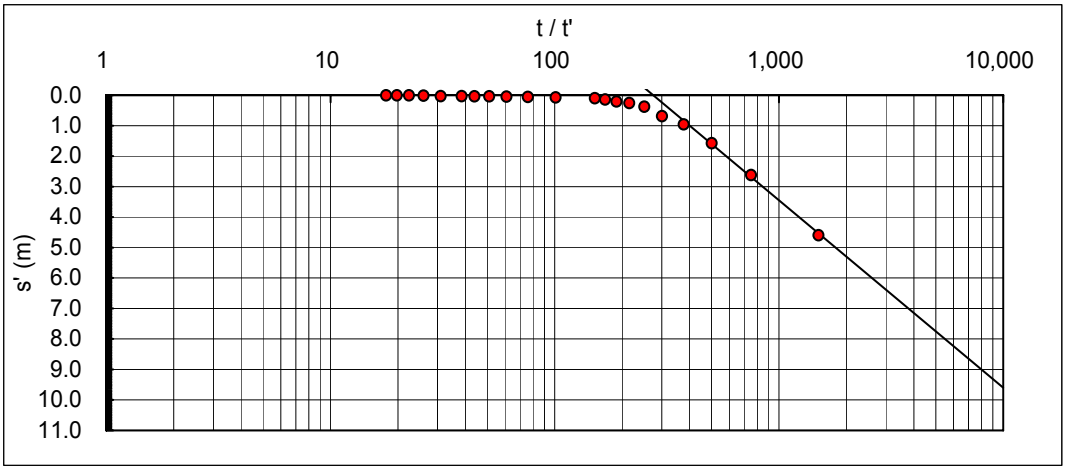
$$S = \frac{2.25Tt_0}{r^2} = \frac{0.0042}{0.08} = 0.0562$$

LS-MFEZ JICA STUDY TEAM

RECOVERY TEST

PROJECT TITLE	: The Study on Master Plan of Lusaka South Multi-Facility Economic Zone				
SITE No.	: BH-J5	DRILLED DEPTH	:	100.00	(m)
COMMUNITUY	:	COMPLETED DEPTH	:		(m)
REGION	: Lusaka Park	SWL	:	6.98	(m)
DATE	: 22/3/2002	CASING HEIGHT	:	0.40	(m)

HOUR	ACCUMU-LATED TIME t (min)	RECOVERY TIME t' (min)	t / t'	WATER LEVEL (m)	RECOVERY (m)	REMARKS
8 : 38	1,500	0		13.75	6.77	
8 : 39	1,501	1	1,501.0	11.58	4.60	
8 : 40	1,502	2	751.0	9.60	2.62	
8 : 41	1,503	3	501.0	8.56	1.58	
8 : 42	1,504	4	376.0	7.94	0.96	
8 : 43	1,505	5	301.0	7.67	0.69	
8 : 44	1,506	6	251.0	7.36	0.38	
8 : 45	1,507	7	215.3	7.24	0.26	
8 : 46	1,508	8	188.5	7.19	0.21	
8 : 47	1,509	9	167.7	7.12	0.14	
8 : 48	1,510	10	151.0	7.08	0.10	
8 : 53	1,515	15	101.0	7.06	0.08	
8 : 58	1,520	20	76.0	7.04	0.06	
9 : 3	1,525	25	61.0	7.03	0.05	
9 : 8	1,530	30	51.0	7.02	0.04	
9 : 13	1,535	35	43.9	7.02	0.04	
9 : 18	1,540	40	38.5	7.01	0.03	
9 : 28	1,550	50	31.0	7.01	0.03	
9 : 38	1,560	60	26.0	7.00	0.02	
9 : 48	1,570	70	22.4	6.99	0.01	
9 : 58	1,580	80	19.8	6.99	0.01	
10 : 8	1,590	90	17.7	6.99	0.01	



Q	=	235.32 0				SWL	=	6.98 (m)
△s	=	6.15	△s1	=	-2.70	△s2	=	3.45
		SCREEN PIPE LENGH		=	20.00 (m)			
T	=	$\frac{0.183Q}{\triangle s} = \frac{43.06}{6.15}$		=	7.00221 (l/min/m)		=	0.007 (m2/min)
K	=	$\frac{T}{m} = \frac{0.007}{20.00}$		=	0.00035 (m/min)		=	5.83E-04 (cm/sec)

LS-MFEZ JICA STUDY TEAM

Appendix E

Air Quality Survey for the Proposed LS-MFEZ Area

APPENDIX E

AIR QUALITY SURVEY FOR THE PROPOSED LS-MFEZ AREA

Air survey was conducted 16th September 2008 by MVC Consulting Engineers and General Dealers. An air sampling point is shown in *Figure E. 1.*

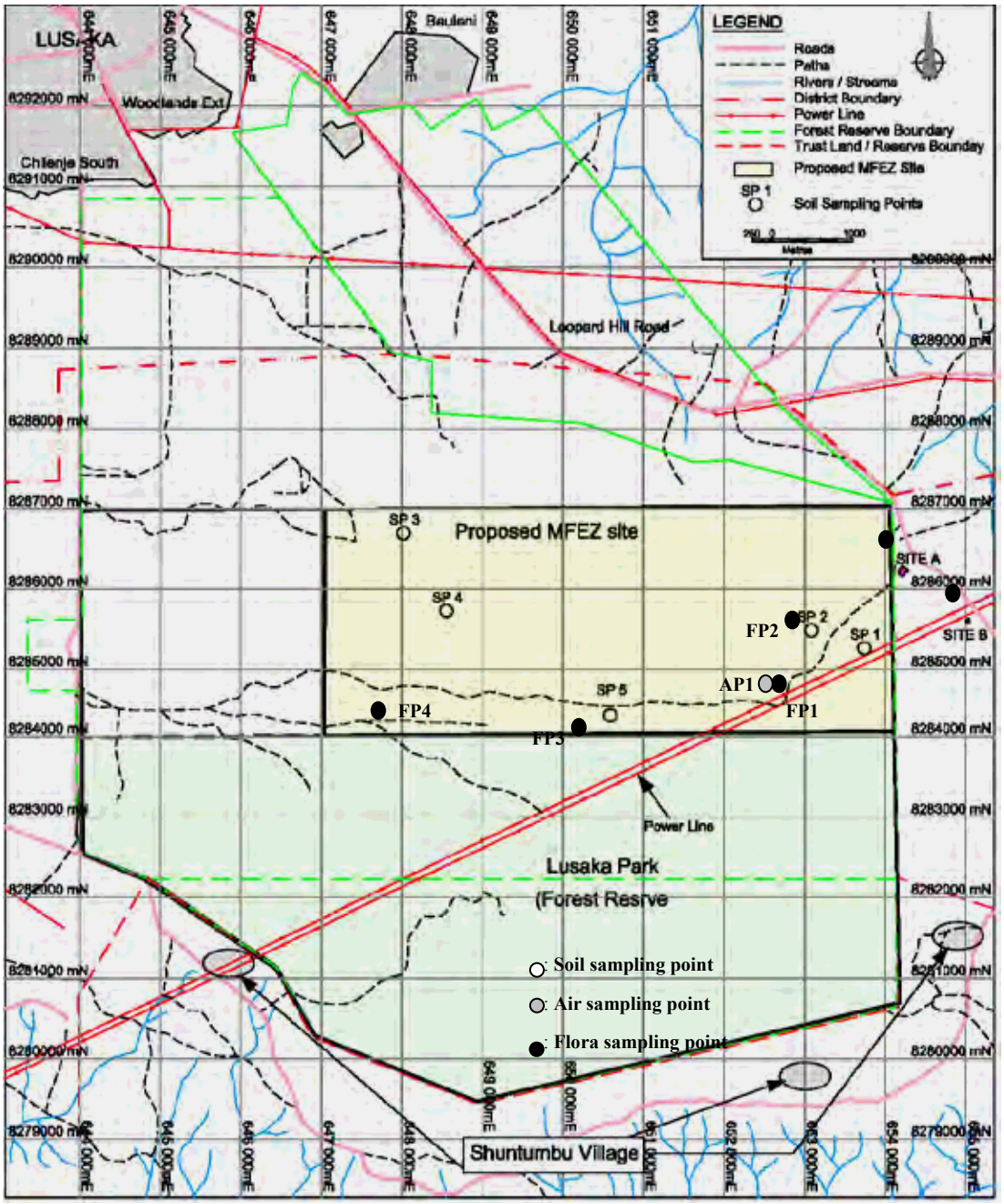


Figure E.1 Air, Soil and Flora Sampling Points

The study on the baseline air quality status in the proposed LS-MFEZ area is an essential and primary requirement for assessing the impacts on the air especially for the projects which might release pollutants to ambient air.

Grassland and forest fires, charcoal burning and traditional Chitmene slash and burn agriculture during the dry season generates smoke and dust. This air pollution hangs over the area and forms a distinctive haze. The haze layer is mainly visible from the air and worst during the coolest months (June and July) when temperature inversions tend to trap the smoke near ground level. The haze lasts until the arrival of the rains in November. Localized and temporary air quality deterioration is also associated with village domestic fires.

The measurement items were baseline gases (SO_2 and NOx) and dust (SPM, PM_{10} and lead). In order to conduct this measurement the equipment was set up in such a way that after about 3 hours, it manually changed to another flask in the equipment. The survey was conducted by Mr. Simukoko of National Institute for Scientific and Industrial Research (NISIR) environmental Engineering Laboratory. Results are shown in the *Table E.1*.

Table E.1 Air Quality Analysis Results in the Proposed LS-MFEZ

Sampling time	People on site	SO_2 micro-g/m^3	NOx as NO_2 micro-g/m^3	PM_{10} micro-g/m^3	TSP micro-g/m^3	Pb micro-g/m^3
8:00~11:20	4	0.37	NA	11.2	60	0.002
11:00~13:20	3	NA	0.21	18.8	50	0.001
13:00~16:20	5	0.43	NA	12.7	30	0.001
Zambian Guideline Limits		350 (1hr-average) 125(24hr-average)	400 (1hr-average) 150(24hr-average)	70 (24hr-average)	120 (24hr-average)	1.5 (3month –average)

Source: JST (Survey conducted by National Institute for Scientific and Industrial Research), 16th September 2008; NA: Not analysed

It is seen from the air quality results that all the concentration levels of pollutants were within the prescribed Zambian guideline limits. The observed pollution load of total suspended particles (TSP) and the respirable particles less than 10 micro-m (PM_{10}) could be attributed to the wind movements as well as the vehicles that were coming to site during the survey.

Appendix F

Soil Quality Survey for the Proposed LS-MFEZ Area

APPENDIX F

SOIL QUALITY SURVEY FOR THE PROPOSED LS-MFEZ AREA

Soil survey was conducted 3rd August 2008 by MVC Consulting Engineers and General Dealers. Soil sampling points are shown in *Figure E.1*.

Soil Geochemical Analysis: In addition to the soil classification pits assessed, an additional 5 shallow 500 mm deep augur pits were dug in the area to collect near surface soil sample (0 – 500 mm depth) for soil geochemical analysis and agricultural potential assessment. The soil pit sites were chosen to cover the project area. Soil morphology and horizonation is described according to the FAO-guidelines for soil description (FAO, 2006). Colors were recorded using the Munsell Color Charts (KIC, 1990). Chemical and physical characteristics confirm to the Procedures for Soil analysis.

- Auger-hole number 1: UTM (653951E, 8285174N)
    - Landform: Degraded Central African Plateau;
    - Soil Classification (FAO 2006): Chromic-haplic LIXISOLS; and
    - Well drained; deep; with occurrence of stones in some places or boulders on the surface; red to dark red; level to nearly level (0-2%); course sandy to sandy clay loams with loamy sand to sandy loam topsoil, strongly acidic soil.
- Auger-hole number 2: UTM (653292E, 8285394N)
    - Landform: Degraded Central African Plateau;
    - Soil Classification (FAO 2006): Chromic-haplic LIXISOLS; and
    - Well drained; strong brown to yellowish red, level to nearly level (0-2%), sandy clay loams to sandy clays with sandy loam topsoils; strongly acidic soil.
- Auger-hole number 3: UTM (648228E, 8286614N)
    - Landform: Degraded Central African Plateau;
    - Soil Classification (FAO 2006): Orthi-eutric LEPTOSOLS; and
    - Well drained; moderately shallow to shallow with rock outcrops; yellowish red; gravelly sandy clay loams to sandy clays with sandy loam to sandy clay loam topsoil; slightly acidic; developed on undifferentiated biotite schist and quartzites.
- Auger-hole number 4: UTM (648758E, 8285639N)
    - Landform: Degraded Central African Plateau;
    - Soil Classification (FAO 2006): Chromic-haplic LIXISOLS; and
    - Well drained; moderately shallow to moderately deep; dark red to reddish brown; sandy clay loams to sandy clays; level to nearly level (0-2%); occurrence of rocks on the surface; medium acid.

- Auger-hole number 5: UTM (650795E, 8284336N)
  - Landform: Degraded Central African Plateau;
  - Soil Classification (FAO 2006): Chromic-haplic LIXISOLS; and
  - Well drained; deep; strong brown; sandy clay loams to sandy clays with sandy loam to sandy clay loam topsoil; level to nearly level (0-2%); medium acid soils; developed on mixed quartzites and biotites.

The results of the soil analysis of Auger Hole 1 to 5 are summarized in the *Table F.1*:

Table F.1 Soil Quality Analysis Results in the Proposed LS-MFEZ

Sample ID	pH $CaCl_2$	Cr mg/kg	Cd mg/kg	Pb mg/kg	As mg/kg	Moisture content %	Loss on ignition %	Oil content %
No.1	4.22	23	<0.05	4.9	49	5.6	6.6	2.2
No.2	4.92	20	<0.05	3.8	<10	5.2	6.3	2.4
No.3	5.47	39	<0.05	7.4	52	4.6	6.0	3.6
No.4	5.09	26	5	9.8	33	6.9	5.1	1.1
No.5	5.53	23	<0.05	11.1	43	3.8	5.4	3.8
#		5-1500	0.01-2.0	2-300	0.01-40			
##		75-100	3-8	100-400	20-50			

Source: JST (Analysis conducted by the University of Zambia, Department of Soil Science, Service Laboratory), 3rd August 2008

#: Normal range in soils (B.J. Alloway, Heavy metals in soils (2nd Edition), 1994, Kluwer Academic Publishers)

##: Critical soil total concentration (B.J. Alloway, Heavy metals in soils (2nd Edition), 1994, Kluwer Academic Publishers)

Observed concentration of Arsenic in the proposed LS-MFEZ area is within the natural background level, but is within the boundary level of critical soil concentration. However, the arsenic concentration of the groundwater in the proposed LS-MFEZ area is below the detection limit (0.001 mg/L).

Soil survey for arsenic was conducted December 2008 by MVC Consulting Engineers and General Dealers. Soil sampling points are shown in *Figure E.1*. The results of the soil analysis of Auger Hole 1 to 5 are summarized in the *Table F.2*:

Table F.2 Soil Quality Analysis Results in the Proposed LS-MFEZ in Rainy Season

Sample ID	As (mg/kg)
No.1	20.25
No.2	3.60
No.3	10.45
No.4	15.28
No.5	17.45

Appendix G

Flora and Vegetation Survey for the Proposed LS-MFEZ Area

APPENDIX G

FLORA AND VEGETATION SURVEY FOR THE PROPOSED LS-MFEZ AREA

Flora and Vegetation survey was conducted on 2nd-4th August and on 12th – 15th December 2008 by MVC Consulting Engineers and General Dealers. Flora sampling points are shown in *Figure E.1*.

The LS-MFEZ area forms part of the extensive flat land found in the Lusaka province. This surface is represented by the Lusaka-Kalomo upland which falls gently towards the Kafue river basin on its southern side.

The vegetation of the LS-MFEZ area had been mainly Miombo and Munga woodlands, with isolated few Riparian woodlands along drainage lines. These vegetation types had been described as:

- Riparian woodland: the original vegetation was a mixture of *Khaya – Trichilia – Syzygium guineense* species along a narrow belt on both banks of the major rivers and streams of the district. This type of vegetation has since disappeared and has been replaced by *Bridelia – Homalium – Syzygium cordatum* species mix. Presently, dominants in the existing riparian woodlands are *Bridelia micrantha*, *Ficus capensis*, *Homalium abdessamadii*, *Syzygium cordatum*, *S. guineense* ssp *barotsense*, *Trichilia emetica* and pure stands of the invasive *Acacia polycantha*.
- Miombo woodland: the Miombo originally occurred on the plateau and on the escarpment. The escarpment Miombo still occurs in more or less its origin form although highly disturbed by charcoal production. The plateau Miombo has largely disappeared and has been replaced by agriculture fields and Munga/Acacia woodlands. The canopy species are largely *Brachystegia boehmii* and *Julbernardia globiflora* with *Brachystegia glaucescens* on rock outcrops. These trees grow up to 15m on good soil and to 6m on stony shallow soils. Canopy associates are mainly *Albizia antunesiana*, *Brachystegia speciformis*, *Br. taxifolia*, *Burkea africana*, *Combretum collinum* and *Parinari curatellifolia*. Fire and grazing have also contributed to the destruction of the Miombo in the district.
- Munga woodland: characteristically an open Savanna type of woodland dominated by species of *Acacia*, *Faidherbia*, *Combretum* and *Terminalia*. It occurs on the red clay soils of the plateau that are also the premier agricultural soils, there is very little of this type of woodland left in the area.

The study carried out in the LS-MFEZ area was based on these three woodland types as they represented the major vegetation types encountered in the area. The purpose of the study was to collect data and information on existing vegetation (flora) and associated wildlife (fauna), and analyzing these to give trends in patterns of vegetation growth, utilization, management and conservation.

The sample plots used for assessments were rectangular plots (20m x 10m). Four sample plots were sampled. The following data were collected from the sample plots:

- Species densities using counts of individual species in each sampling plot;
- Diameter measured in centimeters at breast height using a diameter tape;
- Height distribution in meters measured using a tame; and
- Lists of species encountered in the study area.

The *Table G.1* showing locality of sampling plots and description of vegetation:

Table G.1 Description of Vegetation in the Proposed LS-MFEZ

Site 1 (tree species in rectangular plot: 20m x 10m)

Species	(Diameter (cm), Height (cm))	Quantity	Tree ratio (%)
Brachystegia spiciformis	(7, 600) + 1 tree	2	6
Brachystegia boehmii	(4, 250), (3, 350), (3, 260), (4, 250) + 3 trees	7	21
Bauhinia Petersania	(4, 280), (4, 400), (2, 160) + 2 trees	5	15
Vitex trifoliate	(3, 250) + 2 trees	3	9
Ochna pulchra	(3, 230), (4, 240) + 1 tree	3	9
Bridelia micrantha	(3, 220) + 2 trees	3	9
Pseudolachynostylis maprouneifolia	(3, 240)	1	3
Swartzia madagascariensis	(6, 350)	1	3
Combretum celastroides	(4, 250), (2, 200) + 1 tree	3	9
Diplorhynchus condylocarpon	(3,240) + 1 tree	2	6
Ziziphus abyssinica	(5, 250)	1	3
Acacia spp	(4, 270), (6, 550) + 1 tree	3	9
total		34	100

Site 1 (grass. herbs and forbes species in squared plot: 2m x 2m) in dry season

	Species
Grass	*Hyparrhenia spp*, *Andropogon spp*, *Loudetia spp*, *Digitaria spp*, *Manocymdium spp* and *Eragrastis spp*
Herbs and forbes	*Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp* and *Nidorella spp*

Site 1 (grass. Herbs and forbes species in squared plot: 2m x 2m) in rainy season

	Species
Grass	*Hyparrhenia spp*, *Andropogon spp*, *Loudetia spp*, *Digitaria spp*, *Manocymdium spp, Bidens pilosa, Erlangea Misera* and *Eragrastis spp*
Herbs and forbes	*Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp, Ipomoea richardsiae* and *Nidorella spp*

Site 2 (tree species in rectangular plot: 20m x 10m)

Species	(Diameter (cm), Height (cm))	Quantity	Tree ratio (%)
Dichrostachys cinerea	(3, 130) + 2 trees	3	9
Flacourtia indica	(5, 250), (4, 310), (4, 460), (2, 150) + 1 tree	5	16
Brachystegia spiciformis	(3, 200), (6, 620), (2, 260), (3, 320), (4, 320)	5	16
Bauhinia Petersania	(2, 220), (5, 340), (3, 350), (4, 400) + 2 trees	6	19
Ochna pulchra	(2, 200)	1	3
Pseudolachynostylis maprouneifolia	(4, 330)	1	3
Swartzia madagascariensis	(6, 350)	1	3
Combretum celastroides	(6, 610), (6, 630)	2	6
Diplorhynchus condylocarpon	(4, 300), (5, 350), (5, 600) + 4 tree	7	22
Parinari excelsa	(3, 160)	1	3
total		32	100

Site 2 (grass. herbs and forbes species in squared plot: 2m x 2m)

	Species
Grass	*Hyparrhenia spp*, *Andropogon spp*, *Loudetia spp*, *Digitaria spp*, *Manocymdium spp*, *Eragrastis spp* and *Themedia spp*
Herbs and forbes	*Fockea multiflora, Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp* and *Nidorella spp*

Site 2 (grass. herbs and forbes species in squared plot: 2m x 2m) in rainy season

	Species
Grass	*Hyparrhenia spp*, *Andropogon spp*, *Loudetia spp*, *Digitaria spp*, *Manocymdium spp*, *Eragrastis spp* and *Themedia spp*
Herbs and forbes	*Fockea multiflora, Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp* and *Nidorella spp*

Site 3 (tree species in rectangular plot: 20m x 10m)

Species	**(Diameter (cm), Height (cm))**	**Quantity**	**Tree ratio (%)**
Brachystegia spiciformis	(2, 200) + 1 tree	2	4
Brachystegia boehmii	(3, 350), (2, 240), (4, 360), (2, 340) + 6 trees	10	18
Bauhinia Petersania	(3, 360), (4, 300), (3, 250), (4, 350), (2, 260) + 4 trees	9	16
Vitex trifoliate	(3, 620)	1	2
Protea spp	(2, 150) + 1 tree	2	4
Albizia versicolor	(3, 220), (7, 700), (4, 300)	3	5
Albizia adianthifolia	(4, 400)	1	2
Pseudolachynostylis maprouneifolia	(3, 150), (2,180), (4, 420), (3, 290), (4, 320), (4, 500), (5, 500), (5, 500)	8	14
Swartzia madagascariensis	(6, 380)	1	2
Combretum celastroides	(4, 500), (2, 200) + 1 tree	2	4
Diplorhynchus condylocarpon	(2, 210), (6, 700), (10, 800), (3, 240) + 4 tree	8	14
Hurungana madagascariensis	(8, 700) + 1 tree	2	4
Lannea discolor	(7, 300) + 1 tree	2	4
Acacia spp	(4, 270), (6, 550) + 1 tree	3	5
Gardinia spp	(2, 400), (4, 400)	2	4
total		56	100

Site 3 (grass. herbs and forbes species in squared plot: 2m x 2m)

	Species
Grass	*Hyparrhenia spp*, *Andropogon spp*, *Loudetia simplex*, *Mircanthus spp*, *Digitaria spp*, *Manocymdium spp* and *Eragrastis spp* and *Themedia spp*
Herbs and forbes	*Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp* and *Nidorella spp*

Site 3 (grass. herbs and forbes species in squared plot: 2m x 2m) in rainy season

	Species
Grass	*Panicum maximum, Hyparrhenia spp*, *Andropogon spp*, *Loudetia simplex*, *Mircanthus spp*, *Digitaria spp*, *Manocymdium spp, Eragrastis spp, Themedia spp, Chloris gayana and Pennisetum spp*
Herbs and forbes	*Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp*, *Nidorella spp, Stylosanthes gracilis, Centrosema Pubescens, Asparagus migoedii, Aspidotis schimperi, Begonia princeae, Costus spectabilis, Ensete homblei and Sage spp*

Site 4 (tree species in rectangular plot: 20m x 10m)

Species	(Diameter (cm), Height (cm))	Quantity	Tree ratio (%)
Brachystegia boehmii	(2, 500) + 2 trees	3	12
Bauhinia Petersania	(4, 450), (5, 400), (4, 600), (2, 500), (3, 300), (6, 500) + 4 trees	10	38
Combretum celastroides	(3, 600), (4, 500), (3, 260)	3	12
Diplorhynchus condylocarpon	(3, 400), (3, 400), (2, 350), (3, 300) + 2 tree	6	23
Pericopsis angolensis	(4, 600)	1	4
Pterocarpus angolensis	(2, 260), (2, 280)	2	8
Annona senegalensis	(4, 200)	1	4
total		26	100

Site 4 (grass. herbs and forbes species in squared plot: 2m x 2m)

	Species
Grass	*Hyparrhenia spp*, *Andropogon spp*, *Loudetia spp*, *Loudetia simplex*, *Mircanthus spp*, *Digitaria spp*, *Manocymdium spp* and *Eragrastis spp* and *Themedia spp*
Herbs and forbes	*Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp* and *Nidorella spp*

Site 4 (grass. herbs and forbes species in squared plot: 2m x 2m) in rainy season

	Species
Grass	*Chrolis gayana, Hyparrhenia spp*, *Andropogon spp*, *Loudetia spp*, *Loudetia simplex*, *Mircanthus spp*, *Digitaria spp*, *Manocymdium spp*, *Eragrastis spp* and *Themedia spp*
Herbs and forbes	*Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp, Ipomoea richardsiae* and *Nidorella spp*

Two sample plots (Site A and Site B) were sampled outside of LS-MFEZ area. The Site A is on the private property and the Site B is not protected but the Site B is on a traditional land. This choice was made so as to see how ownership also affects the problem of deforestation. Results are shown in the *Table G.2*:

Table G.2 Description of Vegetation near the Proposed LS-MFEZ

Site A (tree species in rectangular plot: 20m x 10m)

Species	(Diameter (cm), Height (cm))	Quantity	Tree ratio (%)
Bauhinia Petersania	(24, 650), (18, 420), (19, 525) + 1 trees	5	8.9
Brachystegia boehmii	(21, 590), (18, 560) + 2 trees	4	7.1
Brachystegia spiciformis	(17, 545) + 3 trees	4	7.1
Bridelia micrantha	(20, 602) + (13, 560) + (17, 502)	3	5.4
Vitex trifoliate	(17, 340) + 3 trees	4	7.1
Ochna pulchra	(18, 270), (15, 480) + 4 trees	6	10.7
Pseudolachynostylis maprouneifolia	(15, 450) + 2 trees	3	5.4
Swartzia madagascariensis	(18, 580) + 4 trees	5	8.9
Combretum celastroides	(17, 480), (18, 540) + 4 trees	6	10.7
Diplorhynchus condylocarpon	(16,480) + 5 tree	6	10.7
Ziziphus abyssinica	(15, 380) + 3 trees	4	7.1
Acacia spp	(18, 630), (20, 550) + 4 tree	6	10.7
total		56	100

Site A (grass. herbs and forbes species in squared plot: 2m x 2m)

	Species
Grass	*Hyparrhenia spp*, *Andropogon spp*, *Loudetia spp*, *Digitaria spp*, *Manocymdium spp* and *Eragrastis spp*
Herbs and forbes	*Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp* and *Nidorella spp*

Site B (tree species in rectangular plot: 20m x 10m)

Species	(Diameter (cm), Height (cm))	Quantity	Tree ratio (%)
Bauhinia Petersania	(3, 360), (4, 300), (3, 250), (4, 355), (2, 275) + 2 trees	7	19.4
Brachystegia boehmii	(3, 340), (2, 230), (4, 355), (2, 335) + 3 trees	7	19.4
Brachystegia spiciformis	(2, 190) + 2 trees	3	8.3
Protea spp	(2, 145) + 4 trees	5	13.9
Albizia versicolor	(3, 228), (7, 690), (4, 305)	3	8.3
Albizia adianthifolia	(4, 400) + 1 tree	2	5.6
Pseudolachynostylis maprouneifolia	(3, 150), (2, 180), (4, 320), (3, 380), (4, 310), (4, 490) , (5, 495), (5, 500)	8	22.2
Diplorhynchus condylocarpon	(2, 210)	1	2.8
total		36	100

Site B (grass. herbs and forbes species in squared plot: 2m x 2m)

	Species
Grass	*Hyparrhenia spp*, *Andropogon spp*, *Loudetia spp*, *Digitaria spp*, *Manocymdium spp*, *Eragrastis spp* and *Themedia spp*
Herbs and forbes	*Fockea multiflora, Hibiscus spp*, *Ambrosia spp*, *Heliopuim spp* and *Nidorella spp*

The Forest Act provides for the protection of 6 national tree species, whether in a protected area or outside it. These are:

- *Entandrophragma caudatum* (Mountain Mahogany)
- *Khaya nyasica* (Red Mahogany)
- *Pterocarpus angolensis* (African Teak)
- *Afzelia quanzensis* (Pod Mahogany)
- *Faurea saligna* (Beechwood)
- *Baikiaea plurijuga* (Teak)

Pterocarpus angolensis was found in the Site 4.

In the Lusaka North Forest Reserve No.28 (368 ha), the natural vegetation of the North Forest area is predominately Miombo woodland. However, today the site has been deforested and disturbed by human activities. At present the natural vegetation is almost devoid of full-grown trees and mainly consists of the regeneration of trees, shrubs and grasses. There were a few fully grown trees and these were mainly the *Ficus sycomorus* and *Albizia* spp. The shrubs and shoots from the stamps were of the following tree species (Environmental impact statement of Realisation of an environmentally sound landfill for Lusaka, Ministry of Local Government and Lusaka City Council, May 2003):

- *Julbernadia globiflora*
- *Brachystegia boehmii*
- *Albizia versicola*
- *Albizia antunesiana*
- *Ficus sycomorus*

- *Bauhinia spp*
- *Pilostigma thonningii*
- *Cassia sp.*

The Lusaka East Forest Reserve No.27 (1,764/1,895 ha) is an indigenous forest and intact. It provides fuel wood. The characteristic of the forest is shown in the Environmental Impact Assessment of Chalimbana Country Club and Eco-Golf Estate, Safari International (Z) limited, 2008. Tree species are shown in *Table G.3*.

Table G.3 Tree Species, Composition, Height and Diameter Breast Height (DBH)

Species Name	Frequency in 13 plots (20m x 10m)		Height (m)	DBH (cm)
	Ridge	Stream		
Brachystegia boemiee	22	-	8.86 +/- 4.16	19.89 +/- 7.77
Brachystegia utilis	15	-	5.0 +/- 2.63	11.44 +/- 6.64
Diplorhynchus condylocarpon	13	-	5.83 +/- 2.11	10.07 +/- 5.14
Lannea discolor	6	-	6.83 +/- 2.86	16.29 +/- 4.86
Brachystegia taxifolia	2	-	8	26.74 +/- 7.20
Pseudolochynostylis maprouneifolia	2	-	5	15.44 +/- 1.58
Julbernardia globiflora	1	-	-	-
Jurbernardia paniculata	1	-	-	-
Priscorpsis angolensis	8	1	9.50 +/- 4.66	18.58 +/- 9.63
Terminalia spp.	7	6	-	9.42 +/- 7.34
Piliostigma thonningii	-	8	6.64 +/- 5.78	13.8 +/- 15.26
Acacia polyacantha	-	7	6.64 +/- 4.61	9.23 +/- 2.54
Syzygium guineense		5	7.40 +/- 1.67	24.45 +/- 0.41
Acacia albida		4	15.67	43.77 +/- 1.13
Brachstegia microfolia		3	7.33 +/- 1.15	24.72 +/- 6.18
Parinari curatellifolia	-	2	7.00 +/- 1.40	21.17 +/- 5.18
Acacia sieberana	-	1	-	-
Brachystegia spiciformis	-	1	-	-
Strychnos cocculides	-	1	-	-
Total	77	39		

Source: the Environmental Impact Assessment of Chalimbana Country Club and Eco-Golf Estate, Safari International (Z) limited, 2008.

Appendix H

Fauna Survey for the Proposed LS-MFEZ Area

APPENDIX H

FAUNA SURVEY FOR THE PROPOSED LS-MFEZ AREA

The information gathered was based on oral traditions, sightings and presence of droppings or hoof prints in areas where animals are still suspected to occur. The fauna of LS-MFEZ area assessed were large mammals, birds and reptiles; their habitats and feeding habits.

This account of fauna is based more on oral tradition or local knowledge than actual sightings because the large mammals have more or less been exterminated from the area. According to the local people several factors have led to the existing scenario:

- High poaching levels and destruction of animal habitats;
- Creation of human settlements along wildlife corridors impending movement of larger mammals such as elephants and buffalo;
- Introduction of livestock in areas once populated by wildlife;
- Lack of environmental awareness campaigns to encourage local people to conserve natural resources such as wildlife; and
- Viewing primates as pests during cropping season a fact that leads to their being hunted down and killed.

The sighted birds during the study are shown in the *Table H.1*:

Table H.1 Birds Sighted in LS-MFEZ Area

Science Name	English name	Habitat	Comments on sightings
Bubo Africana africana	Spotted eagle-owl	Wooded places	Widely distributed
Bucorvus leadbeateri	Southern ground-hornbill	Woodland	Generally distributed
Buteo rufofuscus augur	Augur Buzzard	Hilly country	Frequent
Caprimulgus sp.	Nightjar	Non specific	Generally distributed
Cisticola sp.	Cisticola	Woodland	Common
Corvus sp.	Crow	Partial to village	Common
Falco sp.	Falcon and Kestrel	Non specific	Frequent
Hirundo sp.	Swallow	Non specific	Common
Milvus sp.	Kite	Non specific	Generally distributed
Numida sp.	Guineafowl	Non specific	Common
Pternistus sp.	Spurfowl	Tall grassland	Frequent
Pycnonotus barbatus	Common bulbul	Woodland	Common
Saxicola torquata robusta	African stonechat	Open places	Common
Tockus sp.	Hornbill	Woodland	Frequent

For the list of mammals, there were no actual sightings. The local people gave names of mammals that were once abundant or are sighted occasionally. The only exception was that droppings of a jackal were found on the southeastern side of the LS-MFEZ. Commonality as indicated below was based on past and not current local knowledge of the populations of the animals listed.

Table H.2 List of Mammals once found in LS-MFEZ Area

Science Name	English name	Habitat	Comments on sightings
Canis adustus	Side-stepped jackal	Woodland/open areas	Reasonably common
Cercopithecus aethiops	Vervet monkey	Woodland/forest	Common/pest to crops
Dendrohyrax brucei	Yellow-spotted rock hyrax	Rocky outcrops	Common
Galago crassicaudatus	Greater galago	Woodland (in tree holes)	Common
Hystrix africae-australis	Porcupine	Non specific	Common
Lepus capensis	Cape hare	Open ground/dambo	Common on plateau
Orycteropus afer	Aardvark	Woodland/open areas	Common
Manis temmincki	Pangolin	Anthills in open areas	Less common
Mellivora capensis	Honey badger	Non specific	Common
Papio ursinus	Chacma baboon	Woodland/rocky areas	Common
Paraxerus cepapi	Tree squirrel	Woocland/rocks	Reasonably common
Raphicerus sharpei	Sharpe's Grysbok	Thick grass and scrub	Reasonably common
Sylvicapra grimmia	Common duiker	Woodland/dambo edge	Common

Reptile surveys did not yield sufficient data to describe the reptile communities of the study area, although two of the snakes found, suggested that a moderate level of endemism is present. For the snakes, the local people provided the names of the snakes that they have once seen within the project area. Thus the following is the list of snakes that can be found in the project area.

Table H.3 List of Snakes recorded in LS-MFEZ Area

Scientific Name	**Common Name**	**Comments**
Bitis armate	Puff Adder	Reasonably common
Python Anchieta	Dwarf Python	Common/pest to crops
Dendroaspis	Black Mamba	Common
Naja nigricollis Woodi	Spitting Cobra	Common
Dendroaspis angusticeps	Green Mamba	Common

No subterranean river has been found in the LS-MFEZ area.

Endangered and vulnerable animal species in Zambia are shown in the *Table H.4* according to the State of Environment in Zambia 2000.

Table H.4 Endangered and vulnerable animal species in Zambia

Class	Order	Species	Status
Mammalia	Macroscelidea	Checkere Elephant Shrew (*Rynchocyon cirnei*)	Vulnerable
	Carnivora	African Wild Dog (*Lycan pictus*)	Endangered
		Cheetah (*Acinonyx jubatus*)	Vulnerable
		Lion (*Panthera leo*)	Vulnerable
	Proboscidea	Elephant (*Loxodonta africana*)	Endangered
	Perissodactyla	Black Rhino (*Diceros bicornis minor*)	Endangered
	Artiodactyla	Kafue Lechwe (*Kobus leche kafuensis*)	Vulnerable
		Black Lechwe (*Kobus leche smithemani*)	Vulnerable
Aves		Slatey Egrett (*Egretta vinaceigula*)	Vulnerable
		Taita Flacon (*Falco fascinucha*)	Vulnerable
		Lesser Kestrel (*Falco naumanii*)	Vulnerable
		Black Cheeked Lovebird (*Agapornis nigrigenis*)	Endangered
		Shoebill stork (*Balacenips rex*)	Vulnerable
		Wattled Crane (*Burgeranus caranculatus*)	Vulnerable

Source: State of Environment in Zambia 2000 (ECZ, 2001)

Appendix I

Location of LWSC Production Wells

APPENDIX I

LOCATION OF LWSC PRODUCTION WELLS

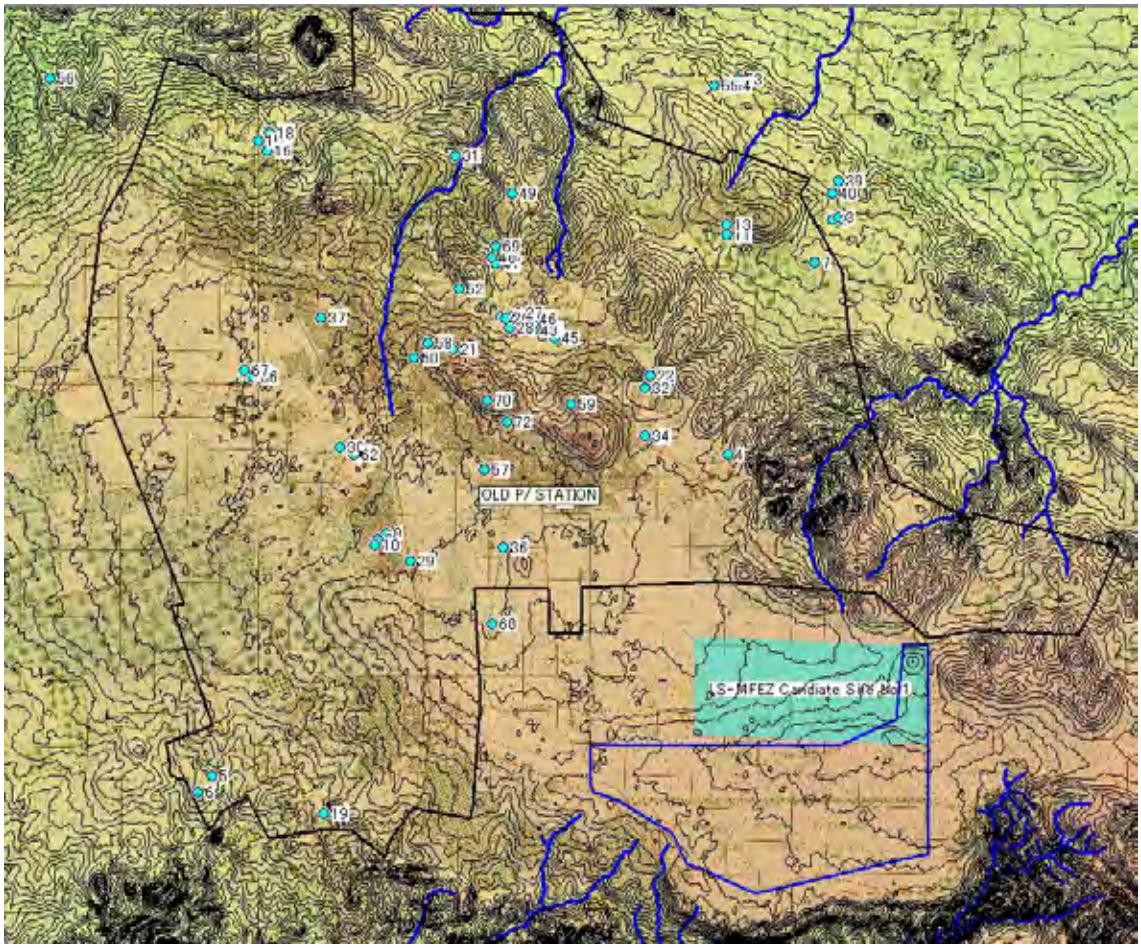


Figure I.1 Location Map of LWSC Production Wells

Table I.1 PRODUCTION BOREHOLES (LWSC)

DAILY STATUS /INSPECTION REPORT (Thursday 24th January, 2008)

NO.	LOCATION		Status on/off	Actual Run Hrs	B/Hole Specif. Yield m3/hr	Pump Design Disch. m^3/hr	Actual Disch. m3/hr	Prod m^3/day	REMARKS
1	AVONDALE1 (DE14 - 9/40)		on	14	99.5	95	77.6	1086.4	ZESCO power fail 11:05 - 21:29hrs.
2	AVONDALE2 (F12 -33W)		on	14	21.4	15	16.11	225.54	ZESCO power fail 11:05 - 21:29hrs.
3	AVONDALE3 (F12 -Q7)		on	14	57.25	75	29.35	410.9	ZESCO power fail 11:05 - 21:29hrs.
4	AVONDALE 4 (NEW No. 1)		off	0	54	65	70	0	Uplifted on 04/09/2007
5	AVONDALE 5 (NEW No 2)		off	0	90	54	10.5	0	Pump uplifted ,taken to PHI reservoir (19/09/2007)
6	BAULENI		on	24	26.64	25	32.7	784.8	
7	BUCKLEY 1		on	12	23.26	10	7.6	91.2	Runs from 06:00hrs to 18:00hrs.
8	BUCKLEY 2		on	12	14.4	17	7.5	90	Runs from 06:00hrs to 18:00hrs
9	CHAINDA		on	12	25.92	26	25.92	311.04	Runs from 06:00hrs to 18:00hrs
10	CHAWAMA 1		on	24	29.88	51	100	2400	
11	CHAWAMA 2		on	13	64.8	95	95	1235	On timer (00:00 - 06:00hrs, 10:00 - 17:00hrs)
12	CHAWAMA 3		on	24	90	100	119	2856	
13	CHELSTON 1		on	14	15.3	14	18.9	264.6	ZESCO power fail 11:05 - 21:29hrs.
14	CHELSTON 2		on	14	22.68	24	24	336	ZESCO power fail 11:05 - 21:29hrs.
15	CHELSTON 3		off	0	90	95	67.25	0	Pump tripped off on 31/10/2007, Discovered down and was uplifted on 01/11/2007
16	CHILENJE SOUTH		on	24	57.6	75	57.6	1382.4	
17	CHUNGA 1		on	12	57.6	18	23.54	282.48	Runs from 06:00hrs to 18:00hrs
18	CHUNGA 2		on	12	9	8	12	144	Runs from 06:00hrs to 18:00hrs
19	CHUNGA E		on	12	126	65	66	792	Runs from 06:00hrs to 18:00hrs
20	CHUNGA F		on	12	58	58	38.31	459.72	Runs from 06:00hrs to 18:00hrs
21	FARM 1080 A		on	24	56.12	36	64.2	1540.8	
22	HEAD OFFICE 1		on	24	2.8	6.0	4	96	
23	HEAD OFFICE 2		on	24	5	5	5	120	
24	IBEX HILL		off	0	21.24	16	14.33	0	Switched off due burst pipe in ibexhill (11/01/2007)- repaired but pump still off .
25	INTER. SCH 6A		on	24	72	75	82	1968	
26	INTER. SCH 6B		on	24	108	50	56.23	1349.52	
27	INTER. SCH 6C		off	0	25	50	25.52	0	Switched off on 21/11/2007 due to leak on flange)- Pump requires uplifting.
28	INTER. SCH 6D		on	24	108	150	158	3792	
29	INTER. SCH 6E		on	24	90	100	72.6	1742.4	
30	INTER. SCH 6F (D12-50N)		on	24	45	45	45	1080	
31	JOHN HOWARD		off	0	6.012	23	15.9	0	Pump found off and discovered down to earth (30/12/2007), uplifted (04/01/2008)
32	JOHN LAING		on	12	9.36	10	18.74	224.88	Runs from 06:00hrs to 18:00hrs
33	KABANANA		on	24	44	44	47.4	1137.6	
34	LAKE ROAD		off	0	36	24	18.29	0	Switched off due to a burst pipe in ibexhill (11/01/2007)- repaired but pump still off .
35	LEOPARDS HILL 1		on	18	180	255	188	3384	On timer (04:00 - 22:00hrs)
36	LEOPARDS HILL 2		on	24	72	95	80.6	1934.4	
37	LILAYI ROAD 1		on	24	100.8	100	118	2832	
38	LILAYI ROAD 2		on	24	100.8	100	116	2784	
39	LUMUMBA RD 4A		on	24	126	75	137.9	3309.6	
40	MALO FARM 1		on	14	180	180	120	1680	ZESCO power fail 11:05 - 21:29hrs
41	MALO FARM 2		on	14	72	75	94	1316	ZESCO power fail 11:05 - 21:29hrs
42	MARIAN SHRINE		on	14	129.6	39	21.8	305.2	ZESCO power fail 11:05 - 21:29hrs
43	MASS MEDIA 1 (MM1)		on	20	180	150	129.2	2584	ZESCO power fail 15:15 - 19:05hrs.
44	MASS MEDIA 2 (MM2)		on	20	306	45	50	1000	ZESCO power fail 15:15 - 19:05hrs.
45	MASS MEDIA 3 (MM3)		off	0	180	72	29.2	0	Switched off 18/01/2008 to avert overflow
46	MASS MEDIA 4 (C5Gs)		on	20	90	90	73	1460	ZESCO power fail 15:15 - 19:05hrs.
47	MASS MEDIA 5 (F1/25W)		off	0	80	80	73.6	0	Switched off 18/01/2008 to avert overflow
48	MASS MEDIA 6 (C3/50W)		on	20	54.58	45	39	780	ZESCO power fail 15:15 - 19:05hrs.
49	MULUNGUSHI 6A		on	24	10.08	50	15	360	
50	MULUNGUSHI 6H		on	24	100.8	65	20.6	494.4	
51	NIPA		on	24	72	75	18.8	451.2	
52	NORTHMEAD 1		on	24	72	75	75	1800	
53	NORTHMEAD 2		on	24	100.8	75	70.1	1682.4	
54	NRDC 1 (B6 - 3/55)		on	7	53.9	30	18.99	132.93	ZESCO power fail 07:00 - 00:000hrs.
55	NRDC 2 (B10 - 30N)		on	7	86.4	100.8	35.1	245.7	ZESCO power fail 07:00 - 00:000hrs.
56	NRDC 4 (D13/50W)		off	0	46.8	30	7.9	0	Pump tripped off on 29/11/2007, Uplifted 04/12/2007
57	OLD P/ STATION		off	0	72	75	73.35	0	Found off 20/12/2007 - Open winding & was uplifted on 26/12/07
58	PARERINYATWA		on	24	14.4	10	10.8	259.2	
59	PARKS NURSERY		on	24	20.16	8	47.8	1147.2	
60	QUARRIES 1 (Q6)		on	17	149	122	35	595	ZESCO power fail 06:07 - 10:55hrs, 19:12 - 21:25hrs.
61	QUARRIES 2 (Q5)		on	17	149	95	51	867	ZESCO power fail 06:07 - 10:55hrs, 19:12 - 21:25hrs.
62	QUARRIES 3 (QA4)		on	17	149	95	41	697	ZESCO power fail 06:07 - 10:55hrs, 19:12 - 21:25hrs.
63	ROADSIDE 1		on	24	144	100	124.6	2990.4	
64	ROADSIDE 2		on	24	144	130	151	3624	
65	ROADSIDE 4		off	0	100.8	95	108	0	Pump uplifted after discovering that the pump was uncoupled to the motor
66	ROADSIDE 5		on	24	100.8	75	75	1800	
67	ROADSIDE 6		on	24	180	150	150	3600	
68	SHAFT 5	Pump 1	on	24	1200	600	547	13128	
69		Pump 2	on	24		600	507	12168	
70	SHOWGROUNDS		on	24	69.84	60	42	1008	
71	U.T.H		on	24	25.2	29	23.4	561.6	
72	WATERWORKS 1		on	24	500	255	330	7920	
73	WATERWORKS 2		on	24	100	100	167	4008	
				1200	7175	6119.8	5541.8	CURRENT	PREVIOUS DAY / TARGET
	TOTAL BOREHOLE INFLOW (m^3/d)							109,113	99,459 / 130,000
	OUTFLOW FROM KAFUE (m^3/d)							96,929	89,297 / 98,000
	TOTAL PRODUCTION (m^3/d)							206,042	188,756 / 228,000

Appendix J

Sewerage

APPENDIX J

SEWERAGE

Rainfall

Station		Lusaka I.A.	Lusaka C.A.	Average of Lusaka Lusaka I.A. Lusaka C.A. Mt. Malulu	Average of Zambia
Ave 10years	mm/year	810	832	842	977
Max	mm/year	1299	1366	1318	1432
Min	mm/year	530	483	527	616
Max 1day	mm/1day	105	190	–	–
Max 2day	mm/2day	150	190	–	–
Max 3day	mm/3day	170	208	–	–
Max 5day	mm/5day	236	251	–	–
Max 10day	mm/10day	378	365	–	–
Max 1month	mm/1m	528	452	–	–
Ave 10years	Day/year	72	74	74	93
Max	Day/year	109	112	108	122
Min	Day/year	49	49	48	68

Location of Lusaka C.A.

Latitude: 15Deg 25Min
Longitude: 28Deg 19Min

Lusaka (Ave)

Month	Month	Rainfall (mm) A	Rainday (day) B	Rain fall (mm/day) A/B	Rain fall (mm/day) A/30
Oct	10	17	3	5.7	0.6
Nov	11	96	9	10.7	3.2
Dec	12	204	17	12.0	6.8
Jan	1	217	18	12.1	7.2
Feb	2	183	16	11.4	6.1
Mar	3	100	11	9.1	3.3
Apr	4	33	3	11.0	1.1
May	5	4	1	4.0	0.1
Jun	6	0	0	0.0	0.0
Jul	7	0	0	0.0	0.0
Aug	8	0	0	0.0	0.0
Sep	9	1	0	0.0	0.0
Total		855	78	11.0	2.3

Zambia (Ave)

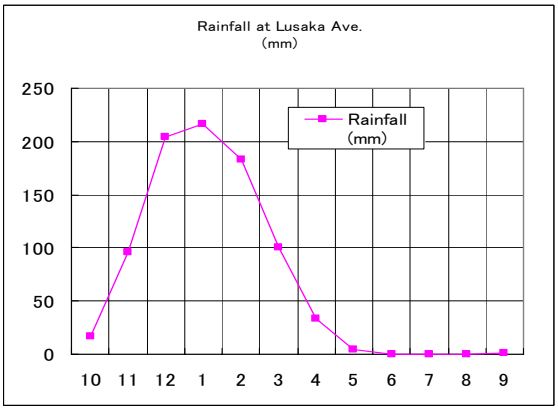
Rainfall (mm) A	Rainday (day) B	Rain fall (mm/day) A/B	Rain fall (mm/day) A/30
32	5	6.4	1.1
108	12	9.0	3.6
221	19	11.6	7.4
231	20	11.6	7.7
196	18	10.9	6.5
152	15	10.1	5.1
50	6	8.3	1.7
7	1	7.0	0.2
1	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
3	1	0.0	0.1
1001	97	10.3	2.7

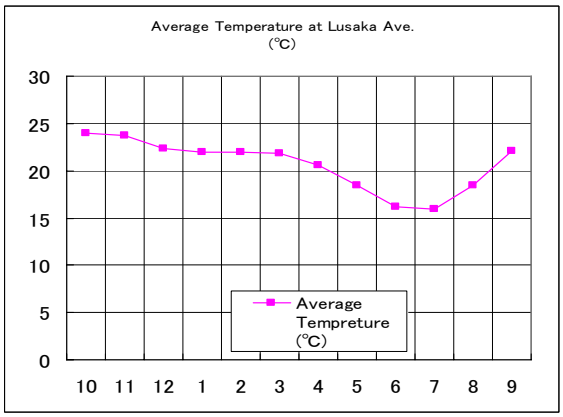
Temperature

Lusaka (Ave)

Month	Month	Average Temperature (℃)
Oct	10	24.0
Nov	11	23.7
Dec	12	22.3
Jan	1	22.0
Feb	2	22.0
Mar	3	21.8
Apr	4	20.6
May	5	18.5
Jun	6	16.2
Jul	7	**16.0**
Aug	8	18.4
Sep	9	22.1
Average		20.7

Ave 10years	20.9
Ave 30years	20.7
Ave Max	21.5
Ave Min	19.8
Max	31.0
Min	8.4





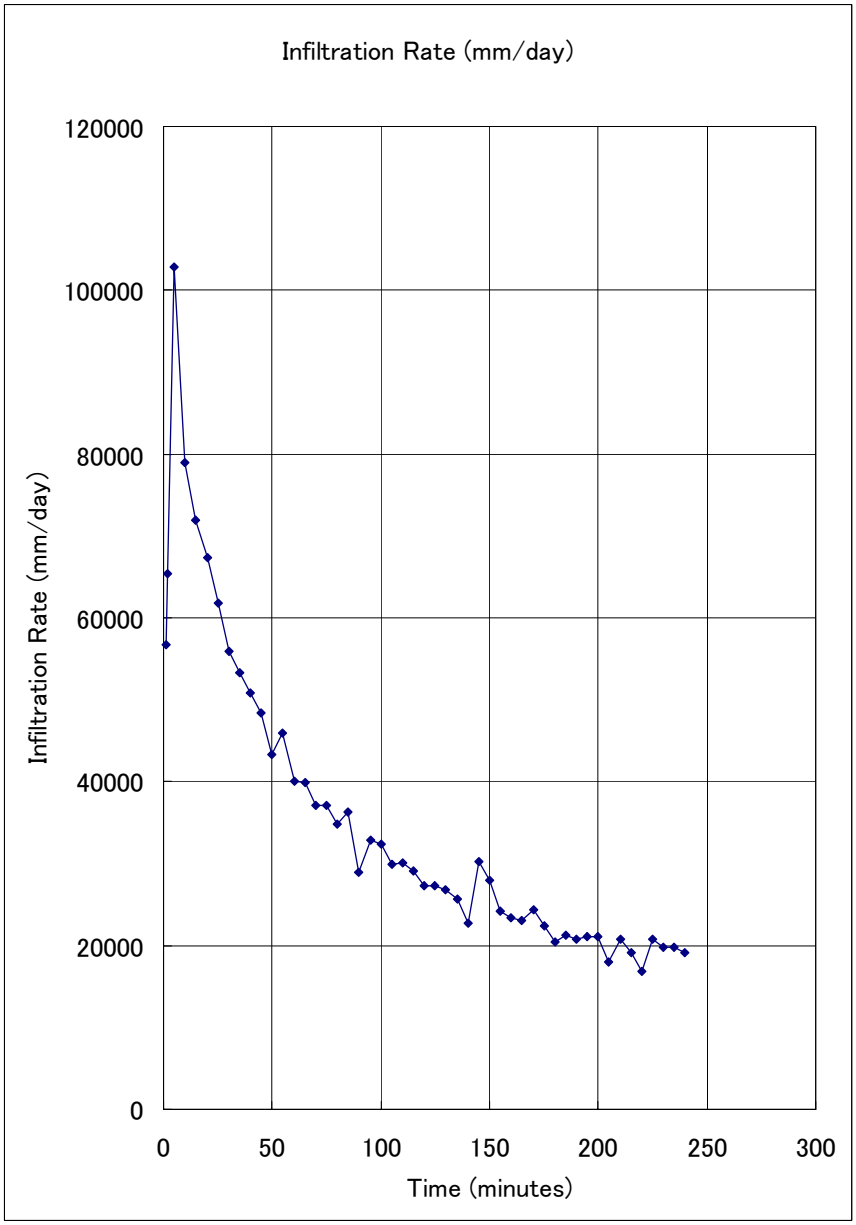
Evapotranspiration

	Altitude (m)	Evapotranspiration (mm/year)	Same to left (mm/year)	Temperature (℃)
		Actual	Potential	
Lusaka C.A.	1280	730	1533	20.4
Lusaka I.A.	1154	739	1590	20.7
Mt. Malulu	1213	733	1591	20.9
Average		734	1571	20.7
		(mm/day)	(mm/day)	
Lusaka C.A.		2.0	4.2	
Lusaka I.A.		2.0	4.4	
Mt. Malulu		2.0	4.4	
Average		2.0	4.3	

Result of Infiltration Test 1

Type of Infiltration Test:	Constant Water Level Test
Date:	9 August, 2008
Time:	10:30-15:30
Place:	Location of the Infiltration Pond
Attendance:	Mr. Yoritate, Hashimoto
Diameter of circular cylinder:	13.7 cm
Cross section area of cylinder:	147.411 cm2
Height of cylinder:	17 cm
Water level from bottom of cylinder	14.5 cm
Inserted cylinder depth	9.5 cm
Soil condition	The test is carried out where 20cm of surface soil is removed to appear uniform soil.

Time	Infiltration Rate
(minutes)	(mm/day)
0	
1	56,658
2	65,450
5	102,766
10	78,930
15	71,897
20	67,403
25	61,738
30	55,876
35	53,337
40	50,797
45	48,452
50	43,373
55	45,912
60	40,051
65	39,856
70	37,121
75	37,121
80	34,776
85	36,339
90	28,915
95	32,823
100	32,432
105	29,892
110	30,087
115	29,110
120	27,352
125	27,352
130	26,766
135	25,594
140	22,663
145	30,283
150	27,938
155	24,226
160	23,445
165	23,054
170	24,422
175	22,468
180	20,514
185	21,296
190	20,709
195	21,100
200	21,100
205	17,974
210	20,709
215	19,146
220	16,802
225	20,709
230	19,733
235	19,733
240	19,146

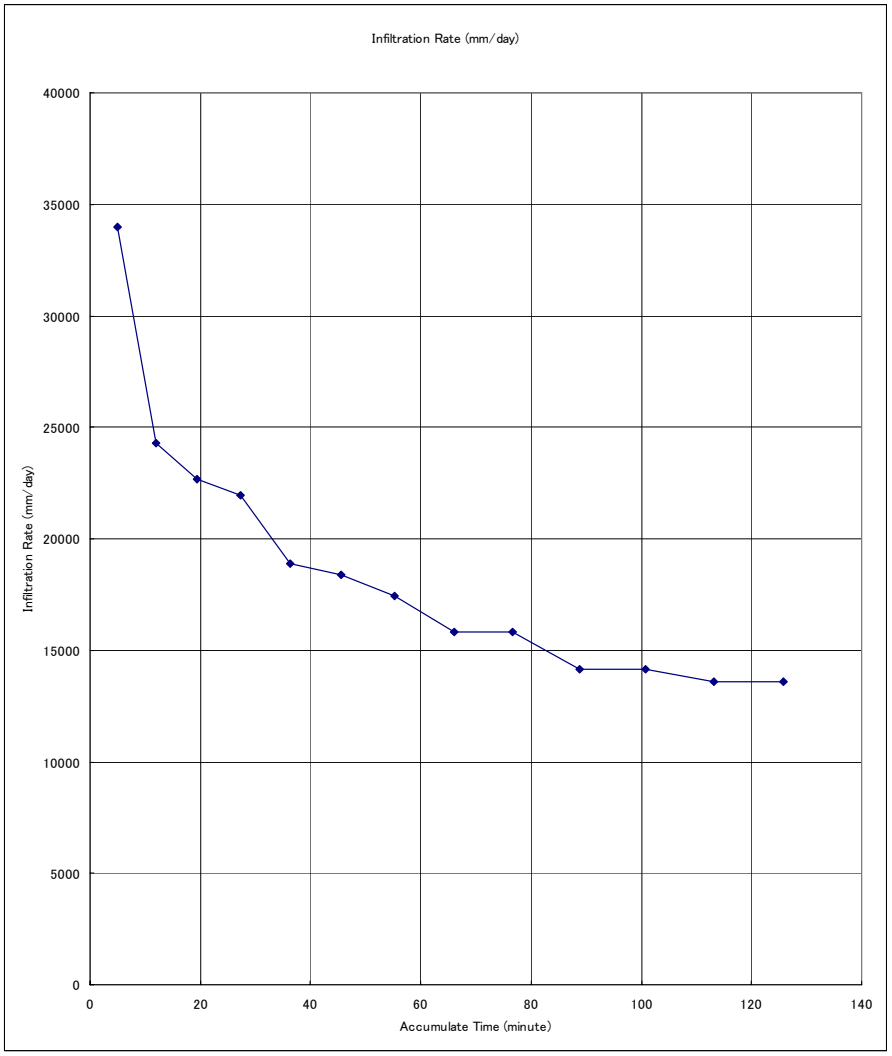


Result of Infiltration Test 2

Type of Infiltration Test:	Variation Water Level Test	
Date:	10 August, 2008	
Time:	11:30-15:30	
Place:	Location of the soil treatment site	
Attendance:	Hashimoto	
Height of water variation	H= 118 mm	Measuring time required for dropping water surface a specified distance (min/118mm)

Diameter of Tin:	14.5 cm
Cross section Area of Tin:	1.651 cm2
Height of Tin	200.0 mm
Soil condition	The test is carried out where 20cm of surface soil is removed to appear uniform soil.

Accumulate Time	Infiltration Rate
(minutes)	(mm/day)
0.00	
5.00	33,984
12.00	24,274
19.50	22,656
27.25	21,925
36.25	18,880
45.50	18,370
55.25	17,428
66.00	15,807
76.75	15,807
88.75	14,160
100.75	14,160
113.25	13,594
125.75	13,594



Calculation for Designing Sewers

Proposed Daily Maximum Flow (Qdmax)

	Qdmax (m3/day)	Equivalent served Population (People)
Phase 1 (2015), West WWTP	3000	15,000
Phase 2 (2020), East WWTP =Phase 1	3000	15,000
Phase 3 (2030)	10000	50,000
Half of Phase 3 (2030), =West WWTP = East WWTP	5000	25,000

Proposed Daily Maximum Flow (Qdmax)

	Qdmax (m3/day)	Equivalent served Population (People) *1	Peak Factor =M *3	Qhmax =Qdmax x M (m3/day) *2	Qhmax (m3/sec)	Qhmax (m3/min)	Remark
1/4 of Phase 1 (2015), about 12.5Ha	375	1,875	4.4	1,650	0.019	1.15	-
1/4 of Phase 1 (2015), about 25Ha	750	3,750	3.8	2,850	0.033	1.98	-
Phase 1 (2015), West WWTP = Phase 2 (2020), East WWTP, about 100Ha	3000	15,000	2.9	8,700	0.101	6.04	-
Half of Phase 3 (2030) =West WWTP = East WWTP	5000	25,000	2.6	13,000	0.150	9.03	-
Inflow Pumping Station Pump up area 142ha 142/500 x 4000m3/day	1120	5,600	3.5	3,920	0.045	2.72	3pumps (1standby), 1.36m3/min/pc

*1)
Estimated unit daily maximum wastewater discharge Qcd
Qcd = 200 L/capta/day
*2)
Estimation of the Hourly Maximum Flow (Qhmax)
Qhmax = M x Qdmax
M (Peak factor) is estimated based on the Babbit formula
*3)
Babbit Formulla
M = 5 / P^(1/5)
P < 1.0 (1000people), M = 5
P > 1,000 (1million people), M = 1.25
P: 1,000 people

Proposed Sewer with Capacity with slope
Condition
Minimum velocity 0.6 m3/sec
Minimum covering depth 1.0 m

Manning Formula
V = 1/n x R^(2/3) x I^(1/2)
Roughness Coefficient n = 0.013 (RC)

Allowance of Sewer Capacity

Dia			Allowance
150	-	300	80%
350	-	800	40%
900	-		25%

Design of Standard Sewer to Discharge Required Flow

Peak Discharge Capacity (m3/s)		**Pipe Diameter**	**Slope**	Velosity	Capacity
Min	Max.	**(mm)**	**(0/00)**	(m/s)	(m3/s)
0.000	0.006	**150**	**4.9**	0.603	0.011
0.007	0.010	**200**	**3.4**	0.609	0.019
0.011	0.016	**250**	**2.5**	0.606	0.030
0.017	0.023	**300**	**2.0**	0.612	0.043
0.024	0.044	**350**	**1.8**	0.643	0.062
0.045	0.061	**400**	**1.7**	0.683	0.086
0.062	0.081	**450**	**1.6**	0.717	0.114
0.082	0.104	**500**	**1.5**	0.745	0.146
0.105	0.157	**600**	**1.3**	0.783	0.221
0.158	0.229	**700**	**1.2**	0.834	0.321
0.230	0.313	**800**	**1.1**	0.873	0.439
0.314	0.458	**900**	**1.0**	0.900	0.573
0.459	0.575	**1,000**	**0.9**	0.916	0.719

Result
Largest sewer connecting with WWTP is Diameter of 600mm.
Installed sewer near the WWTP shall be laid not to keep minimum covering depth, to lay the sewers to be shallow to GL.

STABILIZATION POND (1/3)

Calculation for designing Stabilization Pond for Restricted Irrigation Use

Condition

Based on "Design Manual for Waste Stabilization Ponds in Mediterranean Countries, by Duncan Mara"

Design Inflow	Q	3,000	m3/day	
BOD inflow	BOD In=Li	250	mg/L	
Design Temperature	T	16	℃	

Anaerobic Pond

Volumetric Loading	λv	220	g/m3/day	see Table below
Volume of Anaerobic Pond	Va=LixQ/λv	3,409	m3	
Retention Time	RT=Va/Q	1.2	days	
Depth of Pond	D	4	m	2-5m
Area of Pond	A=Va/D	853	m2	
BOD Removal rate	LRR	52	%	see Table below
BOD effluent	BOD out	120	mg/L	

Design values of permissible volumetric BOD loadings on and percentage BOD removal in anaerobic ponds at various temperatures

Temperature ℃	Volumetric BOD loading g/m3/day	BOD Removal %
< 10	100	40
10 - 20	20T-100	2T+20
20 - 25	10T+100	2T+20
25 <	350	70

Facultative Pond

Design Inflow	Q	3,000	m3/day	
BOD inflow	BOD In=Li	120	mg/L	
Design Temperature	T	16	℃	
Surface BOD Loading	λs=60x(1.099)^T			Not applied
		272	kg/ha/day	
Surface BOD Loading	λs=350x(1.107-0.002T)^(T-25)			Applied
		183	kg/ha/day	
Area of Facultative Pond	Af=10xLixQ/λs			
		19,672	m2	λs=10LixQ/Af
Depth of Pond	D	1.5	m	1-2m
Retention Time	RTf=AfxD/Q	9.9	days	
BOD Removal rate in AP and FP to estimate filtered BOD				
	LRR	90	%	
BOD effluent	BOD out	25	mg/L	

Maturation Pond

Design Inflow	Q	3,000	m3/day	
BOD inflow	BOD In=Li	25	mg/L	
Design Temperature	T	16	℃	
No. of Maturation Pond		1	Ponds	
Each Pond BOD Removal rate to estimate filtered BOD				
	LRR	25	%	
BOD effluent	BOD out			
	25x(1-25/100)^1=	19	mg/L	
Depth of Pond	D	1.2	m	1-1.5m
Retention Time	RTm=half of RTf	5	days	
Surface BOD Loading	λsm=10x(0.3xLi)xD/RTm			λs=10LixQ/Af
λsm=10x(0.3x250)x1.2/5=		180	kg/ha/day	
	≒ 75% of λs	=75% x 183=		137.25 kg/ha/da NG
Retention Time	RTm, Trial to be OK	6.5	days	
Surface BOD Loading	λsm=10x(0.3xLi)xD/RTm			λs=10LixQ/Af
λsm=10x(0.3x250)x1.2/6.5=		138	kg/ha/day	
	≒ 75% of λs	=75% x 9.9=		137.25 kg/ha/da OK
Area of Pond	A=QxRTm/D	16,300	m2	

STABILIZATION POND (2/3)

Restricted Irrigation Use

No. of Intestinal Nematode Eggs in Raw Wastewater
EGr 250 pcs/Litter
Percentage of Egg Removal R=100(1−0.41exp(−0.49RT+0.0085RT^2))
Removal Rate in Anaerobic Pond 76.95
Removal Rate in Facultative Pond 99.26
Removal Rate in Maturation Pond 95.62
No. of Intestinal Nematode Eggs in Effluent of Anaerobic Pond
EGea=250x(1−76.95/100)= 58 pcs/Litter
No. of Intestinal Nematode Eggs in Effluent of Facultative Pond
EGef=58x(1−99.26/100)= 0.43 pcs/Litter
<1 OK
No. of Intestinal Nematode Eggs in Effluent of Maturation Pond
EGef=0.43x(1−95.62)= 0.019 pcs/Litter

Check for Removing FC

No. of Faecal Coliform in Raw Wastewater
FCr 5.0E+07 pcs/100mL
Design Temperature T 16 ℃

First Order Rate Constant for Faecal Coliform (FC) Removal
Kt=2.6(1.19)^(T−20)
1.30 /day
Required Retention Time (RT) of Maturation Pond
RTm=((Ni/Ne(1+Kt RTa)(1+Kt RTf))^(1/n)−1) / Kt
base formula: Ne=Ni/((1+Kt x RTa)(1+Kt x RTf)(1+Kt x RTm)^n)
Here,
No. of FC of Influent Ni 5.0E+07 pcs/100mL
Ne=50000000/(1+ 1.3 x 1.2)/(1+1.3 x 9.9)/(1+ 1.3 x 6.5)^1
= 1.5E+05 pcs/100mL
> 1000pcs/100mL NG as Unrestricted Irrigation use

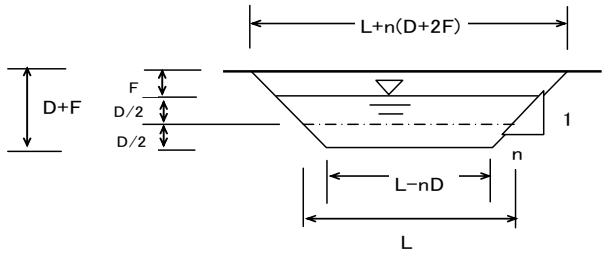
BOD Removal
BOD Removal Rate of Anaerobic Pond and Facultative Pond to estimate filtered BOD
90 %
BOD Removal Rate of Each Maturation Pond to estimate filtered BOD
25 %
No. of Maturation Pond 1 ponds
Final BOD Effluent =250x(1−90/100) x (1−25/100)^1
19 mg/L

Summary
Thus, for unrestricted irrigation, the mid-depth area requirements are:

		Area (m2)	Retention time (day)	Depth D (m)	Square (m)	Pond Size at Mean Water Level W (m)	L (m)	A (m2)	Freeboard F (m)
Anaerobic pond	AP	853	1.2	4	29	19	45	855	0.5
Facultative pond	FP	19,672	9.9	1.5	140	91	217	19,747	1
Maturation pond	MP1	16,300	6.5	1.2	128	83	197	16,351	1

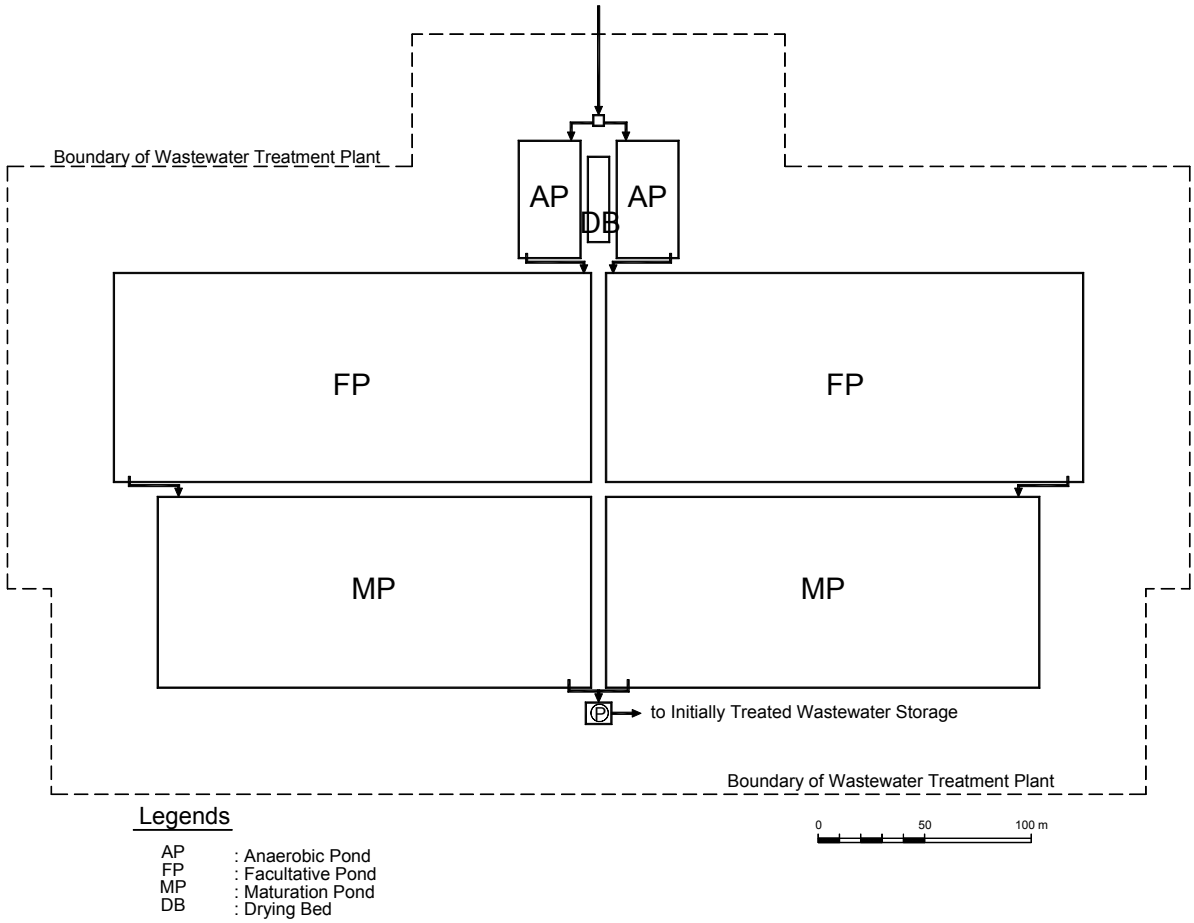
Slope =1/n, n = 2
Major Pond Size

		W−nD	W+ n(D+2F)	L−nD	L+ n(D+2F)	Area B	s slope	Area of Lining
		s1	Wt	s2	Lt	A1= s1 x s2	s3	A1+(s3+1)x2x(Wt+Lt)
Anaerobic pond	AP	11.0	29.0	37.0	55.0	407	10.1	2,271.8
Facultative pond	FP	88.0	98.0	214.0	224.0	18832	5.6	23,082.4
Maturation pond	MP1	80.6	89.4	194.6	203.4	15684.8	4.9	19,139.8



STABILIZATION POND (3/3)

Layout of Stabilization Pond



Calculation for designing Aerated Lagoon (1/2)

Condition Based on "Sewage Treatment in Hot Climates, by Duncan Mara"

Design Inflow	Q	3,000 m3/day		
BOD inflow	BOD In=L	250 mg/L		
BOD Reduction Rate		85 %		
Design Temperature	T	16 ℃		
SS inflow	SS In	250 mg/L		
SS out	SS Out	20 mg/L		

Estimation

Retention Time	t	4 days		2-6days
First Order Rate Constant for Soluble BOD5 Removal				
	k = 5 x 1.035^(T-20)			
	k=	4.36 d^(-1)		
Rate of Autolysis	b	0.07 d^(-1)	at 20℃	
Yield Coefficient	Y	0.65	0.6-0.7	

Soluble BOD in the Effluent

Fe= Li /(1+kt)
= 250 / (1 + 4.36 x 4)
= 14 mg/L

Cell Concentration in AL

X=Y(Li-Fe) / (1+bt)
= 0.65 x (250 - 14) / (1 + 0.07 x 4)
= 120 mg/L

Effluent BOD

BOD Out =Le
Le = Fe + 0.95 X
= 14 + 0.95 x 120
= 128 mg/L

Size of AL

Depth of AL	D	3 m	3-5m
Area of AL	A= Qt/D =		
	= 3000 x 4 / 3		
	=	4000 m2	
No. of Pond of AL	N	2 Pond(s)	
Unit Area of AL	Au = A / N	2000 m2	
Square of the Pond	Side Length	45 m	

Aeration

Oxygen Requirement

RO2= 1.5(Li-Le)Q
= 1.5 x (250 - 128) x 3000
= 549,000 g/day
= 22.9 kg/hour

Oxygen transfer rate in field

N=No x α x(1.024)^(T-20) x ((β x Cs(T,A) - Cl) / Cs(20,0))
= 2 x 0.7 x(1.024)^(16-20) x ((0.9 x 8.7 - 1) / 9.08))
= 1.0 kg O2 / kWh

Here,

Oxygen transfer rate under standard test conditions — Rating of Aerator

No 2 kg O2 / kWh 1.2—2.4

Ratio of the Oxygen transfer rate in the waste to that in tap water at the same temperature (Typically for domestic sewage)

α 0.7

O2 Saturation Concentration (solubility) in distilled water at temperature T and altitude A

Temperature 16 ℃

Oxygen saturation concentration at sea level

Cs(at sea level) 9.86 mg/L

Oxygen solubility correction factor versus elevation

Cs(T,A)= Cs(at sea level) x Fa
Fa ≒ 1.0 - 0.3 / 10000 x Elevation (m) / x 0.3048
Elevation 1200 m
Fa ≒ 0.882

Oxygen saturation concentration at planned elevation

Cs(alt) = Cs(at sea level) x Fa =9.86 x 0.882
Cs(T,A) 8.7 mg/L

O2 Saturation Concentration (solubility) in distilled water at 20℃ and sea level

Cs(20,0)= 9.08 mg/L

DO Concentration in lagoon

Cl 1 mg/L 1-2 mg/L

Ratio of O2 Saturation concentration in the waste to that in distilled water (Typically for domestic sewage)

β 0.9

Calculation for designing Aerated Lagoon (2/2)

Aerator Power Required for Oxygen Supply = RO2 / N 2/2
= 22.9 / 1
= 22.9 kW

Power for Complete Mixing
=A x D x Unit Power for Complete Mixing
= 4000 x 3 x 5
= 60,000 W
= 60 kW

Here,
Unit Power for Complete Mixing 5 W/m3

Conclusion based on the Complete Mixing
No. of Aerator 4 pcs
Unit power of aerator 15 kW
Total Power 60 kW

Sedimentation Pond

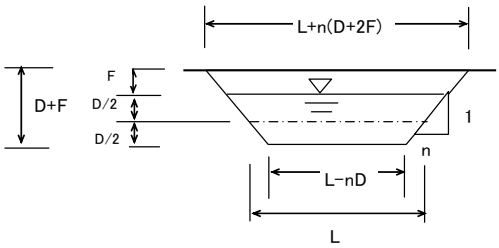
Condition

Retention Time t 1 days
Effective Depth of SP D 1 m
Area of SP A= Qt/D =
= 3000 x 1 / 1
= 3000 m2

Volume of Sedimentation Tank
=Q x Rt
= 3000 x 1
= 3,000 m3

Accumulated SS =(SSi-SSe) x Q x 365
= (250 - 20) x 3000 x 365
= 251,850 kg/year
Rate of volatile solid 70%
Volatile solids 176,295 kg/year
Fix solids 75,555 kg/year
Desludging period 5 years
Reduction rate of Volatile solid 70%
Mas of volatile SS = (1 - 0.7) x 176295 x 5
= 264,443 kg/5year
Mas of fix solid = 75555 x 5
= 377,775 kg/5year
Total solid accumulation 642,218 kg/5year

Density of accumulated solid 1.06
Volume of accumulated solid
=Total solid accumulation / density
= 642218 / 1000 / 1.06
= 606 m3/5/year
Depth of accumulated solid
=V x A
= 606 / 3000
= 0.20 m/5/year



Summary
Thus, for unrestricted irrigation, the mid-depth area requirements are:

		Area (m2)	Retention time (day)	Depth D (m)	Square (m)	Pond Size at Mean Water Level W (m)	L (m)	A (m2)	Freeboard F (m)
Aerated Lagoon	AL	4,000	4	3	64	64	64	4,096	1
Sedimentation Pond	SP	3,000	1	1	55	36	84	3,024	1

Slope =1/n, n = 2
Major Pond Size

		W-nD s1	W+ n(D+2F) Wt	L-nD s2	L+ n(D+2F) Lt	Area B A1= s1 xs2	s slope s3	Area of Lining A1+(s3+1)x2x(Wt+Lt)
Aerated Lagoon	AL	58.0	74.0	58.0	74.0	3364.0	8.9	6,294.4
Sedimentation Pond	SP	34.0	42.0	82.0	90.0	2788.0	4.5	4,240.0

Calculation for Soil Treatment Field

Based on "Wastewater Engineering, Metcalf & Eddy"

Lusaka Average Rainfall			P	ET	Wp	Lw=ET-P+Wp		
Month		Rainfall	Estimated Max Rainfall	Potential Evapotranspiratio	Infiltration	Hydraulic loading rate	Required Area for Treated Wastewater	
		(mm)	(mm)	(mm)	(mm)	(mm)	(m2)	(ha)
Jan	1	217	330	131	1,500	1,301	115,296	11.53
Feb	2	183	278	131	1,500	1,353	110,865	11.09
Mar	3	100	152	131	1,500	1,479	101,420	10.14
Apr	4	33	50	131	1,500	1,581	94,877	9.49
May	5	4	6	131	1,500	1,625	92,308	9.23
Jun	6	0	0	131	1,500	1,631	91,968	9.2
Jul	7	0	0	131	1,500	1,631	91,968	9.2
Aug	8	0	0	131	1,500	1,631	91,968	9.2
Sep	9	1	2	131	1,500	1,629	92,081	9.21
Oct	10	17	26	131	1,500	1,605	93,458	9.35
Nov	11	96	146	131	1,500	1,485	101,010	10.1
Dec	12	204	310	131	1,500	1,321	113,550	11.36
Total		855	1299	1571		18,272		Max=
			1300	1572				11.53

Past Max Rainfall 1299 mm/year

Infiltration Rate (A) 1,000 mm/day
42 mm/hour
Applied Rate 5% 2-6%
Design Infiltration Rate 50 mm/day
1500 mm/month

Required Area for Treated Wastewater Infiltration
Design Inflow Q 5,000 m3/day
150,000 m3/month
1,825,000 m3/year
Required Area for Treated Wastewater Infiltration
A = Q/Lw
=1825000 / 18272/ 1000
= 99880 m2
9.99 ha
⇒ 10 ha
No. of soil treatment field 2 Soil treatment field for phase 1 and 2
Total soil treatment field 20 ha

Interval of application 3 days operation in five days

Applying followings,

As the site infiltration rate is fast than the desirable rate, soil treatment field is secured for the
Desirable infiltration rate (B) 1200 mm/day
Ratio of the (A/B) 80%

Required area with desirable infiltration rate
esu ha
round figure 10 ha
No. of soil treatment field 2 Soil treatment field for phase 1 and 2
Total soil treatment field 20 ha

Calculation for Planning Pumping Stations

Condition

	Flow (m3/day)	Flow (L/min)	Flow (L/sec)
Phase 1 (2015)	3000	2083	34.722
Phase 2 (2020)	6000	4167	69.444
Phase 3 (2030)	10000	6944	115.741
Phase 3 Only	4000	2778	46.296

Calculation of pump

Item		Unit	Phase 1 & 2		Phase 3	
			Phase 1 East WWTP	Phase 2 West WWTP	East WWTP	West WWTP
Flow	Q1	L/min	2083	2083	3472	3472
Flow	Q1	m3/min	2.083	2.083	3.472	3.472
No. of pressure pipe	N	台	1	1	1	1
Flow	Q2=Q1xN	m3/min	2.083	2.083	3.472	3.472
Flow	Q2=Q1xN	m3/day	3000	3000	5000	5000
		m3/sec	0.034717	0.034717	0.057867	0.057867
Pressure pipe						
Pipe diameter	Dia	mm	300	300	300	300
Cross section of pipe (1pc)	a	m2	0.070686	0.070686	0.070686	0.070686
No. of pressure pipe	N	pcs	1	1	1	1
Total pipe cross section	a	m2	0.070686	0.070686	0.070686	0.070686
Velocity	v	m/sec	0.49	0.49	0.82	0.82
LWL of pump suction water level	LWL	m	0	0	0	0
HWL of storage (pump discharge p	HWL	m	15	30	15	30
Actual head	Ha=HWL-LWL	m	15	30	15	30
Pipe friction loss	Hb	m	5.01	5.64	12.9	14.51
Sub total of loss			20.01	35.64	27.9	44.51
Total pump head (sub total ×1.	H=(Ha+Hb)x 1.1	m	22.011	39.204	30.69	48.961
Out put power =0.163 x Q(m3/min) x H(m) x 1.		kw	11.2	20	26.1	41.6
Calculation of pipe friction loss						
H=10.666 x C^-1.85 x D^-4.87 x Q^1.85 x L						
Hazen-Williams formula	C		110	110	110	110
	Dia	m	0.300	0.300	0.300	0.300
	Flow	m3/s	0.03472	0.03472	0.05787	0.05787
	Flow (1pipe)	m3/s	0.03472	0.03472	0.05787	0.05787
	Length	m	4000	4500	4000	4500
	Pipe friction h	m	5.01	5.64	12.9	14.51
	Slope	o/oo	1.3	1.3	3.2	3.2

Specification and No. of Pump

Pump Capacity		m3/min	1.05	1.05	1.05	1.05
Head		m	30	50	30	50
No. of Pump	Normal use	ｐｃ	2	2	1	1
No. of Pump	stand by	ｐｃ	1	1	1	1
Total Pump Capacity		m3/min	2.1	2.1	4.2	4.2
Total Pump Capacity		m3/day	3024	3024	6048	6048
Required flow		m3/day	> 3000	> 3000	> 5000	> 5000
Judge			OK	OK	OK	OK

Cost Estimation of the Proposed Sewerage System (1/2)

Main Sewer

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase1	Dia300－600mm, Depth 0.5-1.5m	m	200	6,300	1,260,000	
Phase2	Dia300－600mm, Depth 0.5-1.5m	m	200	5,400	1,080,000	
Phase3	Dia300－500mm, Depth 10-2.0m	m	100	19,900	1,990,000	
Total					4,330,000	

Tertiary and Secondary Sewer

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase1	Dia150-250mm, Depth 1.0-1.5m	Ha	15,000	75	1,125,000	Sewer length: 250m/ha
Phase2	Dia150-250mm, Depth 1.0-1.5m	Ha	15,000	75	1,125,000	Sewer length: 250m/ha
Phase3	Dia150-250mm, Depth 1.0-1.5m	Ha	7,500	500	3,750,000	Sewer length: 125m/ha
Total					6,000,000	

Inflow Pumping Station for East WWTP

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase 3	Pump Machine with accessaries	Pc	100,000	3	300,000	1.36m3/min x 3pc(1standby)
	Civil / architecture work	m2	2,000	48	96,000	Size: 6 x 8 m
	Total				396,000	

Wastewater Treatment Plant

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase 1, West WWTP						
Excavation	Rock soft	m3	120	31,320	3,758,400	30% of total excavation
Excavation	Soil	m3	15	73,080	1,096,200	70% of total excavation
Landfill	Bank (20% of excavation)	m3	30	20,880	626,400	
Sheet	HDPE or Clay	m2	10	89,000	890,000	
Monitoring well	Depth 30m	pc	4000	2	8,000	
Fence	2.3m, iron polls & bars	m	50	1,700	85,000	Size of WWTP: 500x340m
Subtotal					6,464,000	
Accessary	Drying bed, connection, and others				646,400	10% of the above
Total of Phase1 WWTP					7,110,400	
Phase 2, East WWTP						
Excavation	Rock soft	m3	120	31,320	3,758,400	30% of total excavation
Excavation	Soil	m3	15	73,080	1,096,200	70% of total excavation
Landfill	Bank (20% of excavation)	m3	30	20,880	626,400	
Sheet	HDPE or Clay	m2	10	89,000	890,000	
Monitoring well	Depth 30m	pc	4000	2	8,000	
Fence	2.3m, iron polls & bars	m	50	1,700	85,000	Size of WWTP: 500x340m
SubTotal					6,464,000	
Accessary	Drying bed, connection, and others				646,400	10% of the above
Total of Phase2 WWTP					7,110,400	
Total of WWTP					14,220,800	

Initially Treated Wastewater Pumping Station

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase 1	Pump Machine with accessaries	Pc	132,000	3	396,000	1.05m3/min, 30m x 3pc(1standby)
	Civil / architecture work	m2	2,000	72	144,000	Size: 6 x 12 m
	Subtotal				540,000	
Phase 2	Pump Machine with accessaries	Pc	132,000	3	396,000	1.05m3/min, 50m x 3pc(1standby)
	Civil / architecture work	m2	2,000	72	144,000	Size: 6 x 12 m
	Subtotal				540,000	
Phase 3	Pump Machine with accessaries	Pc	132,000	4	528,000	2 for each PS 1.05m3/min x 2pc
	Civil / architecture work	m2	2,000	0	0	
	Subtotal				528,000	
Total					1,608,000	

Cost Estimation of the Proposed Sewerage System (2/2)

Pressure Pipe

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase1	Dia300mm, Depth 1.0m	m	100	3800	380,000	
Phase2	Dia300mm, Depth 1.0m	m	100	3700	370,000	
Total					750,000	

Initially Treated Wastewater Storage

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase 1						
Landfill	Bank	m3	30	9,800	294,000	
Excavation	Rock soft	m3	120	2,900	348,000	
Excavation	Soil	m3	15	6,800	102,000	
Sheet	HDPE or Clay	m2	10	11,000	110,000	
SubTotal					854,000	
Accessary	Connection, others				85,400	10% of the above
Total of Phase 1					939,400	
Phase 2						
Landfill	Bank	m3	30	9,800	294,000	
Excavation	Rock soft	m3	120	2,900	348,000	
Excavation	Soil	m3	15	6,800	102,000	
Sheet	HDPE or Clay	m2	10	11,000	110,000	
SubTotal					854,000	
Accessary	Connection, others				85,400	10% of the above
Total of Phase 2					939,400	
Total of Phase 1 & 2					1,878,800	

Soil-based Treatment Field

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase1	Aluminium Dia75mm, on GL Irrigation use	m	10	4,100	41,000	
	Excavation for furrow	m3	15	11,400	171,000	
	Excavation of soft rock	m3	120	50,000	6,000,000	20% of surface, 1m depth, 25ha, This is not included.
SubTotal of Phase 1					212,000	
Phase2	Aluminium Dia75mm, on GL Irrigation use	m	10	4,100	41,000	
	Excavation for furrow	m3	15	11,400	171,000	
	Excavation of soft rock	m3	120	50,000	6,000,000	20% of surface, 1m depth, 25ha, This is not included.
SubTotal of Phase 2					212,000	
Total of Phase 1 & 2					424,000	

Sprinkler Truck

	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase1	Sprinkler truck, 10m3, Suction pump	pcs	150000	1	150,000	
Phase2	Sprinkler truck, 10m3, Suction pump	pcs	150000	1	150,000	
Phase3	Sprinkler truck, 10m3, Suction pump	pcs	150000	2	300,000	
Total					600,000	

Appendix K

Drainage

Appendix K Drainage

Daily Rainfall

Period:From Januray 1978 - April 2008

Station: Lusaka 01 UNIT : mm Remark: -99 = MISSING VALUE

Year	Month	Day																														Max
2008	1	31.4	48.8	0	7.7	16.6	2.5	0	6.7	46.1	35.3	0	1.7	27	32.6	23.7	3.2	6.1	5.8	0	8.7	0	0	2.2	38.2	15.4	11.7	0	0	9.9	7.4	22.3	48.8
2008	2	3.1	0	0.6	5.3	4.6	0	0	5.2	14.1	0	0	0	0	6.5	0	2.7	0	0	3.1	38	0	0	0	0	0	0	42	0	4.5	-99	-99	42
2008	3	0	0	0.8	0	0	2.4	9.1	0	0	0	0.6	3.1	0	0	0	44.5	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44.5
2008	4	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-99	2

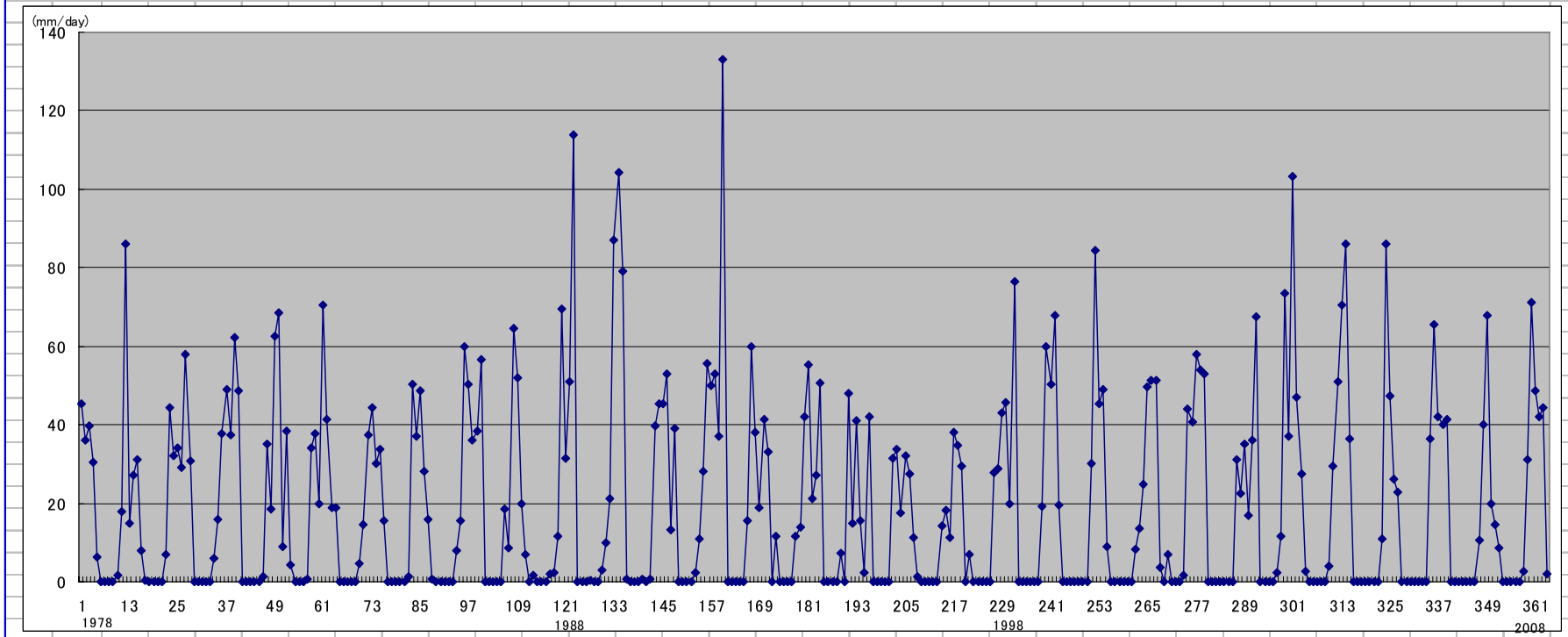
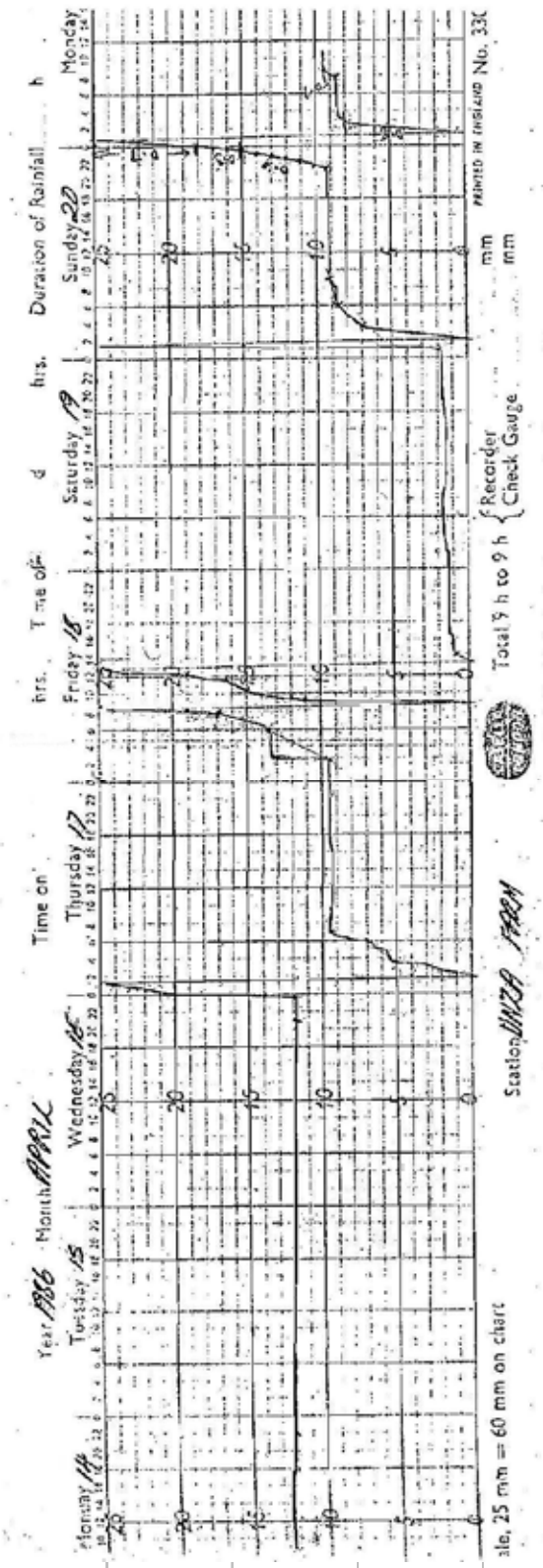


Figure Daily Maximum Rainfall per Month from January 1978 to April 2008

Hourly Rainfall Data
(14 April 1986 – 20 April 1986)

Appendix D3 Hourly Rainfall Data 14 April 1986 – 20 April 1986

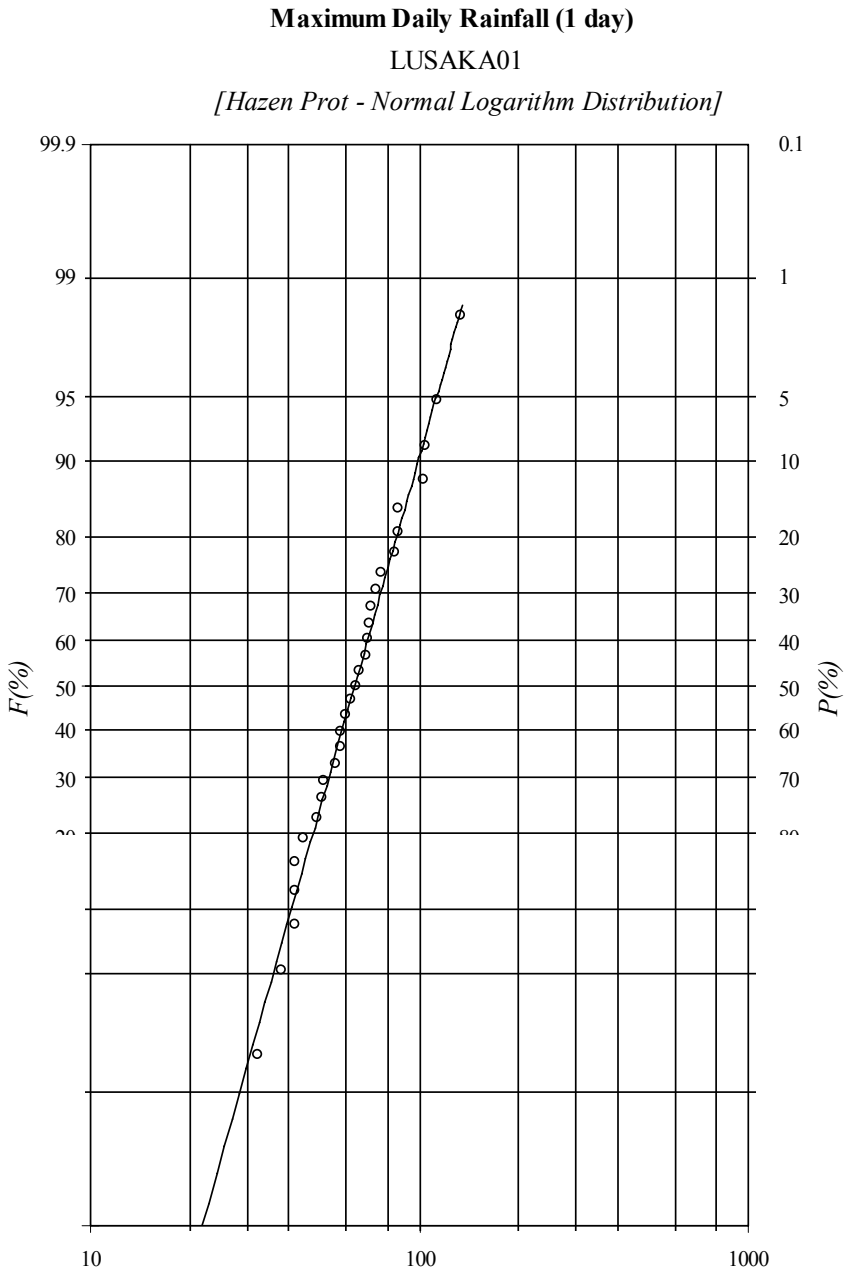
Station: UNZA Farm (Zanbia University Farm)



Calculation of Probability of Exceedance on Daily Rainfall

TITLEMaximum Daily Rainfall (1 day)
STA: LUSAKA01

Year	Serial No.	Max Rainfall in Year (mm/day)
1978	1	86
1979	2	44.5
1980	3	58
1981	4	62.2
1982	5	68.5
1983	6	70.5
1984	7	50.4
1985	8	59.9
1986	9	64.5
1987	10	69.5
1988	11	113.9
1989	12	104.4
1991	13	133
1992	14	42
1993	15	55.4
1994	16	42.1
1995	17	32.1
1996	18	38.1
1997	19	76.4
1998	20	84.5
1999	21	49
2000	22	51.3
2001	23	57.9
2002	24	73.6
2003	25	103.3
2004	26	86
2005	27	65.5
2006	28	42
2007	29	71.1



Calculation of Probability of Exceedance on Daily Rainfall (Result)

CALCURATION SHEET FOR HAZEN PLOT
WITH NORMAL LOGARITHM DISTRIBUTION

Maximum Daily Rainfall (1 day)
LUSAKA01

Probability of Exceedance

Return Period (yrs)	(%)	y	Xi	
200	0.5	2.5758	155.5	
100	1	2.3263	142.6	
50	2	2.0537	129.7	
20	5	1.6449	112.6	
10	10	1.2816	99.3	**Adopted**
5	20	0.8416	85.2	
2	50	0.0000	63.7	

Probability of Nonexceedance

Return Period (yrs)	(%)		Xi
200	0.5	-2.5758	26.1
100	1	-2.3263	28.4
50	2	-2.0537	31.3
20	5	-1.6449	36.0
10	10	-1.2816	40.8
5	20	-0.8416	47.6
2	50	0.0000	63.7

Distribution of Rainfall (1/2)

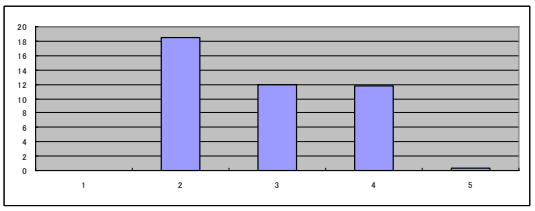
Appendix D5 Distribution of Rainfall

Daily Rainfall Data
May 1959 – April 1962 1986 April 17-18th

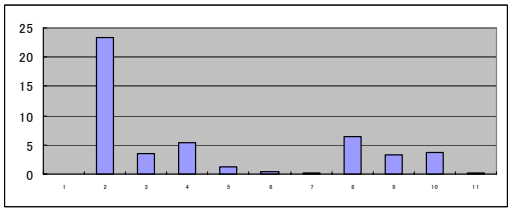
Unit: mm

No.	Y	M	D	0	1	2	3	4	5	6	7	8	9	10	11	Noor	13	14	15	16	17	18	19	20	21	22	23	Total	Continuous rain hour (hour)
1	1959	12	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	12	12	0	42	3
2	1959	12	29	0	0	0	1	0	0	0	0	0	0	0	0	0	23	4	5	1	1	0	6	3	4	0	0	49	9
3	1960	1	5	0	0	23	11	1	0	0	0	0	0	0	0	0	0	0	12	16	0	1	0	0	0	0	2	65	4
4	1960	11	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	14	2	2	6	1	44	6
5	1961	1	17	11	8	7	5	3	2	1	1	0	1	1	0	0	0	0	0	0	0	0	0	6	3	1	2	52	11
6	1961	1	21	0	0	0	0	4	30	3	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43	6
7	1961	11	12	0	0	1	2	3	1	1	1	5	15	3	8	2	4	1	6	5	1	0	0	0	0	0	0	58	16
8	1961	12	7	0	21	22	2	1	0	0	0	4	1	5	2	2	1	0	0	0	0	0	0	0	0	0	0	60	13
9	1962	1	16	0	0	0	0	1	1	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	25	1
10	1962	1	17	5	11	3	5	2	0	0	4	4	1	1	5	2	1	0	0	0	0	0	0	1	0	0	0	44	14
11	1962	3	18	2	2	3	2	0	0	0	2	1	1	2	1	0	7	3	2	0	0	1	0	1	1	3	1	35	24
12	1962	3	19	1	7	11	0	1	3	18	4	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	50	13
13	1986	4	17	10	3	2	4	1	1	3																		23	7
14	1986	4	18				4	0	0	2	10	12	3	1	4	6	1											42	11
15	1986	4	19	0	23	4	3	1	1	0	0																	32	5
16	1986	4	17																						2	4	4	26	6
	1986	4	18	6	5	5																							
																											Total rain hour		149
																											Average Continuous Rainfall Time		9.3

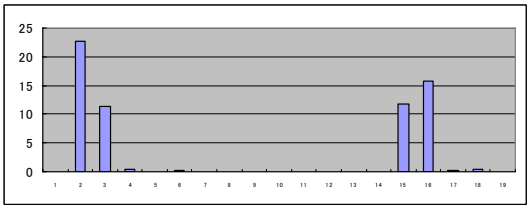
Y	M	D	Rainfall	Concentration of the rainfall
59	12	28	42 mm/rain	Front



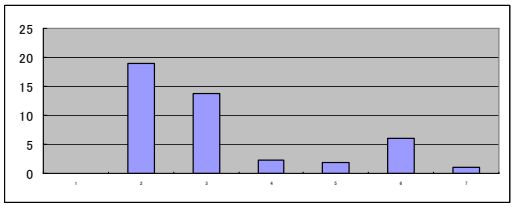
Y	M	D	Rainfall	Concentration of the rainfall
'59	12	29	49 mm/rain	Front



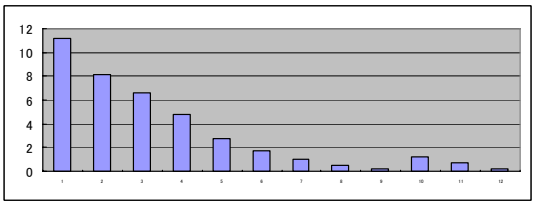
Y	M	D	Rainfall	Concentration of the rainfall
1960	1	5	65 mm/rain	Other



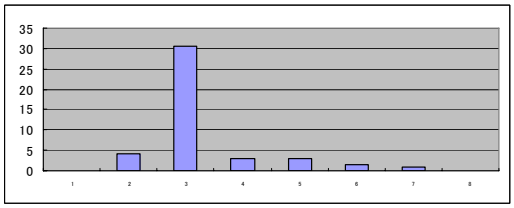
Y	M	D	Rainfall	Concentration of the rainfall
'60	11	24	44 mm/rain	Front



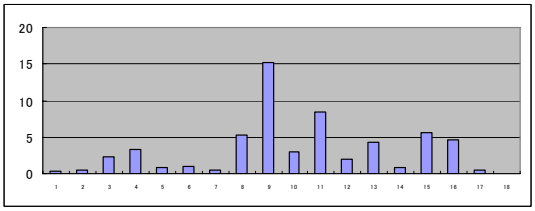
Y	M	D	Rainfall	Concentration of the rainfall
1961	1	17	52 mm/rain	Front



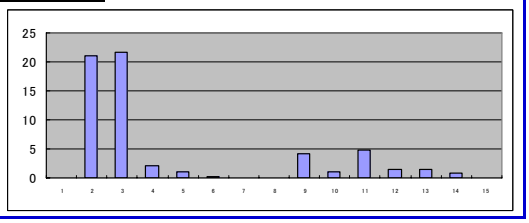
Y	M	D	Rainfall	Concentration of the rainfall
'61	1	21	43 mm/rain	Front



Y	M	D	Rainfall	Concentration of the rainfall
1961	11	12	58 mm/rain	Center

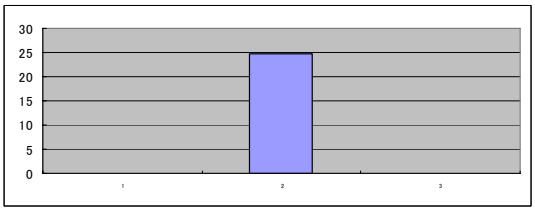


Y	M	D	Rainfall	Concentration of the rainfall
'61	12	7	60 mm/rain	Front

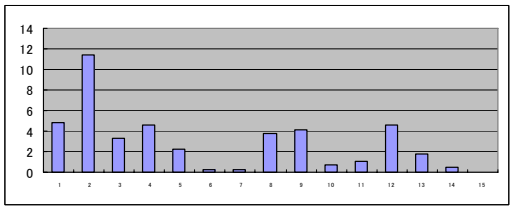


Distribution of Rainfall (2/2)

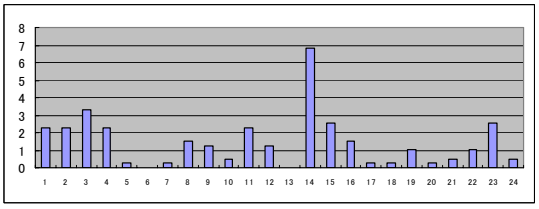
Y	M	D	Rainfall	Concentration of the rainfall
1962	1	16	25 mm/rain	Center



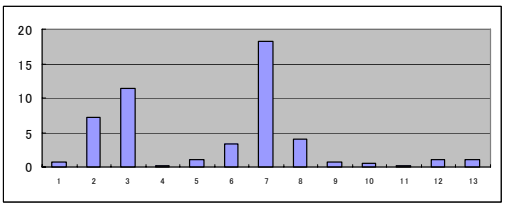
Y	M	D	Rainfall	Concentration of the rainfall
'62	1	17	44 mm/rain	Front



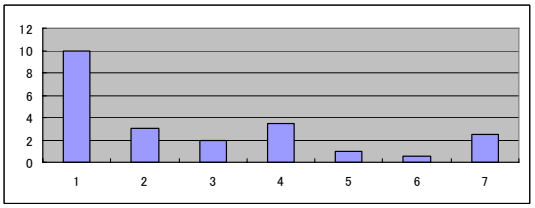
Y	M	D	Rainfall	Concentration of the rainfall
1962	3	18	35 mm/rain	Center



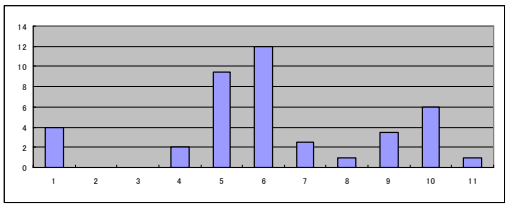
Y	M	D	Rainfall	Concentration of the rainfall
'62	3	19	50 mm/rain	Center



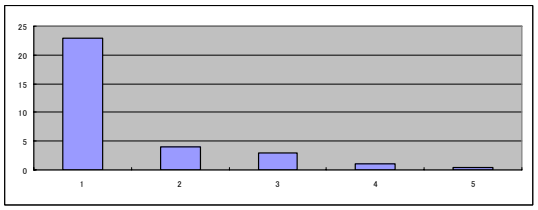
Y	M	D	Rainfall	Concentration of the rainfall
1986	4	17	23 mm/rain	Front



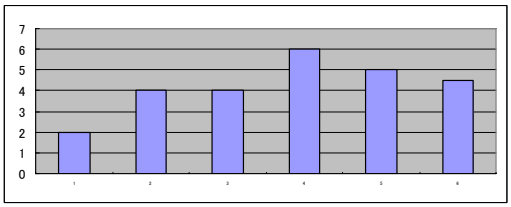
Y	M	D	Rainfall	Concentration of the rainfall
'86	4	18	42 mm/rain	Center



Y	M	D	Rainfall	Concentration of the rainfall
1986	4	19	32 mm/rain	Front



Y	M	D	Rainfall	Concentration of the rainfall
'86	4	17	26 mm/rain	Center



Concentration of the rainfall

	Front side	Center	Back side	Others	Total
No. of Case	9	6	0	1	16

Planning and Designing of Drainage

Appendix D6 **Planning and Designing of Drainage**

In calculation of the flood run-offs by the Rational Formula, following condition is adopted,
Q = 1/360 x (C x I x A) m3/sec
Condition

Run-off coefficient	C		0.65
Rainfall intensity	I	mm/Hr	31.3 :calculated in Appendix 7
Basin area	A	see below Ha	

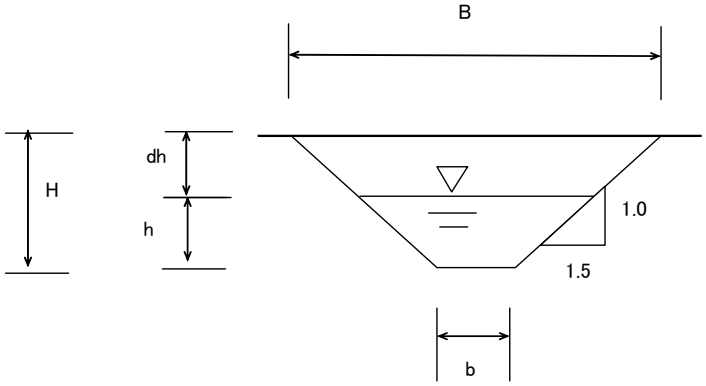
Generally drainage is placed along road on the both sides, so drainage size is calculated for Q/2 as follows,

Location of the drainage *1		Unit	①	②	③	④	⑤
Basin area	A	Ha	360.25	125	175	70	15
Run-off	Q	m3/sec	20.359	7.064	9.89	3.956	0.848
Half of Run-off	Q/2	m3/sec	10.18	3.532	4.945	1.978	0.424
Specific Discharge		(m3/sec)/Ha	5.7	5.7	5.7	5.7	5.7

*1: Location of the drainages is shown in Drawing No. 6.4.2.

Slop All of the slop is assumed same as 3o/oo.

b (Bottom wide)		m	1	1	1.2	1	0.3
h (Water depth)		m	1.9	1.2	1.3	0.9	0.6
L	=b+2(h^2+(1.5xh)^2)^0.5	m	7.9	5.3	5.9	4.2	2.5
A	=(2b + 3h)/2 x h	m2	7.3	3.4	4.1	2.1	0.7
R	=A/L	m	0.924	0.642	0.695	0.5	0.28
I	Slope		0.003	0.003	0.003	0.003	0.003
n	Manning roughness coefficient		0.035	0.035	0.035	0.035	0.035
	人工水路:0.014-0.02						
V	q=1/n x R^(2/3) x I^0.5	m/sec	1.485	1.165	1.228	0.986	0.67
	=q/A >0.6m/s		OK	OK	OK	OK	OK
q		m3/sec	10.841	3.961	5.035	2.071	0.469
Judge	whether > Q/2		OK	OK	OK	OK	OK
Size of Drainage							
dh(Freeboard)	(15 + V^2/20)/100		0.2	0.2	0.2	0.2	0.2
Size of Drainage							
H	=H + dh		2.1	1.4	1.5	1.1	0.8
B	=b + H x 1.5		4.2	3.1	3.5	2.7	1.5
b			1	1	1.2	1	0.3



Calculation Designing Retention / Infiltration Basins (1/2)

Design Daily Rainfall
99 mm/day
Proberbility of exceedance
10 years return period

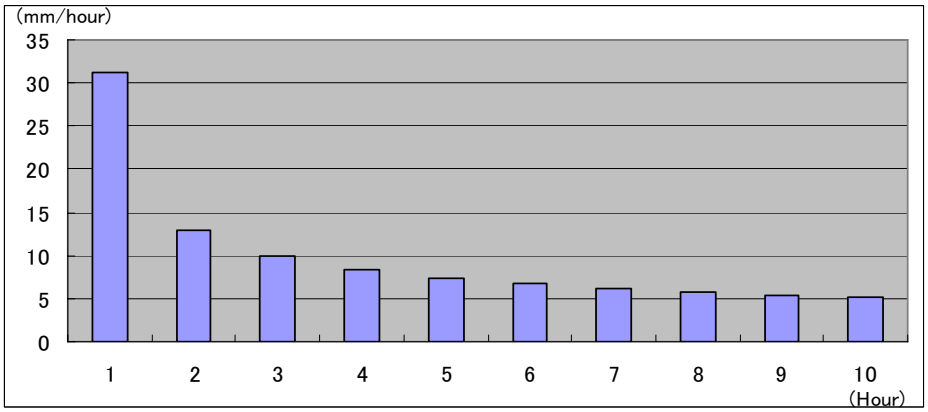
Design rainfall is distributed based on the Sherman formula.
Sherman formula
Rt = RT (t/T)^k
RT Total rainfall amount to be distributed to T hours
Rt Maxmimum rainfall during the t hours
k Constant: 1/3 - 2/3 ≒1/2,The constant varies based on the reigion.

Applied Figures
RT 99 mm/hour
T 10 hour
k 0.5

t	1	2	3	4	5	6	7	8	9	10	Total
Rt	31.3	44.3	54.2	62.6	70	76.7	82.8	88.5	93.9	99	-
r	31.3	13	9.9	8.4	7.4	6.7	6.1	5.7	5.4	5.1	99

Hyetograph with Front Shift

Hour	mm/hour
1	31.3
2	13
3	9.9
4	8.4
5	7.4
6	6.7
7	6.1
8	5.7
9	5.4
10	5.1



Runoff Volume
Q=1/360 x C x I x A

Q	Runoff volume	m3/sec
C	Runoff Coefficient	-
I	Rainfall intensity	mm/hour
A	Basin area	ha

Applied Figures
Runoff Coefficient C 0.65
Basin area A

Phase	ha
Phase 1	100
Phase 2	100
Phase 3 W	350
Phase 3 E	350

Design Infiltration Rate Ic 1359 mm/day

Calculation Designing Retention / Infiltration Basins (2/2)

Phase 1= Phase 2

Basin area	A	100	ha
Area of Infiltration Basin	Ai	4	ha
Design Infiltration Flow	Qo=Ic x Ai	0.63	m3/sec

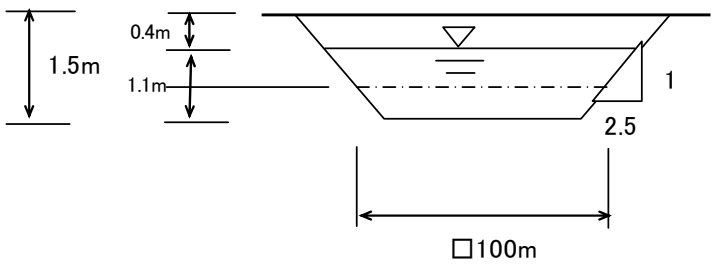
Hour	Qi m3/sec	Qr=Qi-Qo (m3/sec)	Vr=Qr x t (m3/h)	Accumulate Vr	Depth= Qr/A (m)
1	5.7	5.07	18,252	18,252	0.46
2	2.3	1.67	6,012	24,264	0.61
3	1.8	1.17	4,212	28,476	0.71
4	1.5	0.87	3,132	31,608	0.79
5	1.3	0.67	2,412	34,020	0.85
6	1.2	0.57	2,052	36,072	0.9
7	1.1	0.47	1,692	37,764	0.94
8	1	0.37	1,332	39,096	0.98
9	1	0.37	1,332	40,428	1.01
10	0.9	0.27	972	41,400	1.04

Phase 3 W = Phase 3 E

Basin area	A	350	ha
Area of Infiltration Basin	Ai	14	ha
Design Infiltration Flow	Qo=Ic x Ai	2.2	m3/sec

Hour	Qi m3/sec	Qr=Qi-Qo (m3/sec)	Vr=Qr x t (m3/h)	Accumulate Vr	Depth= Qr/A (m)
1	19.8	17.6	63,360	63,360	0.45
2	8.2	6	21,600	84,960	0.61
3	6.3	4.1	14,760	99,720	0.71
4	5.3	3.1	11,160	110,880	0.79
5	4.7	2.5	9,000	119,880	0.86
6	4.2	2	7,200	127,080	0.91
7	3.9	1.7	6,120	133,200	0.95
8	3.6	1.4	5,040	138,240	0.99
9	3.4	1.2	4,320	142,560	1.02
10	3.2	1	3,600	146,160	1.04

Unit size of the basin



Cost Estimation of the Proposed Drainage System

Retention / Infiltration Basin for Storm Water Management						
	Spec/Description	Unit	Unit Price (USD)	Quantity	USD	Remark
Phase 1						
Excavation	Rock soft	m3	120	19,200	2,304,000	30% of total excavation
Excavation	Soil	m3	15	44,800	672,000	70% of total excavation
Landfill	Bank (20% of excavation)	m3	30	12,800	384,000	
Subtotal					3,360,000	
Accessary	Drainage connection, and Drainage, except drainage along road				336,000	10% of the above
Total of Phase1					3,696,000	
Phase 2						
Excavation	Rock soft	m3	120	19,200	2,304,000	30% of total excavation
Excavation	Soil	m3	15	44,800	672,000	70% of total excavation
Landfill	Bank (20% of excavation)	m3	30	12,800	384,000	
Subtotal					3,360,000	
Accessary	Drainage connection, and Drainage, except drainage along road				336,000	10% of the above
Total of Phase2					3,696,000	
Phase 3						
Excavation	Rock soft	m3	120	96,000	11,520,000	
Excavation	Soil	m3	15	224,000	3,360,000	
Landfill	Bank (20% of excavation)	m3	30	64,000	1,920,000	
Subtotal					16,800,000	
Accessary	Drainage connection, and Drainage, except drainage along road				1,680,000	10% of the above
Total of Phase3					18,480,000	
Total of Phase 1, 2 & 3					25,872,000	

Appendix L

Outline of Lusaka South Multi Facility Economic Zone Act.

APPENDIX L

OUTLINE OF LUSAKA SOUTH MULTI-FACILITY ECONOMIC ZONE ACT

1. PURPOSES AND OBJECTIVES: ESTABLISHMENT AND NATURE OF MFEZ

(1) Title of the Act

(2) Declaration of Policy

(3) Purposes, Intents and Objectives of the Act

(4) Definition of Terms

- ZDA
- MFEZ
- LS-MFEZ
- MFEZ Board
- Export Processing Zone
- Free Trade Zone
- General Industrial Zone
- Special Economic Zone
- LS-MFEZ Administration

  The Administration refers to the State administration management unit which is the "One-Stop Service" mechanism at the site of the MFEZ and has the duties to approve and issue permits, licenses and registration to the Zone investors, including the approval of incentives, pursuant to the full authority delegated by the line ministries and institutions and to address all requests related to the management competence of the State, concerning investments in the zone
- Zone developer

  The developer refers to a Zambian or / and foreign natural or legal person, who implements the Qualified Investment Project, and is permitted to invest in the development of physical infrastructures in the Zone ensuring the safety and security of the Zone investors
- Zone investor

  The investor refers to a Zambian or / and foreign natural or legal person, who implements the Qualified Investment Project and purchases or rents the immovable property from the Zone developer and perform investment activities such as production, services and trade in the Zone

(5) Establishment of LS-MFEZ

Lusaka area shall be developed through anyone of the following schemes

- Private initiative
- Local government initiative
- National government initiative
- BOT contract

  BOT contract means a written document signed by MFEZ Board and investor(s) for the construction and commercial operation of an infrastructure facility for a fixed duration; upon expiry of the duration, the investor(s) shall, without compensation, transfer the facility to Zambian national of local government

(6) Features of LS-MFEZ

LS-MFEZ shall be developed into a decentralized, self-reliant and self-sustaining zone as much as possible. LS-MFEZ shall be provided with transportation, telecommunication and other facilities needed to generate linkage with industries and employment opportunities for its own inhabitants and those of nearby towns and cities

(7) LS-MFEZ Administration

LS-MFEZ shall be managed and operated by the on-site management unit as separate customs territory. The Administration is hereby vested with the authority to issue certificate of origin for products manufactured or processed in the Zone in accordance with the prevailing rules or origin, and the pertinent regulations of the Ministry of Commerce, Trade and Industry and / or the Ministry of Finance

1) "One – Stop Service" mechanism

The Administration is the "One-Stop Service" mechanism set up by the ZDA in order to be permanently stationed in the LS-MFEZ and is structured and has the duties as follows:

- The composition of the Administration is:
  - ✓ Representative of ZDA
  - ✓ Representative of the Custom and Excise Department
  - ✓ Representative of the Custom Control
  - ✓ Representative of the Ministry of Commerce, Trade and Industry
  - ✓ Representative of the Ministry of Labor and Social Security
  - ✓ Representative of Immigration Office
  - ✓ Representative of the Environmental Council of Zambia

  The above members shall be appointed by each line ministry or institution to be permanently stationed at the Zone upon its operation

  The Administration office located in the Zone is provided by the Zone developer, who shall supply materials, water, electricity, accommodations, and provide other necessary supports

  All aforementioned relevant ministries or institutions shall delegate to their representative sufficient power to make decisions on behalf of the ministry or institution in accordance their respective authority in the Zone

  The salary of the members of the Administration shall be paid by the line ministry or institution

2) Duties of the Administration

- To control, based on respective competence, the entry and exit of goods, means of transport and people into and from the Zone: process custom formalities for import-export of goods and facilitate administration formalities with the ministries or institutions of the Government of Zambia for the functioning of the Zone
- To control the implementation of the work of the Zone developer and Zone investors
- To examine the investment proposals for registration, award incentives, issue permits, licenses, and certificates of origin of products requested by Zone investors, such decisions being made at the Zone itself
- To control the activities in the Zone according to its respective competence
- To cooperate with the Zone developer to address issues under its jurisdiction
- To facilitate all relevant formalities in a prompt and efficient manner
- To prepare necessary reports on activities of the Zone to the relevant ministries or institutions and ZDA
- To perform other tasks in order to coordinate and address requests of the Zone Investors with regard to ministries or institutions

(8) Duty of the Zone developer

- To have sufficient capital and means to develop the infrastructure in the Zone, including the human resources to manage the activities of the Zone
- To have the legal rights to possess the land in order to establish the Zone
- To construct infrastructure in the Zone, including electricity, water, road, and telecommunication networks, environment protection and management network, build warehouses, fire-fighting station and other necessary facilities
- To arrange security personnel and ensure good public order in the Zone at all time
- To adopt the rules pertaining to services in the Zone, including internal rules of the Zone, and general rules for the Zone Investors and determine the types of business, production and services permitted to operate in the Zone in accordance with the nature of the Zone
- To promote and attract investment in the Zone and provide detailed information on the formalities, procedures, and eligible benefits for investing in the Zone
- To maintain and repair the infrastructures
- To submit reports to ZDA upon request and perform tax liability obligations
- To cooperate with and assist the Administration regarding the functioning of the Zone

(9) Defense and Security

The defense of the LS-MFEZ and the security of its fence shall be the responsibility of the national government

(10) Immigration

Any investor within the LS-MFEZ whose initial investment shall not be less than US$250,000, shall be granted permanent resident status within the LS-MFEZ for his / her spouse and dependent children under 21years of age shall be granted permanent resident status within the LS-MFEZ.. They shall have freedom of ingress and egress to and from the LS-MFEZ without any need of special authorization from the Bureau of Immigration

- Work visas renewable every two years
- The work residency visas are provided to foreign executives and other aliens possessing highly-technical skills which no Zambian within LS-MFEZ possesses as certified by Ministry of Labor and Social Security

2. GOVERNING STRUCTURES

(1) MFEZ Board

- The Board is established under ZDA
- It has a director general with the rank of department undersecretary
- The director general shall be assisted by three deputy directors
- The Board shall be composed of members as follows: Ministry of Commerce, Trade and Industry, Ministry of Finance, Ministry of Labour and Social Security, Ministry of Local Government and Housing, Ministry of Lands and Tourism and Environment, Ministry of Finance and National Planning, National Development Committee, ZDA and the Environmental Council of Zambia

(2) Functions and Powers of the Board

- Set the general policies
- Regulate and undertake the operation and maintenance of utilities, other services and infrastructure in MFEZ

(3) General Powers and Functions of the Board

- To operate, administer, manage and develop
- To register, regulate and supervise the enterprises in MFEZ in an efficient and decentralized manner
- To coordinate with local government units
- To construct, acquire, own, lease, operate and maintain on its own or through contract, franchise, license,

bulk purchase from the private sector and BOT scheme of joint venture, adequate facilities and infrastructure, such as light and power systems, water supply and distribution systems, telecommunication and transportation, buildings, structures, warehouses, roads, bridges, ports and other facilities for the operation and development of the MFEZ

(4) Powers and Functions of the Director General

3. OPERATIONS WITHIN LS-MFEZ

(1) Development strategy of LS-MFEZ

The development strategy is consistent with the priorities of the Zambian Government as outlined in Zambian national development plan

(2) Fiscal Incentives

Business establishments operating within the LS-MFEZ shall be entitled to the financial incentives as provided for under the law

(3) Leases of lands and buildings

Lands and buildings in the LS-MFEZ may be leased to investors for a period not exceeding 50 years renewable once for a period not more than 49 years as provided for under the law

(4) Protection of Environment

MFEZ Board, in accordance with the appropriate agencies, shall take concrete and appropriate steps and enact the proper measure for the protection of the local environment

(5) Termination of business

Investors in LS-MFEZ are allowed to terminate business or operations when they comply with requirements and procedures

(6) Registration of business enterprises

Business enterprises within the LS-MFEZ shall register with the Administration to avail of all incentives

(7) One-stop service center

The Administration shall establish a one stop service center for the purpose of facilitating the registration of new enterprises in LS-MFEZ. Thus, all appropriate government agencies that are involved in registering, licensing or issuing permits to investors shall assign their representatives to the LS-MFEZ to attend to investor requirements.

4. INDUSTRIAL HARMONY IN LS-MFEZ

(1) Labour and management relations

The relations shall be governed by the existing Labor Code. Employees and personnel in the LS-MFEZ enterprises shall receive salaries and benefits and shall enjoy working conditions not less than those provided under the Zambian Labor Code and other relevant laws, rules and regulations

(2) Promotion of industrial peace

A tripartite body composed of one representative each from Ministry of Labor and Social Security, labor sector and business and industry sectors shall be created.

In addition, a trouble shooting agency is created for solving labor issues smoothly.

(3) Master employment contracts

MFEZ Board, in coordination with Ministry of Labor and Social Security, shall prescribe a master employment contract for all LS-MFEZ enterprise staff members and workers

(4) Percentage of foreign nationals

- Not exceed 5% of its workforce
- Incentive scheme :an additional deduction equivalent to 5% of the value of training expenses incurred in developing skilled or unskilled labor or for managerial or other management development programs incurred by enterprises in the LS-MFEZ

5. NATIONAL GOVERNMENT AND OTHER ENTITIES

(1) Delegation of power for implementation of One-Stop Service

(2) Authority of the President to Advance Initial Funding

Subject to existing laws, the President of Zambia is hereby authorized to advance out of the savings of the Office of the President such funds may be necessary to effect the organization of LS-MFEZ which shall be reimbursed by LS-MFEZ at reasonable terms and condition.

6. MISCELLANEOUS PROVISIONS

RULES AND REGULATIONS TO IMPLEMENT LS-MFEZ ACT

1. GENERAL PROVISIONS

(1) Title

(2) Definition of terms

- MFEZ
- MFEZ Board
- LS-MFEZ
  - ✓ Industrial estate
  - ✓ Export processing zone
  - ✓ Free trade zone
  - ✓ R&D zone
  - ✓ Tourist / Recreational center
- Customs territory
- Restricted area
- LS-MFEZ Export enterprise
- LS-MFEZ Domestic market enterprise
- LS-MFEZ Pioneer enterprise
- LS-MFEZ Free trade enterprise
- LS-MFEZ Utilities enterprise
- LS-MFEZ Facilities enterprise
- LS-MFEZ Developer / Operator
- LS-MFEZ Service enterprise
- LS-MFEZ Tourism enterprise
- Certificate of registration and registration agreement
- One- Stop Service
- Training expense

(3) Basic rights and guarantees

1) Protection of investment

- Repatriation of investments
- Remittance of earnings
- Foreign loans and contracts
- Freedom from expropriation
- Freedom of requisition of investment

2) Protection of labor

- Basic rights of workers
- Humane conditions of work
- Self-organization

2. REGISTRATION OF LS-MFEZ ENTERPRISES

(1) Application and registration

- Qualification of applicants
- Board action
- E-register, duration, and fee
- Certificate of registration

(2) One-Stop Service Center

- Facilitate the registration, licensing and issuance of permits to LS-MFEZ enterprises
- Government agencies involved shall assign their respective representatives in the LS-MFEZ for the purpose

3. ESTABLISHMENT OF LS-MFEZ

(1) Criteria for the establishment of an MFEZ

- Regional growth center
- Strategically located
- Availability of infrastructure and land
- Availability of water source and electric power supply
- Easily controlled

(2) Development of the area / Documentary requirements

1) A proposed MFEZ

- Notarized application
- Anti-graft certificate
- SEC registration certificate
- Articles of incorporation
- Audited financial statements
- Board resolution
- Project description / Feasibility study
- Vicinity map
- Proof of land ownership

2) Documents on detailed engineering / development plans

(3) Timetable of development

(Example)

a. Phase 1 : 30% of the area
b. Phase 2 : 30% of the area
c. Phase 3 : 20% of the area
d. Phase 4 : 10% of the area
e. Phase 5 : 10% of the area

(4) Inspection and changes

To monitor and supervise the development, ZDA shall have the right to conduct periodic inspections and if necessary to examine the books of accounts of the LS-MFEZ developer / operator

4. INFRASTRUCTURE FACILITIES AND UTILITIES

(1) Lease of land and buildings, lease period

Terms and conditions shall be formulated by the Board, however, lease period of land to LS-MFEZ enterprises wholly owned or controlled by aliens shall not exceed 50years extendable once for a period not more than 49 years

Any long lease contract may be cancelled at the instance of the Board, if the project is not initiated within the period as stated in the contract.

All leasehold rights acquired under long term lease contracts may be sold, transferred, assigned or conveyed.

(2) Sale of land or building / structure: formulated by the Board

(3) Permits and other requirements

1) Construction of building, structures, facilities and utilities

- The ZDA issues permit to construct building, structure, facility, utility and electro-mechanical equipment and to improve thereon within LS-MFEZ. ZDA issues LS-MFEZ enterprises occupancy permit for the building or permit to operate such facility and utility.
- LS-MFEZ enterprises shall pay ZDA all the corresponding fees and dues
- One time flat fee for legal fee, connection charge for water and sewerage, survey fee, building plan submission fee etc.

5. TAX TREATMENT OF MERCHANDISE IN LS-MFEZ

(1) Tax treatment of merchandise in restricted areas

- Exemptions

Merchandise brought to the restricted areas in LS-MFEZ by registered Export or Free trade enterprises shall not be subject to all customs and internal revenue laws and regulations

(2) Tax treatment of merchandise in non-restricted areas

5. MOVEMENT OF GOODS, PERSONS AND VEHICLES

(1) Entry and exist of goods

(2) Inventory of finished products, raw materials and other assets

(3) Defense, security and firefighting forces

6. ONE-STOP SERVICE

(1) Delegation of power

7. INCENTIVES TO LS-MFEZ ENTERPRISES

(1) Application and entitlement

- General incentive matrix: tax holidays by industrial sector and type of investor
- Additional incentive matrix

(2) Different incentives by type of actor

- Incentives to LS-MFEZ developers / operators
- Incentives to LS-MFEZ export and free trade enterprises
- Incentives to LS-MFEZ domestic market, facilities, utilities and tourism enterprises
- Incentives to LS-MFEZ high-tech enterprises
- Incentives to LS-MFEZ SMEs
- Permanent resident status for foreign investors

Any investor within the LS-MFEZ whose initial investment shall not be less than US$250,000,his / her spouse and dependent children under 21 years of age shall be granted permanent resident status within the LS-MFEZ

They shall have freedom of ingress and egress to and from the LS-MFEZ without need of special authorization from the Immigration office

8. EMPLOYMENT OF FOREIGN NATIONALS

(1) Type of job

- Executives (President, vice-president, treasurer and general manager)
- Supervisory
- Technical and advisory position

(2) Conditions

It is a case that qualification and experience are not available and appropriate documents are to be submitted

(3) Limitation on number

- Some percentage of total work force
- It is required to train local people submitting its program and annual reports
- On the other hand, some percent of training expenses will be deducted from income tax

(4) Remittance of earnings from investments

(5) Gross income taxation

- Income tax matrix for employees

	Net aggregated incomes	Tax rate	Deduction
Up to	700,000	0	--
From	700,000 to 2,800,000	10	70,000
From	2,800,000 to 11,200,000	15	210,000
Other	11,200,000	20	770,000

9. IMMIGRATION REGULATIONS

10. INDUSTRIAL HARMONY IN LS-MFEZ

(1) Labor and management relations

1) Establishment of Labor Center

Consistent with the One-Stop Shop center, a Labor Center shall be established within the LS-MFEZ. Under the supervision of the LS-MFEZ Administrator, the Center shall be handled by the LS-MFEZ Human Resources Unit in coordination with a Tripartite Oversight Committee composed of representative from the Ministry of Labor and Social Security, a representative from the labor sector and one from the management sector.

It will serve as a window for all labor related activities and shall offer service for the following

a. Manpower pool
b. Training

A Tripartite body shall be created to formulate a mechanism for the enhancement and preservation of industrial peace in the LS-MFEZ.

2) Establishment of Trouble shooting committee

11. Protection of the environment

(1) Guiding environmental policies and regulations

- Environmental standards for MFEZ
- Pre-registration requirement for Environmental Impact Statement
- Regulatory functions
- Waste management program by the LS-MFEZ
- Environmental Management Services under BOT scheme

(2) Other provisions

12. INVESTOR RIGHTS

(1) Entry and exits

(2) Ownership, property and management control

Matrix of limitation on the number of foreign members of statutory boards

Operational years	First 2 years	3-5 years	6-10 years	11 years-
% of foreign member	80	60	55	40

(Note) % is only example

(3) Exchanging and remitting funds

(4) Free from foreign exchange control

(5) Intellectual property rights

- Purpose: to create conditions favorable to technological development and to enable technology transfer and

transfer of new technology

(6) Guarantee on free to import equity and loan, remittance of funds, repatriation of capital

ATTACHMENT : ESSENCE OF LAW AND REGULATIONS ON BOT[1]

CHAPTER I GENERAL PROVISIONS

Article 1

Definition

1 "Build-Operate-Transfer contact"(abbreviated in English as BOT) means a written document entered into by an authorized State body of Zambia and a foreign investor(s) for the construction and commercial operation of an infrastructure facility (including expansion, upgrading, and modernization thereof) for a certain duration in order to recover the invested capital and earn reasonable profits, upon the expiry of such duration, the foreign investor(s) shall, without compensation, transfer the facility to the State of Zambia.

2 "Build-Transfer-Operate contract"(abbreviated in English as BTO) mean a written document entered into by an authorized State body of Zambia and a foreign investor(s) for the construction of an infrastructure facility (including expansion, upgrading, and modernization thereof) upon the completion of which the foreign investor shall transfer the facility to the State of Zambia. The Government of Zambia shall grant the investor(s) the right to commercially operate the facility for a certain duration in order to recover the invested capital and earn reasonable profits.

3 "BOT enterprise" or "BTO enterprise" (hereinafter referred to as BOT enterprise) means a joint venture enterprise or an enterprise with 100% foreign owned capital established in accordance with the *ZDA Act* for the purpose of implementing a BOT or BTO contract.

4 "State body authorized to enter into a BOT or BTO contract"(hereinafter referred to as authorized State body) means any ministry or government body or any people and committee of a province or city under central authority, which is appointed by the President to enter into and perform a BOT or BTO contract with a foreign investor(s).

5 "Foreign investor(s) entering into a BOT or BTO contract" means any foreign organization or individual performing a BOTor BTO contract (hereinafter referred to as foreign investor) and being fully responsible for their undertaking under the BOT or BTO contracts.

6 "Sub-contractor" means any Zambian or foreign contractor who enters into a contract with a BOT enterprise in order to carry out each part of a BOT or BTO project.

7 "Sub-contract" means any contract entered into by a BOT enterprise and a sub-contractor to implement each part of a BOT or BTO project.

ARTICLE 2

1 The Government of Zambia encourages foreign organization and individuals to carry out investment on the basis of BOT and BTO contracts in the fields of transportation, production and sales of electricity, water supply and drainage, waste treatment, and other areas as determined by the Government

2 The Government of Zambia protects the ownership of invested capital and other legitimate interests of foreign organizations and individuals carrying out investment on the basis of BOT and BTO contracts and at the same time creates favorable conditions and simple and rapid procedures for the implementation of these project.

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[1] Made reviewing cases in Asian countries such as Thailand and Vietnam

ARTICLE 3

1 For the purpose of carrying out a BOT or BTO project, foreign investor(s) establishes a BOT enterprise.

2 A BOT enterprise shall be established and shall commence operation from the date of issuance of the investment license, and shall be responsible for complying with the provisions of the investment license and the undertakings made by the investor(s) in the BOT or BTO contract.

CHAPTER II PREFRENTIAL TREATMENTS AND INVESTMENT GUARANTEES

ARTICLE 4

1 BOT enterprises shall be subject to the following taxes:

- The profits tax rate of xx% of the Profits earned shall apply for the whole duration of implementation of a project;
- Exemption from profits tax shall be granted for four year commencing from the time when the operations start to earn profits and a xx per cent reduction shall be granted for the four subsequent years. In cases of investment in areas where investment is from the time when the operations start to earn profits.
- The duration for exemption from or reduction of taxes shall be continuously counted foam the first year of profitable operations
- Withholding tax rate shall be xx per cent of the profits remitted abroad.
- In addition to the above-mentioned taxes, BOT enterprises shall pay other taxes in accordance with the laws of Zambia

2 Foreign sub-contractors participating in BOT and BTO projects shall pay taxes and shall be entitled to incentives in relation to exemption from and reduction of taxes in accordance with current provisions applicable to foreign contractors.

Zambian sub-contractors participating in BOT and BTO projects shall fulfill tax obligations in accordance with the current regulations applicable to Zambian enterprises.

ARTICLE 5

1 BOT enterprises and sub-contractors shall be exempted from import duties for the purpose of carrying out BOT and BTO projects in respect of the following:

- Equipment and machinery imported for the purpose of framing fixed assets (including equipment, machinery and spare parts used for survey, design and contraction of works)
- Specialized means of transportation included in a technological process imported for the purpose of forming fixed assets and means of transportation used to transport workers (vehicles with 24 or more seats, and watercraft);
- Components, small parts, accessories, spare parts, attachments, moulds, kits accompanying the above-mentioned equipment, machinery, specialized and other means of transportation referred to in this article including those used for replacement, warranty or maintenance during the operation the projects;
- Fuel, raw material and supplies imported for the implementation of BOT and BTO projects, including fuel, raw materials and supplies required for production or operation of projects.

2 The exemption from import duties in respect of the above-mentioned equipment, machinery, means of transportation, raw materials and supplies applicable to the expansion of the scale of a project or change or renovation of technology.

ARTICLE 6

1 During the implementation of a projects, a BOT enterprise shall be permitted to pledge or mortgage the following assets in accordance with the laws of Zambia

a. Equipment, plant, architectural works and real estate properties which have been purchased or constructed with the invested capital of the BOT enterprise
b. Other assets owned by the BOT enterprise
c. Value of the land use right in accordance with the laws of Zambia;
d. Property rights of the BOT enterprise

ARTICLE 7

1 The Government shall assure that BOT enterprise are permitted to use land, roads and other public support facilities for the implementation of BOT and BTO projects

2 BOT enterprises shall be exempted from payment of land rent for the duration of implementation of projects

3 Cities under central authority where investment projects are located shall be responsible for marking compensation, carrying out site clearance and completing the procedures for allocation of land to BOT enterprises in a accordance with the laws and within the undertaken time limit.

All costs of compensation and site clearance shall be paid by investor(s) and included in total invested capital, unless otherwise stipulated in the BOT or BTO contract.

ARTICLE 8

1 Zambian enterprises shall participate in BOT or BTO projects to approval of the authorized State body

2 Where necessary, the Government shall, depending on the nature of each project, delegate the authorized State by to act on behalf of the Government as a guarantor for the fulfillment of undertakings relating to financial obligations by Zambianenterprises participating in the implementation of the project as defined in the a BOTor BTO contract and for the obligation of Vietnamese enterprises with respect to sale of raw materials and purchase of main products or services for the purpose of carry out o BOT or BTO contract.

CHAPTER III METHODS OF IMPLEMENTATION OF BOTAND BTO PROJECTS

ARTICLE 9

1 Based on the planning and orientation of social and economic development in each period, the ZDA shall be responsible for co-ordination with ministries ,sectors and provinces and cities under central authority to submit to the President for approval the list of investment projects on the basis of BOT and BTO contracts

ARTICLE 10

1 Procedures and methods of selection of foreign investor(s) to enter into BOTor BTO contracts shall be carried out in accordance with the laws of Zambia in relation to tendering

2 The results of the selection of foreign investor(s) to enter into a BOTor BTO contract must be approved by the MFEZ Board

ARTICLE 11

1 An application file for an investment license shall comprise:

- Application for investment
- Initialed BOTor BTO contract
- Joint venture contract (in the case where the BOT enterprise is a joint venture enterprise)
- Charter of the BOT enterprise;
- Feasibility study
- Initialed contracts or hears of agreement on purchase of materials or sale of products (if any)
- Documents evidencing the legal status and financial standing of investors

2 A BOT or BTO contract and contracts for purchase of material or sale of products (if any) shall be sent to the Ministry of Planning and Investment after being officially signed

ARTICLE 12

1 The MFEZ Board shall issue an investment license to a BOTor BTO project within a period of xxx days

2 The investment license shall conditions of the following main issues:

- Main terms and conditions of the contract;
- Amount of invested capital, objectives and duration of operation of the project
- Requirements of design, technical conditions and conditions for normal operation of the project upon being transferred to the State of Vietnam
- Financial and tax obligations;
- Right to use land and support- facilities
- Conditions regarding environmental protection
- Principles for determining and adjusting prices and other charges
- Importation or exportation of equipment, machinery and goods
- Right and conditions for operating the projects.
- Main principles for evaluation of assets upon transfer;
- Undertakings of the Government and relevant State bodies;

ARTICLE 13

1 The principles for determining prices, rates, fees and other charges of BOT and BTO project must be provided for in BOT and BTO contracts.

2 Increases in prices, fees and other charges must be agreed and provided for in BOT or BTO contracts. Any changes in prices or fees or other charger shall be subject to a XX-day notice to the authorized State body.

Any changes in prices, fees or other charges other than those contemplated and agreed in contracts shall be subject to the authorized State body prior to implementation

ARTICLE 14

1 The duration of a BOT or BTO contract, the time limit for transfer of a BOTor BTO project and the duration of operation of a BTO project shall be agreed upon by the parties and parties and

specified in the Investment License in accordance with the laws in relation to foreign investment in Zambia

2 Upon the expiry of the duration of operation of a BOT project, the foreign investor(s) shall transfer the project to the State of Zambia without compensation. With respect to a BTO project, the foreign investor(s) transfer the project the State of Zambia in accordance with the term and conditions stipulated in the BTO contract upon completion of construction.

3 The complement state body shall take over BOTor BTO project transfer accordance with the Regulation.

ARTICLE 15

Upon transfer of project to the state of Zambia, the authorized state body and BOT enterprises must check again the terms and condition stipulated in the investment license and the BOTor BTO project. The file for hand over of the project shall contain the following main issues:

- The condition of the project upon transfer,
- The list of assets transferred. Including documents relating to surveys designs, construction, installation, operation, maintenance and management of the project.
- The written report on evaluation of the value and quantity of the project transferred.
- The responsible of the parties for the continued operation of the project transferred.
- The duration, condition for maintenance and warranty of the project after being transferred.

ARTICLE 16

Before a BOT or BTO project is transferred, the BOT enterprises must carry out any maintenance, repair and necessary technical activities to transfer the projects as agreed in the BOT or BTO contract.

The authorized State body shall only take over the project in accordance with the terms and conditions stipulated in the BOT or BTO contract and the investment license.

CHAPTER IV BOT AND BTO CONTRACTS AND SUB -CONTRACTS

ARTICLE 17

1 A BOTor BTO contracts shall contain the followings:

- Nationalities, address and authorized representatives of the contracts;
- Objectives and scope of operations;
- Investment capital , schedule of implement;
- Capacity , technology and equipment; requirement for designs and technical Standard of the project; quality standard and control and supervisions of the quality of the project
- Provisions regarding environment protection;
- Terms and conditions relating to the use of land infrastructure and support facilities necessary for construction and operation;
- Schedule for construction of the project, the duration of operation of the BOT enterprises and the time upon which the project shall be transferred;
- Right and obligations of the parties ; undertaking to provide guaranty and to share risk between two parties;
- Provision regarding price, fees and other charges;

Obligation to maintain normal operations of the project;

Consultancy and evaluation of design, equipment, construction, acceptance , operation, and maintenance;
Technical conditions, status of operation, quality of the project upon transfer; principles used for determination of the value of the project and order of the transfer of the project;
Validity of the contract circumstance of early termination of the contract; provisions regarding assignment of the contract;
Body and method of resolution of disputes between parties to the contract; distribution of risks between the BOT company and government body;
Dealing with breaches by the parties causing failure to perform the term and condition of the contract.

Event of Force majeure and principles of remedy;

Provision regarding the assistance and undertakings of the government;

Conditions for implement of other projects in the case of the BT contract

2 For purpose of carrying out a BOTor BTO project, a BOT enterprises may enter into contracts for land use, construction installation, of machinery, equipment, consultancy service, inspection, purchase of materials, sale of main products and service, provision of technical service, loans. Pledge or mortgage of assets and other contracts in accordance with the law of Zambia

3 Where there is no provisions in the law of Vietnam governing the relations relating to investment on the basic of a BOT or BTO contract, the parties may agree in the contract upon the application of foreign law provided that such agreement shall not be contrary to the provision of the laws of Zambia

CHAPTER V RIGHTS AND OBLIGATIONS OF THE AUTHORIZED STATE BODY

ARTICLE 18

The authorized State body shall have the following powers

- To determine economic and technical targets of projects and to organize the consideration and approval of pre-feasibility studies
- To negotiates, agree and decide the contents of BOTand BTO contracts;
- To co-ordinate with the Ministry of Construction, other ministries, sectors and provinces and cities under central authority in the consideration and evaluation of technical designs of projects;
- To organizes the supervision of construction and participates in the acceptance of quality of construction works during the course of construction;
- To approve contracts for purchase of materials and sale of main products and services signed by BOT Enterprises and Zambian specialized economic organizations in cases where these contracts require a guarantee as referred to in clause 2 of article 10 of these Regulations;
- To supervises the parties in the performance of their obligations undertaken in BOTand BTO contracts and sub-contracts;
- To take over the project transferred as stipulated

ARTICLE 19

The authorized State body shall have the following responsibilities:

- To provide support to foreign investors in the preparation and implementation of BOTand BTO projects;
- To provide support to BOT enterprises in the completion of procedures for preparation for investment, construction and operation (if any) in accordance with BOTand BTO contracts and sub-contracts,
- To assume the responsibility for or to co-ordinate with other State bodies in the consideration and resolution of legitimate requirements of BOT enterprises during the implementation of BOTand BTO projects.
- To performs the obligations undertaken in BOTand BTO contracts.
- To perform other duties related to the management and administration of actives under BOTand BTO projects in accordance with law

Appendix M

Pollution Control Regulations in Zambia (1)

APPENDIX M

POLLUTION CONTROL REGULATIONS IN ZAMBIA (1)

1. ENVIRONMENTAL PROTECTION AND POLLUTION CONTROL ACT (EPPCA 1990), CAP 204 OF THE LAWS OF ZAMBIA, AMENDMENT ACT, 1999

The Environmental Protection and Pollution Control Act (EPPCA), Cap 204, Part IV to VIII sets the role of ECZ in setting environmental quality standards for waste, water, air, pesticides, toxic substances, noise, ionizing radiation and natural resources conservation and the ECZ is responsible for the enforcement of the EPPCA.

2. AIR POLLUTION CONTROL (LICENCING AND EMISSIONS STANDARDS) REGULATIONS, 1996:

Regulation 3: Ambient air quality guidelines: The Council shall, in accordance with the guidelines set out in *Table M.1*, assess the quality of ambient air in order to safeguard the general health, safety or welfare of persons, animal life, plant life or property affected by the workers, industrial or business activities undertaken by an operator.

Table M.1 Guideline Limits for Ambient Air Pollutions

Parameter	Reference Time		Guideline Limit
Sulphur dioxide (SO_2)	10 minutes		500 micro-g/m^3
	1 hour		350 micro-g/m^3
Sulphur dioxide (SO_2) in combination with Total Suspended Particles (TSP)*1) and PM_{10}	SO_2	24 hours	125 micro-g/m^3
		6 months	50 micro-g/m^3
	TSP	24 hours	120 micro-g/m^3
		6 months	50 micro-g/m^3
	PM_{10}	24 hours	70 micro-g/m^3
Respirable particulate matter PM10*2)	PM_{10}	24 hours	70 micro-g/m^3
Oxides of nitrogen (NO_x) as nitrogen dioxide (NO_2)	1 hour		400 micro-g/m^3
	24 hours		150 micro-g/m^3
Carbon monoxide (CO)	15 minutes		100 mg/m^3
	30minutes		60 mg/m^3
	1 hour		30 mg/m^3
	8 hours		10 mg/m^3
Ambient Lead (Pb)	3 months		1.5 micro-g/m^3
	12 months		1.0 micro-g/m^3
Dustfall	30 days		7.5 tonnes/km^2

*1) Total suspended particles (TSP) are particles with diameter less than 45 micrometers.
*2) Respirable particles (PM10) are particles with diameter less than 10 micrometers. These can deeply penetrate to the lung.
Note: Reference times are the 98th percentile averaging times.

Regulation 4: Long term emission limits: The long term emission limits shall be as set out in *Table M.2*.

Table M.2 Long-Term Emission Limits for Air Pollution by Type of Industry/Process

	Industry/Process	Parameter	Long-Term Emission Limit
A	Copper Production		
1.	Smelters and Converters	Sulphur dioxide (SO_2)	1000 mg/Nm^3
		Dust	50 mg/Nm^3
2.	Coal preparation	Dust	50 mg/Nm^3
3.	Concentrate dryer	Dust	50 mg/Nm^3
		SO_2	500 mg/Nm^3
4.	(Heavy Metal Content in Dust)	Arsenic (As)	0.5 mg/Nm^3
		Cadmium (Cd)	0.05 mg/Nm^3
		Copper (Cu)	1.0 mg/Nm^3
		Lead (Pb)	0.2 mg/Nm^3
		Mercury	0.05 mg/Nm^3
B	Cement and Lime Production		
1.	Cement production	Dust	50 mg/Nm^3
2.	Lime production	Dust	50 mg/Nm^3
C	Nitric Acid and Sulphuric Acid Production		
1.	Nitric acid production	NOx as NO_2	100-1,400 kg/day
2.	Sulphuric acid production	SO_2	700-4,300 kg/day
D	Fertiliser Production		
1.	Ammonium nitrate production	Dust	500 kg/day
2.	Coal treatment	Dust	150 kg/day
3.	NPK production	Dust	100 kg/day
E	Combustion Units		
1.	Oil fired <50 MW (2)	Dust	50-150 mg/Nm^3 (3)
		SO_2	850 mg/Nm^3
		CO	100 mg/Nm^3
2.	Coal fired <10 MW (2)	Dust	150 mg/Nm^3
		SO_2	2000 mg/Nm^3
3.	Coal fired 10~50 MW (2)	Dust	50 mg/Nm^3
		SO_2	1000 mg/Nm^3
		CO	175 mg/Nm^3
F	Other Processes		

1. The limits are normalised to 273K, 101.3 Pa and 3 Vol-% O_2
2. The limits are normalised to 273K, 101.3 Pa and 7 Vol-% O_2
3. Stricter limits for light oil, less strict limits for heavy oil. Smaller combustion units need limits less strict than larger units. For this reason the Inspectorate will prescribe limits based on this range on a case to case basis.
4. CO limits are not necessary for oil combustion units <5MW and coal combustion units <1 MW.

3. WATER POLLUTION CONTROL (EFFLUENT AND WASTE WATER) REGULATIONS, 1993:

Regulation 5(2): The licence to discharge effluent into the aquatic environment shall conform to the conditions and standards for chemical and physical parameters contained in the table of standards for effluent and waste water, set out in *Table M.3*:

Table M.3 Standards (Limits) for Effluents and Waste Water

	Parameter	Standards (limits)
A	Physical	
1.	Temperature (Thermometer)	40°C at point of entry
2.	Colour (Hazen Units)	20 Hazen units
3.	Odour or Taste (Threshold odour number)	Must not cause any deterioration in taste or odour as compared with natural state
4.	Turbidity (NTU scale)	15 Nephelometer turbidity units
5.	Total suspended solids (Gravimetric method)	100 mg/L must not cause formation of sludge or scum in receiving water
6.	Settleable matter sedimentation in 2 hours (Imhoff funnel)	0.5 mg/L in two hours. Must not cause formation of sludge in receiving water
7.	Total Dissolved Solids (Evaporation at 105°C and Gravimetric method)	3000 mg/L the TDS of waste water must not adversely affect surface water
8.	Conductivity (Electrometric method)	4300 microS/cm
B	Bacteriological	
9.	Total Coliform/100 ml (Membrane Filtration method)	2500
10.	Faecal Coliform/100ml (Membrane Filtration method)	5000
11.	Algae/100 ml (Colony counter)	1000 cells
C	Chemical	
12.	pH (0-14 scale) (Electro-metric method)	6.0-9.0
13.	Dissolved oxygen mg Oxygen/L (Modified Winkler method and membrane electrode method)	5 mg/L after complete mixing extreme temperature may result in lower values
14.	Chemical Oxygen Demand (COD) (Dichromate method)	COD based on the limiting values for organic carbon 90 mg O_2/L average for 24 hours
15.	Biochemical Oxygen Demand (BOD) (Modified Winkler method and Membrane Electrode method)	50 mg O_2/L (mean value over 24 hours period) according to circumstances in relation to the self cleaning capacity of waters
16.	Nitrate (NO_3 as nitrogen) (Spectro-photometric method and electrometrict method)	The nitrates burden must be reduced as far as possible according to circumstance: water course 50 mg NO_3-N/L; Lakes 20 mg NO_3-N /L
17.	Nitrite (NO_2 as nitrogen Spectrometric sulphanilamide)	2.0 mg NO_2-N/L
18.	Organic Nitrogen (Spectrophotometric method N-Kjeldahl)	5.0 mg/L Mean* (* the % of nutrient elements for degradation of BOD should be 0.4-1% for phosphorous (different for processes using algae)
19.	Ammonia and ammonium (Total) (NH_3 as nitrogen) (Nesslerization method and Electrometric method)	The burden of ammonium salts must be reduced to 10 mg NH_3-N/L (depending upon temperature, pH and salinity)
20.	Cyanides (Spectrophotometric method)	0.2 mg/L
21.	Phosphorous (Total) (PO_4 as P/L)	Treatment installation located in the

	Parameter	Standards (limits)
	(colorimetric method)	catchment area of lakes: 1.0 mg/L; located outside the catchment area: reduced the load of P as low as possible (PO_4/L)
22.	Sulphates (Turbidimetric method)	Sulphate burden must be reduced to 1500 mg/L
23.	Sulphite (Iodometric method)	0.1 mg/L (presence of Oxygen changes SO_3 to SO_4)
24.	Sulphide (Iodometric and electrometric method)	0.1 mg/L (depending on temperature, pH and dissolved O_2)
25.	Chlorides Cl/L (Silver nitrate and Mercuric nitrate)	Chloride levels must be 800 mg/L
26.	Active chlorine Cl2/L (Iodometric method)	0.5 mg/L
27.	Active bromine (Br_2/L)	0.1 mg/L
28.	Fluorides F/L (Electro-metric method and Colorimetric method with distillation)	2.0 mg/L
D	Metals	
29.	Aluminum compounds (Atomic absorption method)	2.5 mg/L
30	Antimony (Atomic absorption method)	0.5 mg/L
31	Arsenic compounds (Atomic absorption method)	0.05 mg/L
32.	Barium compounds (water soluble concentration) (Atomic absorption method)	0.5 mg/L
33.	Beryllium salts and compounds (Atomic absorption method)	0.5 mg/L
34.	Boron compounds (Spectrophotometric method – curcumin method)	0.5 mg/L
35.	Cadmium compounds (Atomic absorption method)	0.5 mg/L
36.	Chromium Hexavalent, Trivalent (Atomic absorption method)	0.1 mg/L
37.	Cobalt compounds (Atomic absorption method)	1.0 mg/L
38.	Copper compounds (Atomic absorption method)	1.5 mg/L
39.	Iron compounds (Atomic absorption method)	2.0 mg/L
40.	Lead compounds (Atomic absorption method)	0.5 mg/L
41.	Magnesium (Atomic absorption method and flame photometric method)	500 mg/L
42.	Manganese (Atomic absorption method)	1.0 mg/L
43.	Mercury (Atomic absorption method)	0.002 mg/L
44.	Molybdenum (Atomic absorption method)	5.0 mg/L
45.	Nickel (Atomic absorption method)	0.5 mg/L
46.	Selenium (Atomic absorption method)	0.02 mg/L
47.	Silver (Atomic absorption method)	0.1 mg/L
48.	Thallium (Atomic absorption method)	0.5 mg/L

	Parameter	Standards (limits)
49.	Tin compounds (Atomic absorption method)	2.0 mg/L
50.	Vanadium compounds (Atomic absorption method)	1.0 mg/L
51.	Zinc compounds (Atomic absorption method)	10 mg
E	Organics	
52.	Total hydrocarbons (Chromatographic method)	10.0 mg/L
53.	Oils (Mineral and Crude) (Chromatographic method and Gravimetric method)	5.0 mg/L
54.	Phenols (steam distillable) (Colorimetric method)	0.2 mg/L
	(Non-steam distilled) (Colorimetric method)	0.05 mg/L
55.	Fats and saponifiable oils (Gravimetric method and chromatographic method)	20 mg/L
56.	Detergents (Atomic) (Atomic absorption method)	2.0 mg/L (Detergents should contain at least biodegradable compounds
57.	Pesticides and PCB's (Total) (Chromatographic method)	0.5 mg/L
58.	Trihalomethanes (Chromatographic)	0.5 mg/L
F	Radioactive Materials	
59.	Radioactive materials specified by International Atomic Energy Agency	No discharge accepted

4. LOCAL ADMINISTRATION (TRADE EFFLUENT) REGULATIONS BY THE MINISTER CAP. 281 STATUTORY INSTRUMENT 161 OF 1985

Regulation 4: Any discharge of trade effluent into a public sewer shall conform to the conditions and standards for chemical and physical parameters set out in column 2 of the *Table M.4.*

Table M.4 Standards (Limits) for Trade Effluent into Public Sewer

	Parameter	Standards (limits)
A	Physical	
1.	Temperature (Thermometer)	<40°C
2.	Color (Hazen Units)	-
3.	Odor and Taste (Threshold odor number)	The odor must not cause any nuisance
4.	Total suspended solids (Gravimetric method)	1200mg/L
5.	Settleable matter (Imhoff funnel)	1.0 ml/L
6.	Salinity/Residue (Evaporation and Gravimetric method)	7500 mg/L
B	Chemical	
7.	pH (0-14 scale) (Electro-metric method)	6-10
8.	Dissolved oxygen mg Oxygen/L	No requirements
9.	Chemical Oxygen Demand (COD) (Dichromate method)	1800 mg O_2/L
10.	Biochemical Oxygen Demand (BOD)	1200 mg O_2/L
11.	Nitrate (NO_3 as nitrogen)	80 mg NO_3-N/L

	Parameter	Standards (limits)
12.	Nitrite (NO_2 as nitrogen)	10.0 mg NO_2-N/L
13.	Organic Nitrogen	300 mgN/L
14.	Ammonia and ammonium (NH_3 as nitrogen)	50 mg NH_3-N/L
15.	Cyanides	0.5 mg/L
16.	Sulphates (Turbidimetric method)	500 mg/L
17	Sulphite (Iodometric method)	10 mg/L
18.	Sulphide	1 mg/L
19.	Chlorides Cl/L	1000 mg/L
20.	Active chlorine Cl_2/L	0.5-3.0mg/L
21.	Active bromine (Br_2/L)	0.5-3.0 mg/L
22.	Fluorides F/L	<30 mg/L
C	Metals	
23.	Aluminium compounds	20 mg/L
24.	Antimony	-
25.	Arsenic compounds	1.0 mg/L
26.	Barium compounds	1.0 mg/L
27.	Beryllium salts and compounds	0.5 mg/L
28.	Boron compounds	50 mg/L
29.	Cadmium compounds	1.5 mg/L
30.	Chromium Hexavalent, Trivalent	5.0 mg/L
31.	Cobalt compounds	0.5 mg/L
32.	Copper compounds	3.0 mg/L
33.	Iron compounds	15.0 mg/L
34.	Lead compounds	1.5 mg/L
35.	Magnesium	1000 mg/L
36.	Manganese	10 mg/L
37.	Mercury	0.01 mg/L
38.	Molybdenum	5.0 mg/L
39.	Nickel	2.0 mg/L
40.	Selenium	1.0 mg/L
41.	Silver	0.1 mg/L
42.	Thallium	1.0 mg/L
43.	Tin compounds	2.0 mg/L
44.	Vanadium compounds	1.0 mg/L
45.	Zinc compounds	25.0 mg
D	Organics	
46.	Total hydrocarbons	20.0 mg/L
47.	Oils	100 mg/L (after installation of oil separators)
48.	Phenols	5.0 mg/L
49.	Fats and saponifiable oils	No requirement but installation of oil and grease separators)
50.	Detergents	10.0 mg/L
51.	Pesticides and PCB's	1.0 mg/L
52.	Trihalomethanes (Chromatographic)	1.0 mg/L
E	Radioactive Materials	
53.	Radioactive materials specified by International Atomic Energy Agency	No discharge accepted

5. HAZARDOUS WASTE MANAGEMENT REGULATIONS (STATUTORY INSTRUMENT NO125 OF 2001)

Regulation 3 (1) Application: These Regulations apply to the control and monitoring of generation, collection, storage, transportation, pre-treatment, treatment, disposal, export, import and trans-boundary movement of hazardous waste as listed in *Table M.5* or any waste specified in *Table M.7*, if that waste exhibits characteristics found in *Table M.6* to these Regulations.

Table M.5 List of Hazardous Waste

A1	**Metal or metal bearing waste**
ECZ A1010	Metal wastes and wastes containing alloys of arsenic, cadmium, lead, mercury, selenium.
ECZ A1020	Wastes having as constituents or contaminated (excluding metal wastes in massive form) with cadmium, lead, selenium or their compounds.
ECZ A1040	Wastes having as constituents hexavalent chromium.
ECZ A1060	Waste liquors from pickling of metals
ECZ A1070	Leaching residues, dust and sludge from zinc processing.
ECZ A1090	Ashes from the incineration of insulated copper wire.
ECZ A1160	Waste lead-acid batteries.
ECZ A1180	Waste electrical or electronic assemblies or scrap containing accumulator or other batteries, mercury switches, activated glass, polychlorinated biphenyls (PCBs), or contaminated with materials having hazard characteristics listed in Schedule 4.
A2	**Wastes containing in-organic constituents**
ECZ A2020	Waste (spent) catalysits
ECZ A2050	Waste Asbestos
A3	**Organic**
ECZ A3020	Waste mineral oils, including that contaminated by polychlorinated biphenyls (PCBs)
ECZ A3140	Waste non-halogenated organic solvents.
ECZ A3150	Waste halogenated organic solvents.
ECZ A3180	Waste containing polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCTs), polychlorinated naphthalanes (PCNs), polybrominated biphenyls(PBBs).
ECZ A4010	Waste from pharmaceuticals
ECZ A4020	Waste from clinics and other related wastes (medical, veterinary, investigations and research), excludes office and kitchen wastes.
ECZ A4040	Wood preservation chemicals
ECZ A4050	Inorganic or organic cyanides
ECZ A4070	Wastes from inks, dyes, pigments, and paints.
ECZ A4080	Explosive wastes
ECZ A4150	Chemicals from research and development, and teaching.

Table M.6 List of Hazardous Characteristics

UN Class	Code	Characteristics
I	H1	**Explosive** An explosive substance or waste is a solid or liquid substance or waste (or mixture of substances or wastes) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such speed as to cause damage to the surroundings.
3	H3	**Flammable liquids** The word "flammable" has the same meaning as inflammable." Flammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc., but not including substances or wastes otherwise classified on account of their dangerous characteristics) which give off a flammable vapor at temperatures of not more than 60.5^{o} C, closed-cup test, or not more than 65.6^{o}C, open-cup test. (Since the results of open-cup tests and of closed-cup tests are not strictly comparable and even individual results by the same test are often variable, regulations varying from the above figures to make allowance for such differences would be within the spirit of this definition.)
4.1	H4.1	**Flammable solids** Solids, or waste solids, other than those classed as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.
4.2	H4.2	**Substances or wastes liable to spontaneous combustion** Substances or wastes, which are liable to spontaneous heating under normal conditions, encountered in transport, or to heating upon contact with air, and being then liable to catch fire.
4.3	H4.3	**Substances or wastes, which, in contact with water emit flammable gases** Substances or wastes, which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.
5.1	H5.1	**Oxidizing** Substances or wastes which, while in themselves not necessarily combustible, may, generally by yielding oxygen cause, or contribute to, the combustion of other materials.
5.2	H5.2	**Organic Peroxides** Organic substances or wastes, which contain the bivalent-O-O- structure, are thermally unstable substances, which may undergo exothermic self-accelerating decomposition.

UN Class	Code	Characteristics
6.1	H6.1	**Poisonous (Acute)** Substances or wastes liable either to cause death or serious injury or to harm health if swallowed or inhaled or by skin contact
6.2	H6.2	**Infectious substances** Substances or wastes containing viable micro-organisms or their toxins which are or known or suspected to cause disease in animals or humans.
8	H8	**Corrosives** Substances or wastes which, by chemical action, will cause severe damage when in contact with living tissue, or, in the case of leakage, will materially damage, or even destroy, other goods or the means of transport; they may also cause other hazards.
9	H10	**Liberation of toxic gases in contact with air or water** Substances or wastes, which, by interaction with air or water, are liable to give off toxic gases in dangerous quantities.
9	H11	**Toxic (Delayed or chronic)** Substances or wastes which, if they are inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity.
9	H12	**Exotoxic** Substances or wastes which if released present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic systems.
9	H13	**Capable, by any means, after disposal, of yielding other material,** e.g., leachate, which possesses any of the characteristics listed above.

Table M.7 Categories of Wastes to be Controlled

Waste Streams	
Y1	Clinical wastes from medical care in hospitals, medical centers and clinics
Y2	Wastes from the production and preparation of pharmaceutical products
Y3	Waste pharmaceuticals, drugs and medicines
Y4	Wastes from the production, formulation and use of biocides and phytopharmaceuticals
Y5	Wastes from the manufacture, formulation and use of wood preserving chemicals
Y6	Wastes from the production, formulation and use of organic solvents
Y7	Wastes from heat treatment and tempering operations containing cyanides
Y8	Waste mineral oils unfit for their originally intended use
Y9	Waste oils/water, hydrocarbons/water mixtures, emulsions
Y10	Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
Y11	Waste tarry residues arising from refining, distillation and any pyrolytic treatment
Y12	Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish

Waste Streams	
Y13	Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
Y14	Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known
Y15	Wastes of an explosive nature not subject to other legislation
Y16	Wastes from production, formulation and use of photographic chemicals and processing materials
Y17	Wastes resulting from surface treatment of metals and plastics
Y18	Residues arising from industrial waste disposal operations
Waste having as constituents:	
Y19	Metal carbonyls
Y20	Beryllium; beryllium compounds
Y21	Hexavalent chromium compounds
Y22	Copper compounds
Y23	Zinc compounds
Y24	Arsenic; arsenic compounds
Y25	Selenium; selenium compounds
Y26	Cadmium; cadmium compounds
Y27	Antimony; antimony compounds
Y28	Tellurium; tellurium compounds
Y29	Mercury; mercury compounds
Y30	Thallium; thallium compounds
Y31	Lead; lead compounds
Y32	Inorganic fluorine compounds excluding calcium fluoride
Y33	Inorganic cyanides
Y34	Acidic solutions or acids in solid form
Y35	Basic solutions or bases in solid form
Y36	Asbestos (dust and fibers)
Y37	Organic phosphorus compounds
Y38	Organic cyanides
Y39	Phenols; phenol compounds including chlorophenols
Y40	Ethers
Y41	Halogenated organic solvents
Y42	Organic solvents excluding halogenated solvents
Y43	Any congener of polychlorinated dibenzofuran
Y44	Any congener of polychlorinated dibenzo-p-dioxin
Y45	Organohalogen compounds other than substances referred to in this schedule (e.g. Y39,Y41, Y42, Y43, Y44)

Appendix N

Pollution Control Regulations in Zambia (2)

APPENDIX N

POLLUTION CONTROL REGULATIONS IN ZAMBIA (2)

1. WORLD HEALTH ORGANIZATION (WHO) GUIDELINES FOR DRINKING WATER

Since Zambia does not have a standard or a guideline for drinking water, the WHO guidelines for drinking water are shown in *Table N.1*:

Table N.1 Guideline Values for Chemicals that are of Health Significance in Drinking-Water

Chemical	Guideline value a(mg/liter)	Remarks
Acrylamide	0.0005b	
Alachlor	0.02b	
Aldicarb	0.01	Applies to aldicarb sulfoxide and aldicarb sulfone
Aldrin and dieldrin	0.00003	For combined aldrin plus dieldrin
Antimony	0.02	
Arsenic	0.01 (P)	
Atrazine	0.002	
Barium	0.7	
Benzene	0.01b	
Benzo[*a*]pyrene	0.0007b	
Boron	0.5 (T)	
Bromate	0.01b (A, T)	
Bromodichloromethane	0.06b	
Bromoform	0.1	
Cadmium	0.003	
Carbofuran	0.007	
Carbon tetrachloride	0.004	
Chlorate	0.7 (D)	
Chlordane	0.0002	
Chlorine	5 (C)	For effective disinfection, there should be a residual concentration of free chlorine of ≥0.5 mg/liter after at least 30 min contact time at pH <8.0
Chlorite	0.7 (D)	
Chloroform	0.3	
Chlorotoluron	0.03	
Chlorpyrifos	0.03	
Chromium	0.05 (P)	For total chromium
Copper	2	Staining of laundry and sanitary ware may occur below guideline value
Cyanazine	0.0006	
Cyanide	0.07	
Cyanogen chloride	0.07	For cyanide as total cyanogenic compounds

Chemical	Guideline value a(mg/liter)	Remarks
2,4-D (2,4-dichlorophenoxyacetic acid)	0.03	Applies to free acid
2,4-DB	0.09	
DDT and metabolites	0.001	
Di(2-ethylhexyl)phthalate	0.008	
Dibromoacetonitrile	0.07	
Dibromochloromethane	0.1	
Dibromo-3-chloropropane, 1,2-	0.001b	
Dibromoethane, 1,2-	0.0004b (P)	
Dichloroacetate	0.05b (T, D)	
Dichloroacetonitrile	0.02 (P)	
Dichlorobenzene, 1,2-	1 (C)	
Dichlorobenzene, 1,4-	0.3 (C)	
Dichloroethane, 1,2-	0.03b	
Dichloroethene, 1,2-	0.05	
Dichloromethane	0.02	
1,2-Dichloropropane (1,2-DCP)	0.04 (P)	
1,3-Dichloropropene	0.02b	
Dichlorprop	0.1	
Dimethoate	0.006	
Dioxane, 1,4-	0.05b	
Edetic acid (EDTA)	0.6	Applies to the free acid
Endrin	0.0006	
Epichlorohydrin	0.0004 (P)	
Ethylbenzene	0.3 (C)	
Fenoprop	0.009	
Fluoride	1.5	Volume of water consumed and intake from other sources should be considered when setting national standards
Hexachlorobutadiene	0.0006	
Isoproturon	0.009	
Lead	0.01	
Lindane	0.002	
Manganese	0.4 (C)	
MCPA	0.002	
Mecoprop	0.01	
Mercury	0.006	For inorganic mercury
Methoxychlor	0.02	
Metolachlor	0.01	
Microcystin-LR	0.001 (P)	For total microcystin-LR (free plus cellbound)
Molinate	0.006	
Molybdenum	0.07	
Monochloramine	3	
Monochloroacetate	0.02	
Nickel	0.07	
Nitrate (as NO3-)	50	Short-term exposure

Chemical	Guideline value a(mg/liter)	Remarks
Nitrilotriacetic acid (NTA)	0.2	
Nitrite (as NO2-)	3	Short-term exposure
	0.2 (P)	Long-term exposure
Pendimethalin	0.02	
Pentachlorophenol	0.009b (P)	
Permethrin	0.3	Only when used as a larvicide for public health purposes
Pyriproxyfen	0.3	
Selenium	0.01	
Simazine	0.002	
Styrene	0.02 (C)	
2,4,5-T	0.009	
Terbuthylazine	0.007	
Tetrachloroethene	0.04	
Toluene	0.7 (C)	
Trichloroacetate	0.2	
Trichloroethene	0.02 (P)	
Trichlorophenol, 2,4,6-	0.2b (C)	
Trifluralin	0.02	
Trihalomethanes	The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1	
Uranium	0.015 (P, T)	Only chemical aspects of uranium addressed
Vinyl chloride	0.0003b	
Xylenes	0.5 (C)	

[a] P = provisional guideline value, as there is evidence of a hazard, but the available information on health effects is limited; T = provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection, etc.; A = provisional guideline value because calculated guideline value is below the achievable quantification level; D = provisional guideline value because disinfection is likely to result in the guideline value being exceeded; C = concentrations of the substance at or below the health based guideline value may affect the appearance, taste or odor of the water, leading to consumer complaints.

b For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking-water associated with an upper-bound excess lifetime cancer risk of 10-5 (one additional cancer per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years).Concentrations associated with upper-bound estimated excess lifetime cancer risks of 10-4 and 10-6 can be calculated by multiplying and dividing, respectively, the guideline value by 10.

2. RESTRICTIONS ON PERMEATION OF SPECIFIED PERCOLATED WATER IN JAPAN

A business establishment where a factory in which harmful substances are produced, used or treated (Specified Factory) is installed (Specified Business Establishment) shall not permeate water containing harmful substances exceeding the standards shown in *Table N.2* (Specified Percolated Water).

Table N.2 Restrictions on Permeation of Specified Percolated Water (Water Pollution Control Law Article 12-3; Environment Agency Notice No.39 appended table) in Japan

Harmful Substance	Standards on Permeation of Specified Percolated Water (mg/L)
Cadmium and its compounds	0.001 as Cadmium
Cyanide compounds	0.1 as cyan
Organophosphate compounds (Parathion, methylparathion, methyl dimethone and EPN)	0.1
Lead and its compounds	0.005 as lead
Chromium (VI) compounds	0.004 as chromium (VI)
Arsenic and its compounds	0.005 as arsenic
Mercury, alkyl-mercury and other compounds	0.0005 as mercury
Alkyl-mercuric compounds	0.0005 as alkyl-mercury
Polychlorinated biphenyl	0.0005
Trichloroethylene	0.002
Tetrachloroethylene	0.0005
Dichloromethane	0.002
Carbon tetrachloride	0.0005
1,2-dichloroethane	0.0004
1,1-dichloroethylene	0.002
Cis-1,2-dichloroethylene	0.004
1,1,1-trichloroethane	0.0005
1,1,2-trichloroethane	0.0006
1,3-dichloropropene	0.0002
Tiuram	0.0006
Simazine	0.0003
Thiobencarb	0.002
Benzene	0.001
Selene and its compounds	0.002 as selene
Boron and its compounds	0.2 as boron
Fluor and its compounds	0.2 as fluor
Ammonia, ammonium compounds, nitrite compounds, and nitrate compounds	Ammonium-nitrogen 0.7
	Nitrite-nitrogen 0.2
	Nitrate-nitrogen 0.2

3. ENVIRONMENTAL QUALITY STANDARDS FOR NOISE IN JAPAN

Since there are no environmental quality standards for noise in Zambia, the Japanese environmental quality standards for noise will be used as environmental quality criteria of this project. The Japanese environmental quality standards are shown in *Table N.3* and *Table N.4*:

Table N.3 Environmental Quality Standards for Noise for each Area Type and Time Category in Japan

Type of area	Standard value dB(A)	
	Daytime (from 6:00 am to 10:00pm)	Nighttime (from 10:00 p.m. to 6:00 a.m.)
AA	50 or less	40 or less
A and B	55 or less	45 or less
C	60 or less	50 or less

a) Area category AA shall be applied to areas where quietness is specially required, such as those where convalescent facilities and welfare institutions are concentrated.
b) Area category A shall be applied to areas used exclusively for residences.
c) Area category B shall be applied to areas used mainly for residences.
d) Area category C shall be applied to areas used for commerce and industry as well as for a significant number of residences.

Table N.4 Environmental Quality Standards for Noise for Area Facing Roads in Japan

Area category	Standard value dB(A)	
	Daytime	Nighttime
Area A facing roads with two or more lanes	60 or less	55 or less
Area B facing roads with two or more lanes, and area C facing a road with one or more lanes	65 or less	60 or less

Note: "Lane" refers to a longitudinal strip of road with uniform width to enable a single line of cars to travel safely and without hindrance.

The Japanese standard of noise for construction work shall not exceed 85dB(A) at a site borderline of a construction work. This standard of noise shall be only permitted from 7 o'clock in the morning to 7 o'clock in the evening on the week days. This standard shall be used as criteria of noise.

4. CRITERIA FOR A-WEIGHTED SOUND LEVEL FROM THE WORLD HEALTH ORGANIZATION

The World Health Organization (WHO), an agency of the United Nations, recommends a 16-hour daytime average sound level of not more than 55 dB and, approximately, an 8-h nighttime average sound level of not more than 45 dB to prevent "serious annoyance" in residential areas. A-frequency-weighted sound level from any single sound source should not exceed 60 dB to avoid disruption of sleep. *Table N.5* summarizes the recommendations of the WHO regarding noise levels in residential areas for avoidance of serious and moderate annoyance.

Table N.5 Criteria for A-weighted Sound Level from the World Health Organization for Assessment of Annoyance to Sources of Environmental Noise in Residential Areas

Impact characterization	16-h daytime average sound level (dB)	8-h nighttime average sound level (dB)	Nighttime maximum sound level (dB)
Serious annoyance	55	45	60
Moderate annoyance	50	40	60

Note: Criteria for maximum sound levels are for protection against disruption of sleep. Actual sound levels should not exceed the criterion levels to avoid serious or moderate annoyance.

5. CRITERIA FOR A-WEIGHTED SOUND LEVEL FROM THE WORLD BANK GROUP

The World Bank Group (WBG) has a strong program in pollution management so as to ensure that their projects in developing countries are environmentally acceptable. Noise is one of the pollutants covered by their policy. *Table N.6* shows the WBG limits for A-weighted sound level at locations outside the boundary of general industrial projects including foundries, iron and steel manufacturing, and thermal power plants for which the World Bank Group provides, or guarantees, loans.

Table N.6 WBG Limits on A-weighted Sound Level at Receptor Location outside the Boundary of an Industrial Project for which WBG Money is lent

Receptor	Time period	Time-period average sound level (dB)
Residential, institutional, educational	Daytime Nighttime	55 45
Industrial, commercial	Daytime Nighttime	70 70

6. WORLD HEALTH ORGANIZATION (WHO) AIR QUALITY GUIDELINES FOR EUROPE

The numerical guideline values (in Table N.7) and the risk estimates for carcinogens (in Table N.8) should be regarded as the shortest possible summary of a complex scientific evaluation process. They are proposed in order to help avoid major discrepancies in reaching the goal of effective protection against recognized hazards for human health and the environment.

Table N.7 Guideline Values for Individual Substances (Eliminating NO_2, SO_2 and CO) based on Effects other than cancer or Odour/annoyance

Substance	Time-weighted average	Averaging time
Cadmium	5 ng/m^3 [a]	annual
Carbon disulfide	100 micro-g/m^3	24 hours
1,2-Dichloroethane [b]	0.7 mg/m^3	24 hours
Dichloromethane	3 mg/m^3	24 hours
Dichloromethane	0.45 mg/m^3	1 week
Formaldehyde	0.1 mg/m^3	30 minutes
Hydrogen sulfide [b]	150 micro-g/m^3	24 hours
Lead	0.5 micro-g/m^3	annual
Manganese	0.15 micro-g/m^3	annual
Mercury	1 micro-g/m^3	annual
Ozone	120 micro-g/m^3	8 hours
Styrene	0.26 mg/m^3	1 week
Tetrachloroethylene	0.25 mg/m^3	annual
Toluene	0.26 mg/m^3	1 week
Vanadium [b]	1 micro-g/m^3	24 hours

a The guideline value is based on the prevention of a further increase of cadmium in agricultural soils, which is likely to increase the dietary intake.

b Not re-evaluated for the second edition of the guidelines.

Source: Air Quality Guidelines for Europe 2nd Edition, World Health Organization Regional Office for Europe, Copenhagen

Table N.8 Carcinogenic Risk Estimate based on Human Studies [a]

Substance	IARC Group	Unit Risk [b]	Site of tumour
Acrylonitrile [c]	2A	$2x10^{-5}$	lung
Arsenic	1	$1.5x10^{-3}$	lung
Benzene	1	6x10-6	Blood (leukaemia)
Butadiene	2A	-	multisite
Chromium (VI)	1	$4x10^{-2}$	lung
Nickel compounds	1	$4x10^{-2}$	lung

Substance	IARC Group	Unit Risk [b]	Site of tumour
Polycyclic aromatic hydrocarbons (BaP) [d]	-	$9x10^{-2}$	lung
Refractory ceramic fibres	2B	1x10-6 (fibre/l)$^{-1}$	lung
Trichloroethylene	2A	4.3x10-7	Lung, testis
Vinyl chloride [c]	1	$1x10^{-6}$	Liver and other sites

a Calculated with average relative risk model.

b Cancer risk estimates for lifetime exposure to a concentration of 1 μg/m^3.

c Not re-evaluated for the second edition of the guidelines.

d Expressed as benzo[a]pyrene (based on a benzo[a]pyrene concentration of 1 μg/m^3 in air as a component of benzene-soluble coke-oven emissions).

Group 1(carcinogenic in humans), Group 2A (probably carcinogenic), Group 2B (possibly carcinogenic),Group 3 (not classifiable), and Group 4 (probably not carcinogenic).

Source: Air Quality Guidelines for Europe 2nd Edition, World Health Organization Regional Office for Europe, Copenhagen

Appendix O

Past Practices on Involuntary Resettlement in Zambia

APPENDIX O

PAST PRACTICES ON INVOLUNTARY RESETTLEMENT IN ZAMBIA

1. WORLD BANK PROJECTS

World Bank requires a recipient county to treat involuntary resettlement following the WB Policy, when involuntary resettlement is involved in a project. And a recipient country should submit a resettlement policy framework as a condition of appraisal.

Lusaka Water and Sewerage Company made a resettlement policy framework for Water Sector Performance Improvement Project (WSPIP). The Ministry of Agriculture and Cooperatives also made another resettlement policy framework for Agricultural Development Support Project for Smallholder Commercialization.

These two examples are summarized in *Table O.1*.

Table O.1 Summary of the Two Resettlement Policy Framework

Project Name	Implementing Agency	Date of the Framework Issued	Project Outline	Resettlement Policy Framework
Agriculture Development Support Project for Smallholder Commercialization (ADSP-SC)	Ministry of Agriculture and Cooperatives	Dec.2005	To enhance smallholder agriculture commercialization by improving sales and incomes of farmers. It is thought that mainly to improve feeder roads need acquire land and involve involuntary resettlement. (Exact project site was not decided as of Dec.2005)	The two frameworks confirm the WB Policy by defining displaced persons/; Taking land results in (i)Relocation or loss of shelter (ii) Loss of assets or access to assets (iii) Loss of income source or means of livelihood -WB Policy recognizes informal occupancy as a form of customary tenure. Meanwhile, Zambian Law does not. This recognition following the WB Policy allows so called squatters, who have no land title or do not own the land under customary arraignments to have right to be compensated, if they have established informal occupancy before a cut-off-date of the project. Having no formal title to land does not affect the eligibility of compensation and other assistance, such as credit facilities, training, and job opportunities. -If WB Policy and Zambian legislation conflict, the higher standard will be applied on that grounds that the other standard is already met as a consequence. - Affected persons should note be only informed and consulted on resettlement and compensation options, but also involved in the selection of supporting options, such as relocation sites or measures of livelihood.
Water Sector Performance Improvement Project (WSPIP)	Lusaka Water and Sewerage Company (LWSC)	Apr.2006	To improve provision of services for sustainable water supply and sanitation in Lusaka. Civil works and construction may result in involuntary resettlement. Encroachment were identified in the land hold by LWSC during the preliminary survey	

The two resettlement policy frameworks state that if WB Policy and Zambian legislation conflict, the higher standard will be applied on that grounds that the other standard is already met as a consequence. Then, even squatters, who have no formal title to the land they occupy, can be given compensation or other assistance.

2. PRIVATE SECTORS

The private sector deals with involuntary resettlement as follows. The standpoint of enterprises toward the environment and society come now under scrutiny and they cannot seek only a profit. Enterprises are now expected to contribute the society and to implement corporate social responsibility (CSR) activities. Therefore, the private sector also follows the international standards, such as the WB Policy or International Finance Cooperation (IFC) Performance Standards.

(1) Sanje Hill Iron Ore Mine Development by Universal Mining and Chemicals Industries Limited

The developer submitted an EIA statement report on Sanje Hill Iron Ore Mine development (45 kilometers south-west of Lusaka) on June 2006. Resettlement Action Plan (RAP) was prepared as a part of the EIA by Advocacy for the Restoration of Environment in collaboration with the developer. In the process of making the RAP, not only the laws of Zambia but also the WB policy as the international best practice was referred. The RAP was made with the involvement of the local community affected by the project through community meeting so that opinions from the local communities were reflected.

Table O.2 Summary of Resettlement Action Plan of Sanje Hill Iron Ore Mine development

The people affected	About 210 households (1200 people). A socio-economic survey was conducted to know the social and economic situations of the local population affected. The survey found that all persons would lose their structures or croplands. The majority of the population engages in agriculture for self consumption and partly sales as well as charcoal production, petty trading, and livestock rising.
Land Tenure	The affected land is customary land.
Compensation (Inventory survey was conducted) or other supporting measures	• Structure (majority of the structures are built using traditional methods and materials, which means earth floor, mud-brick walls, and glass thatch roofs) and crops and fruit trees will be compensated. • Disturbance allowance will be paid to the all affected household to cover invisible cost of resettlement. • Alternative residential lands and farmlands will be provided the affected persons. • The developer is committed to hire the local population and to provide complementary skill training if necessary. • The developer will lunch community development and livelihood improvement projects.
Resettlement	A resettlement area will be prepared in close collaboration with the local authority. The resettling people can request transportation for their goods and animals from the original place to a new plot in the resettlement area. The developer will prepare new and upgraded houses in the resettlement site. If the affected persons do not resettle in the resettlement site, the developer will compensate in cash for residential and non-residential structure.
To Valuation	The developer will commission a valuation survey to the government valuation department. Structure will be surveyed and valued for the design of the new resettlement.

The people affected are not squatters. But, what is important here is the basic concept of RAP is to make the affected persons better off than the pro-resettlement level. The developer will provide variety of compensation and supporting measures.

(2) EIS on Konkola North Mine and Concentrator Project by Konnoco Ltd March 2008 (The report was written by SRK Consulting on behalf of the developer)

The Performance Standard 5 on Land Acquisition and Involuntary Resettlement of the International Finance Cooperation[1](IFC), the private sector development arm of the World Bank group, on resettlement was referred in the EIS.

IFC Performance Standard 5 is almost same of the WB Policy as they are in the same World Bank Group. The main concepts of the IFC Standard are:

- Compensation should be provided to affected people for loss of assets too.
- Necessary assistance also should be ready for them to restore their standard of living in an equal or better living state compared to the pro-project level.
- A person who has no formal title to land is also entitled for compensation and assistance.

Construction of mining related infrastructure will result in loss of farmland and crops cultivated by households in a part of the project area. As the developer has the title to land of the proposed project, the farmers do not have legal title to the land. A household survey in the area found that all households rely on the farmland and crops harvested to survive so that the developer considers they will economically displaced because they will lose income source or means of livelihood. The developer will need providing assistance them. Therefore, the developer has decided to compensate and assist these informal farmers.

The EIS states that a land acquisition and compensation plan, following the IFC Performance Standard, WB policy and other good practices, will be prepared through consultation and negotiation with the people affected. The types of supporting measures are cited namely cash compensation for loss of crops, provision of alternative land, and other development support.

Table O.3 Summary of EIS on Konkola North Mine and Concentrator Project

The people affected	Farmers without title to the land. All households rely on the farmland and crops harvested.
Land Tenure	Lease land of the developer
Compensation or other supporting measures	The detailed plan will be prepared referring IFC Standard. Potential measures will be cash compensation for loss of crops, provision of alternative land, and other development support.

This is an example how to compensate or support economically displaced persons who has no title to the land they occupy.

3. EIA Prepared by Governmental Bodies

(1) Kafwe Gorge Lower Hydropower Project EIA prepared by ZESCO. Sep.2004

ZESCO is a parastatal company. The government has a plan to develop a power station in Kafwe Gorge. 17 households (65 people) live and have structures in the area where the power station and its

[1] "The Performance Standard 5 on Land Acquisition and Involuntary Resettlement of IFC" Available at IFC HP http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/pol_PerformanceStandards2006_PS5/$FILE/PS_5_LandAcqInvolResettlement.pdf

auxiliary facilities such as dam and canals will be constructed. They need to be relocated. Almost all families came from one same village to the area to seek better livelihood by depending fishing as their main income source. In addition there is a farmer in the site.

Most of the project area is state land under ZESCO control. Small parts are customary land. All 17 households do no have title to the land they occupy; on the other hand the farmer has title deeds to the land to cultivate. The affected persons will choose a place to relocate themselves. It is stated in the EIA that adequate compensation will be provided to the both groups. But details of compensation are not stated.

Table O.4 Summary of EIS on Kafwe Gorge Lower Hydropower Project

The people affected	(i) 17 households (65 people) without title deeds to the land they occupy. They rely on fishing for their lives. (ii) One farmer with the title deeds.
Land Tenure	Leased land (state land) to the developer (ZESCO), small parts are customary land
Compensation or other supporting measures	Adequate compensation will be provided to the both groups.

(2) EIA on Realization of an Environmentally Sound Landfill for Lusaka by Ministry of Local Government and Housing and Lusaka Council May 2003

The statement mentions how to deal with resettlement of affected persons. When this EIA was submitted, the final site of landfill out of four candidate sites was not decided. Therefore, the EIS says that a resettlement action plan would be prepared after the final decision of the site, and only a basic framework of resettlement is mentioned.

It is apparent that this EIS refers to the WB Policy in Involuntary Resettlement. Classification of three types of the affected persons is cited below from the EIS. This is the totally same as the classification of the WB Policy.

I. People who have formal legal rights to land (including customary and traditional rights recognized under Zambian Laws
II. People who do not have formal legal rights to land at the time the census begins but have a claim to such land or assets, provided that such claims are recognized under the laws of Zambia
III. People who have no recognizable legal right or claim to the land they are occupying

And the EIS continues that according to the classification, all types are provided compensation and assistance. This is also same as the WB Policy.

- Type I & II are entitled compensation for land and loss of assets except land, and other assistance.
- Type III is also given compensation for loss of assets except land, resettlement assistance

The two practices above show that even governmental bodies sometimes do not expel forcibly informal residents in the land concerned. Although the details of compensation are not clear in the EIAs, those squatters will be entitled to some type of compensation.

Appendix P

Meeting Memo for Local Stakeholder

APPENDIX P

MEETING MEMO FOR LOCAL STAKEHOLDER

(MAHOPO RESIDENTS AND ILLEGAL FARMERS IN LS-MFEZ AREA) MEETING WITH LOCAL EXPERT TEAM ACCOMPANIED BY JICA STUDY TEAM

TIME: 10:30~13:30
DATE: 11th December, 2008
VENUE: Mahopo village

1. ATTENDANTS

(1) Local Stakeholders
1. Rosemary M. Chasaya
2. Evelyn Mwamba
3. Petronela Mukupa
4. Doreen Mwinga [List of farmers in forest reserve No.26:1]
5. Josephine Mulenga [List of farmers in forest reserve No.26: 834]
6. Ruth Thole (51 years old, female, Mahopo, farmer)
7. Tisiyane Daka (65 years old, female, Mahopo, farmer)
8. Ialess Daka
9. Magece Maewe
10. Velonasi Phiri
11. Selestina Zulu
12. Tamalizika Ghoma
13. Ruth Mwelwa
14. Richard Chisulo
15. Size Banda
16. S. Musonda
17. B. Sinfukwe
18. Timothy Phiri [List of farmers in forest reserve No.26: 403]
19. S. Musanga
20. L. Mbewe
21. Joseph K. Lung(u): [List of farmers in forest reserve No.26: 5]
22. Nafital Zulu
23. L. Phiri [List of farmers in forest reserve No.26: Lasina Phiri: 211; Lingson Phiri:802; Landoni Phiri: 192; Liviness Phiri: 740]
24. D. Phiri [List of farmers in forest reserve No.26: Dulani Phiri:28; Dalio Phiri: 249]
25. Maci Nyirenda
26. B. Nyambose [List of farmers in forest reserve No.26: Batson Nyambose: 503]
27. B. Wapacha Musonda
30. Daniel Phiri [List of farmers in forest reserve No.26: 191]
31. D. Musmad
32. Evans A. Phiri
33. L. Banda {Lazarous Banda} (66 years old, male, Mahopo, Farmer) [List of farmers in forest

reserve No.26:Lembani Banda: 322; Langson Banda: 367; Lucas Banda: 395; Lumbea Banda: 565; Layford Banda; 604]
34. G. Lyamupu Nabombe [List of farmers in forest reserve No.26: 4]
35. A. D. Zulu
36. A. Zulu [List of farmers in forest reserve No.26: Akson Zulu: 388; Avela Zulu:1038]
37. A. B. Mwale
38. S.K. Kandla
39. E. Simbaya
40. K. Chongo [List of farmers in forest reserve No.26: Kasanda Ozikin Chongo]
41. George
42. Adwell Singoyi [List of farmers in forest reserve No.26: 553]
43. Commander Mambo [List of farmers in forest reserve No.26: 558]
44. John Banda (33 years old, male, Mahopo, businessman)
45. K. Paria
46. D. Chileshe
47. Geraid Shimbetu
48. Henry Tembo
49. E. Phiri {Emmanuel Phiri} (29 years old, male, Mahopo, farmer) [List of farmers in forest reserve No.26: Elidar Phiri: 75; Elisi Phiri: 121; Ester Phiri: 296; Evelyn Phiri: 355; Estele Phiri: 523; Eliza Phiri: 663; Ezelesi Phiri: 710; Estele Phiri: 911]
50. Jacksong
51. A. Zulu {three persons} [List of farmers in forest reserve No.26: Akson Zulu: 388; Avela Zulu: 1038]
52. N. Likwanya
53. K. M. Criwang
54. D. Daka
55. B. Wrushu
56. Felix Nsowani
57. F. Zulu [List of farmers in forest reserve No.26: Faineli Zulu: 96; Fatness Zulu: 669]
58. A Daka {two persons} [List of farmers in forest reserve No.26: Agness Daka: 160; Anna Daka: 222; Andrew Daka: 1021]
59. H. Nk(h)oma [List of farmers in forest reserve No.26: 536]
60. D. Phiri [List of farmers in forest reserve No.26: Dulani Phiri:28; Dalio Phiri: 249]
61. M. Miranda
62. J. Phai
63. Chilambe Mulabasa(Chairman) (80 years old, male, Mahopo, farmer)
64. A. Mumba [List of farmers in forest reserve No.26: Abson Mumba: 73]
65. M. Banda {four persons} [List of farmers in forest reserve No.26: Madrida Banda: 349; Marcret Banda: 359; Mangani banda: 778; Margaret Banda: 1046]
66. M. Tembo {Margaret Tembo} (23, female, Mahopo, farmer)
67. P. Nkoma
68. G. Tembo {Getrude Tembo} (39 years old, female, Mahopo, farmer)
69. V. Tembo [List of farmers in forest reserve No.26: Violet Tembo: 573; Vinolla Tembo: 661]
70. A. Phiri {Alesi Phiri} (33 years old, female, Mahopo, Businesslady) [List of farmers in forest reserve No.26: Agness Phiri: 201, 418, 425; Atelina Phiri: 429; Acrinah Phiri: 532; Andrew Phiri: 884; Alfred Phiri: 1043]
71. S. Jere
72. M. Machimba
73. S. Tembo {three persons} [List of farmers in forest reserve No.26: Stanelly Tembo: 1032]
74. Z. Malunga
75. A. Kandela
76. I. Manyinda
77. M. Banda {four persons} [List of farmers in forest reserve No.26: Madrida Banda: 349; Marcret

Banda: 359; Mangani banda: 778; Margaret Banda: 1046]
78. A. Mwanza [List of farmers in forest reserve No.26: Alesia Mwanza: 584; Alison Mwanza: 848]
79. M. Banda {four persons} [List of farmers in forest reserve No.26: Madrida Banda: 349; Marcret Banda: 359; Mangani banda: 778; Margaret Banda: 1046]
80. E. Silwamba [List of farmers in forest reserve No.26: Ellen Silwamba]
81. R. Mwansa
82. W. Simbeya
83. Chisoni Nkhoma
84. B. Danend
85. Thomas
86. M. Edwald
87. Abiel Phiri
88. Elizabeth Nampungwe [List of farmers in forest reserve No.26: 453]

(( ): names in list of residents in Mahopo village; [ ]: names in list of farmers in Lusaka South Forest Reserve No. 26)

(2) Local Stakeholders
1. Sylvester Mashamba, Executive Director, NCC
2. Wiseman Sangulube, Chief Extension Officer, MTENR
3. N. Mushota, Inspector EIA, Environmental Council Zambia
4. Maxwell Zulu, Provincial Planner, Lusaka Province
5. Kenneth N. Nyamise, Lusaka Park, ZAWA
6. Patrick Mulenga, Principal Technician, Forestry
7. MRS. Banji Ng'andu, Economist IDP, MCTI

(3) JICA Study Team
1. Hisashi Matsuda, Project Manager, JST
2. Kazuhiko Ikeda, Environmental and Social Consideration, JST
3. Lydia Katutroa, Secretary, JST

2. MEETING MEMO

(1) Opening Remarks

The chairman welcomes everyone in the meeting. Mr. Sangulube (chairman) who is chairing the meeting tells everyone to stay calm and tells the Mahopo people not to worry. Before the discussion Mrs. Mulenga opens the meeting with a prayer and welcomed everyone in the meeting including people from her area as well.

(2) Proceeding of the Meeting

The Chairman tells the people the purpose of the meeting that the reason why he called for this meeting is to announce the people of Mahopo the destination of the new town they {= local expert team} want to build in the village called the Mahopo village. The Chairman tells the people of Mahopo that a lie, in which the land is for the Malaysians, has been told, and tells them that it is not true. The chairman tells the Mahopo people to stay calm, and he tells them that they all come in peace and they need to cooperate with them {= local expert team} during the meeting. He also tells them that he does not come to make trouble but to tell them on what is the construction of a new town. He tells them that the land does not belong to the Japanese or Malaysians and that these two are only helping in planning of the new town and that's all. The Chairman asked the people of Mahopo to stop cultivating by the next year between April and May.

The Chairman tells the people of Mahopo to participate in the meeting by asking questions.

The village Chairman (Mr. Chilambe) from Mahopo asks a question on where the government is standing. The Chairman answers by telling Mr. Chilambe that the land is for the government but is not for ZAWA and therefore the government of Zambia has decided to build a town in Mahopo.

Mr. M.M Mboli also asks the Chairman whether it means that they will have to stop cultivating on the land.

The Chairman (Mr. Sangulube) answers Mr. Mboli that the government does not only tell them to stop the cultivation but also informs them on how the government will support these people in this area.

Mr. Zulu also comments on the issue of the government that it's not serious. He says that they always have been hearing this story and then but no effort has been shown. He says that it is no wonder they have also continued to cultivate the land by growing crops on it, and hunger has made them to plant some food. And he also says that if they vacate the land, where they are going to go because they do not have any other place to go to.

Mr. Sangulube tells the people of Mahopo that it is a crime to dig in the forest area and he also says that he has told these people to stop but they wouldn't stop. The Chairman tells the people that the government is really concerned about the Mahopo people and concerned about the Mahopo people only not people from outside Mahopo.

Mr.Simbay(a) says in the meeting that the law is the law and the people are the government. He also asks them on where they are going to be taken.

Mr. Sangulube tells them to look back in the past on how Lusaka used to look like, and he tells them that Lusaka city in 1930 it used to be a forest and it also had a headman. He tells them that if they look at it now, it is so beautiful with nice buildings. He told the people of Mahopo to work with the Ministry of Lands on how they will resolve this issue so that they will know what to do with the people of Mahopo and so that no one is going to complain that they do not have the land.

Lyamupu Mambila contributes by saying that the government has allowed the foreigners to take charge. He says that these people of Mahopo have been cultivating since 1975 and he has been taken to the police over the same issue. This is why he didn't attend the meeting which was held at MCTI due to the same issue. He says that the forest is now bare with no trees because people have cut down the trees for charcoal and that this is the reason why the farming has continued in the area because people who come for farming do tell others people there is some bare land in Mahopo, and that it is why a lot of people have come to do the farming in Mahopo. He also says that the people of Mahopo have been writing their names for the Government to help them but all has been in vain.

Mr.Sangulube tells the people of Mahopo that they will be given this chance to harvest but that if the next year comes, farming will not take place in the MFEZ area.

The people complain to the Chairman when he says that they have to stop the cultivation by next year in April. They say that the people of Mahopo have the letter which indicates that they are not illegal settlers and nobody can tell them to move. Mr. Sanglube responds to this by telling the people that he also has the same letter and he took the letter back to Kafue.

Mrs. Mukupa, a widow of Mahopo staying in farming in the MFEZ area, asks in the meeting on why she did the cultivation. She says that it is the reason that she does not have a husband to provide for her and she has to take her children to school through farming. She says that there are a lot of widows in the area but that not even one day the government has helped the widows in the area, they only

have seen them during the campaigning period, and after that they have stopped going to visit. She talks about the area of being poor, and she says that even if she has to go to the Ministry of Lands, people might think that she's a mad person because of being poor. And she says that they respect animals more than the people. She says that where she is she can't even manage to buy a sack of mealy meal for herself and her own children. So she asks where we are going to go if they tell us to move. Because they do not have any place to run to. Another widow also complains about what ZAWA did. She says that she had a house and it was burnt down because she refused to move from the land. Mr.Lungu also contributes by telling the chairman that they have heard what he said and he says that they are only asking for only one thing from the government. He says that it is to respect for the people of Mahopo. He also mentions about the government being corrupted. And he says that the government tells the Mahopo people that they are stakeholders. He says why they has been informed on how far the project has reached, if this is true.

He also tells the chairman that people from Mahopo heard a rumour in which there was a meeting at BANS MOTEL, where they invited the police and the army officers to come up with a plan on how they would be chased from the land. He says that this meeting took place in the absence of the Mahopo people. Mr. Mashamba from NCC answers them that they {= Local expert team} don't know anything about the meeting which was at BANS MOTEL and therefore they will do anything in their power to help the people of Mahopo. He says that if really the government is corrupted they have to go at the anti corruption commissioner and report the case to them because they are the right people to handle such cases.

The chairman makes it clear that he will only concentrate on the Mahopo people, not on the people from outside the Mahopo village and that's all. He also clarifies to the Mahopo people that when they work together during the registration period, they shouldn't write down names of other people who do not stay in Mahopo because it can bring problems to the Ministry of Lands. To make things easy for them the registered people must just include people in the Mahopo village.

Mrs. Mukupa also complains on what Dr. Sansakuwa has done. She says that Mr Sansakuwa came to Mahopo and told the people that they had not to vacate from the land because that land belonged to the people of Mahopo and no one could come and told them to vacate and that not even ZAWA could tell the people of Mahopo to move. She says that after telling them those Dr. Sansakuwa promised them that he would come back after two weeks but he was nowhere to be seen since then. She also complains that many people from the government have come there and they have told the people different things.

She says that after they promised them to come back again they have not shown up. She urges Mr. Sangulube to come back and make a final decision about the way forward for the Mahopo people.

(3) Ending Remarks

The Chairman thanks the people for attending the meeting and thanks them for their cooperation. He asks the people to give the government a chance to come up with a solution and to help them build a new town.

Mr. Macson M. Nyirenda closes the meeting with a prayer.