No.

MINISTRY OF INDUSTRY
AND COMMERCE (MOIC)

JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

PREPARATORY SURVEY ON INDUSTRIAL ZONE DEVELOPMENT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT
PART III

FEASIBILITY STUDY FOR VIENTIANE INDUSTRIAL PARK

JUNE 2010

NIPPON KOEI CO., LTD.
INTERNATIONAL DEVELOPMENT CENTER OF JAPAN
MINTECH CONSULTANTS INC.

IDD
CR(3)
10－043

MINISTRY OF INDUSTRY
AND COMMERCE (MOIC)

JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

PREPARATORY SURVEY ON INDUSTRIAL ZONE DEVELOPMENT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT
PART III

FEASIBILITY STUDY FOR VIENTIANE INDUSTRIAL PARK

JUNE 2010

NIPPON KOEI CO., LTD.
INTERNATIONAL DEVELOPMENT CENTER OF JAPAN
MINTECH CONSULTANTS INC.

THE EXCHANGE RATES USED IN THE REPORT ARE:

USD 1 = JPY 90.52

LAK 1 = JPY 0.01

Survey Area for a Basic Plan (Whole of the Lao PDR)

Preparatory Survey
on
Industrial Zone Development
in
the Lao People's Democratic Republic

Final Report

Part III: Feasibility Study for Vientiane Industrial Park

Table of Contents

Page

Part I: National Industrial Development

and

Part II: Industrial Estate Development in Vientiane Capital, Savannakhet and Champasak

are bound separately.

List of Appendices

List of Tables

List of Figures

List of Abbreviations

450-YR	450 Year Road
ADB	Asian Development Bank
AFTA	ASEAN Free Trade Area
AISP	ASEAN Integrated System of Preferences
ASEAN	Association of Southeast Asian Nations
BOI	Board of Investment
BPS	Bit Per Second
BRICs	Brazil, Russia, India, China
CA	Concession Agreement
CBR	California Bearing Ratio
CBTA	Cross Boarder Transport Agreements
CCA	Common Control Area
CDR	Crude Death Rate
CEPT	Common Effective Preferential Tariff
CIQ	Customs, Immigration and Quarantine
CLMV	the four newer ASEAN members consisting of Cambodia, Laos, Myanmar and Vietnam
CPI	Consumer Price Index
CPMI	Committee for Promotion and Management of Investment
DMS	Detailed Measurement Survey
D/D	Detailed Design
DDFI	Department for Promotion and Management of Domestic and Foreign Investment
DHUP	Department of Hosing and Urban Planning
DOF	Department of Forestry, Ministry of Agriculture and Forestry
DoIC	Division of Industry and Commerce
DoS	Department of Statistics, Ministry of Planning and Investment
DPI	Department for Planning and Investment
DPRA	Development Project Responsible Agency
DR-	District Road Number
EA	Environmental Assessment
ECC	Environmental Compliance Certificate
EDL	Electricité du Laos
EIA	Environmental Impact Assessment
EMDP	Ethnic Minority Development Plan
EMP	Environmental Monitoring Plan

EPZ	Export Processing Zone
ESCC	Environmental and Social Compliance Certificate
ESIA	Environmental and Social Impact Assessment
ESIAD	Department of Environmental and Social Impact Assessment
ETL	Enterprise of Telecommunications Lao
EU	European Union
F/S	Feasibility Study
FDI	Foreign Direct Investment
FIA	Foreign Investment Agency
FTZ	Free Trade Zone
FY	Fiscal Year
GDP	Gross Domestic Product
GEL	General Exception List
GMS	Greater Mekong Sub-region
GPS	Global Positing System
GRDP	Gross Regional Domestic Product
GSP	General System of Preference
HQO	Head Quarter’s Office
HS	Harmonized System
IE	Industrial Estate
IEAT	Industrial Estate Authority of Thailand
IEE	Initial Environmental Evaluation
IEZ	Industrial Estate Zone
IL	Inclusion List
IMF	International Monetary Fund
IP	Industrial Park
IPZ	Import Processing Zone
ISA	Initial Social Assessment
ISO	International Organization for Standardization
JBIC	Japan Bank for International Cooperation
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
JIT	Just-In-Time
JST	JICA Survey Team
LACR	Land Acquisition and Compensation Report
Lao PDR	Lao People’s Democratic Republic
LCL	Less Container Load

LDC	Least Development Country
LIEPDA	Laos Industrial Estate Promotion and Development Authority
LMA	Land Management Authority
LNCCI	Lao National Chamber of Commerce and Industry
LPCD	Liter Per Capita Day
MAF	Ministry of Agriculture Forestry
M/M	Minutes of Meeting
MDGs	Millennium Development Goals
MLW	Ministry of Labor and Social Welfare
MoF	Ministry of Finance
MoIC	Ministry of Industry and Commerce
MoPI	Ministry of Planning and Investment
MOU	Memorandum of Understanding
M/P	Master Plan
MPI	Ministry of Planning and Investment
MPWT	Ministry of Public Works and Transport
MSL	Mean Sea Level
NEC	National Environmental Committee
NEM	New Economic Mechanism
NGPES	National Growth and Poverty Eradication Strategy
NPC	Nam Papa UAD
NPS	Nam Papa Savannakhet
NPSEs	Nam Papa State Owned Enterprises
NPVC	Nam Papa Vientiane Capital
NR-	National Road Number
NSEDP	National Socio-Economic Development Plan
NTFPs	Non-Timber Forest Products
O&M	Operation and Maintenance
O&M	Operation & Maintenance
OBOI	Office of the Board of Investment
ODA	Official Development Assistance
OSU	One-Stop-Service Unit
PAPs	Project-affected peoples
PD	Project owner must submit project Description
PDA	Project Development Agreement
PI	Public Involvement
PIs	Public Involvements

PM	Prime Minister
PMO	Prime Minister’s Office
PMU	Project Management Unit
PPA	Power Purchase Agreement
PPP	Public Private Partnership
R&D	Research and Development
RAP	Resettlement Action Plan
S/W	Scope of Work
SA	Social Assessment
SASEZ	Savan-Seno Special Economic Zone
SC	Steering Committee
SDH	Synchronous Digital Hierarchy
SED	Social and Environment Division
SEMC	Social and Environment Management Committee
SEZ	Special Economic Zone
SEZA	Savan-Seno Special Economic Zone Authority
SIDA	Swedish International Development Cooperation Agency
SL	Sensitive List
SOG	Secretariat of Government
SPT	Standard Penetration Test
STEA	Science, Technology and Environment Agency
STM	Synchronous Transport Module
TA	Technical Assistance
TEL	Temporary Exclusion List
TFR	Total Fertility Rate
TOR	Term of Reference
UDAA	Urban Development and Administration Authority
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar
UXO	Unexploded Ordinance
VAT	Value-Added Tax
VEPZ	Vientiane EPZ
VIP	Vientiane Industrial Park
VIPA	Vientiane Industrial Park Authority
VIZ	Vientiane Industrial Zone
VLP	Vientiane Logistics Park

VMI	Vendor Management Inventory
VUDAA	Vientiane Urban Development and Administration Authority
WASA	Water Supply Authority
WREA	Water Resources and Environment Agency
WREO	Office of Water Resources and Environment
WSD	Water Supply Division
WSRC	Water Supply Regulatory Committee
WSRO	Water Supply Regulatory Office
WTO	World Trade Organization
WTPs	Water Treatment Plants

PART III FEASIBILITY STUDY FOR VIENTIANE INDUSTRIAL PARK

CHAPTER 1 RATIONALE FOR INDUSTRIAL PARK DEVELOPMENT IN VIENTIANE

1.1 Background of Industrial Park Development in Vientiane

1.1.1 Study on Industrial Area Development (IAD) Scenario

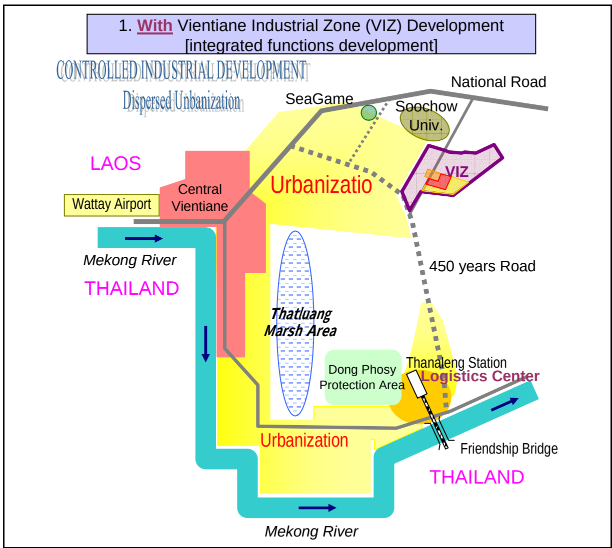
Three alternatives are evaluated for selecting the best IAD scenario in Vientiane from the viewpoint of appropriate urban development. The proposed alternatives are:

Alternative-1: With Vientiane Industrial Zone (VIZ) development (concentrated area accommodating factories with integrated function)

Alternative-2: With VIZ development (concentrated area accommodating factories specifically for manufacturing/processing products)

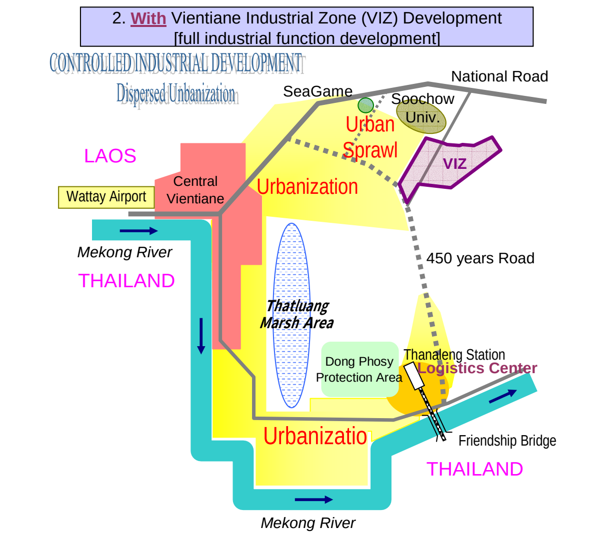
Alternative-3: Without VIZ development (locations of factories are scattered)

The above-mentioned alternatives are presented in detail in Figure 1.1.1.



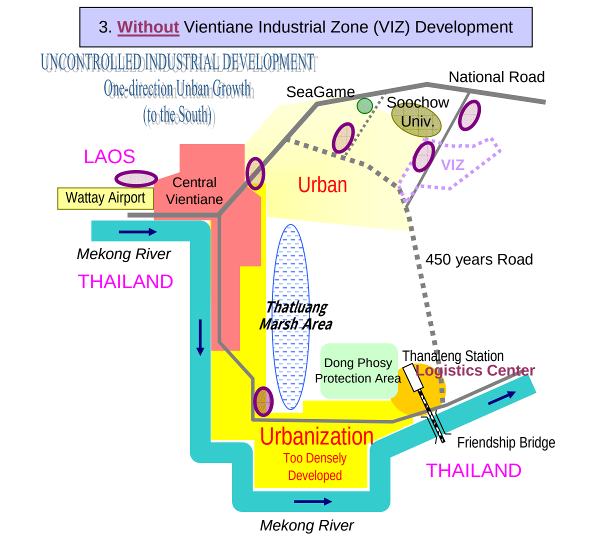
Alt-1. With VIZ Development <u>with Related Functions</u>

1. IAD will be well managed and controlled within VIZ.
2. Urban area including residential and related functions will be properly developed within VIZ.
3. Urbanization of Vientiane will be easily controlled and managed due to the establishment of satellite urban core (VIZ), which may reduce the concentration in the existing city center and south side.



Alt-2. With VIZ Development without Related Functions (with Industrial Function Only)

1. IAD will be well managed and controlled within VIZ.
2. Based on the urban development framework, considering the labor potential, an industrial lot/area of only around 480 ha will be required until year 2025, which necessitates 840 ha industrial park (including public infrastructure). However, VIZ has a huge area of 2,000 ha, which will require a long time to attract investors.
3. Urban area, especially residential area for workers of VIZ, will be developed without comprehensive plan leading to urban sprawl.



Alt-3. Without VIZ Development

1. As there is no integrated industrial zone development, the industrialization trend is not different from the current situation.
2. Factories will be constructed at every available space without any guidelines and without proper control.
3. Industrial/heavy vehicles will move around the city.
4. Environmental impacts, such as wastewater, solid waste and air pollution will be difficult to monitor and manage.
5. Urbanization will continue to concentrate in the south side due to the major economic activities which may be related to Thailand.

Source: JICA Survey Team

Figure 1.1.1: Industrial Development Alternatives in Vientiane

The evaluation result of the alternatives is shown in Table 1.1.1.

Table 1.1.1: Evaluation of the Three Alternatives

	Valuation Basis	Alternative-1 (Integrated Functions)	Alternative-2 (Industrial Function Only)	Alternative-3 (Zero Option)
1	Factories Location	Planned	Planned	Unplanned/ Scattered
2	Convenience in global economic action	Not good	Fine	Good
3	Traffic Safety/ Efficiency	Good	Good	Not good
4	Control and management of negative environmental impact (wastewater, noise, etc)	Less difficult	Less difficult	Difficult
5	City planning (Zoning)	Properly zoned	Properly zoned	No zoning control
6	Factory commuters/workers' convenience	Good (*Because residential & commercial functions exist in the vicinity)	Not Good	Not Good

As evaluated in Table 1.1.1, judging from the viewpoint of balanced industrial development together with that of a desirable city planning policy, it is concluded that Alternative-1 is the best alternative.

1.2 Industrial Park Development Context

1.2.1 Development Principles

VIZ should be developed in line with the following principles:

1) Role of the Lao PDR for Rapid Industrialization Growth

With spacious land and good access to the center of Vientiane and Thailand, VIZ should assume the role of an industrial center of the Lao PDR, linked with all relevant government agencies.

2) Special Zone should Meet Global Standards

In order for the Lao PDR to cope with the competitive industrialization among its neighboring countries, it is essential to invite foreign investors and foster domestic investors to utilize their capacity in technology, capital, management, marketing and others. To achieve this objective, it is requisite to prepare special zones with competitive financial incentives, simple legal procedures, sufficient infrastructure, and institutional and legal frameworks meeting global standards.

3) Satellite City of Vientiane

VIZ should be the independent satellite city of Vientiane, to support both daily manufacturing activities and people involved in the manufacturing activities. All necessary functions to ensure efficiency and amenity of the activities should be established within the zone.

4) Interface between Enterprises and Educational Functions

Maintain an interface among the manufacturing enterprises (employment demand) and educational functions (e.g., schools and universities as the demand supply side) in surrounding provinces to achieve rapid growth of competitive industrial climate and improvement of the living standards of the people.

1.2.2 Development Concepts

In compliance with the development principles, VIZ should be developed following the concepts given below:

1) Deregulation to meet global standards
Incentives should be offered through IZ decrees, EPZ decrees, characteristic of VIZ, land price, etc.

2) Multiple support functions
It is necessary for industrialization to support functions such as housing and commercial establishments to provide suitable living standards for the workers.

3) Borderless organizational linkages
Cooperation with all relevant government authorities and private developer/supplier should be initiated to support the investors' demands and VIP operations.

4) Provide sufficient infrastructure
It is necessary to consider cost performance for both the implementing body and investors. Over-specified infrastructure will create heavy economic burden to both.

1.3 Development Framework

1.3.1 Needed Industrial Estate Development Area

The target areas of industrial estate development were settled by JICA Survey Team based on comparison of values determined between two methods: the macro framework estimation (labor population) and the investment demand survey conducted through the Study. The larger value was taken for both target years. As a result, the target area for year 2015 was determined based on the result of the demand survey, while that for Year 2025 was determined based on the macro framework estimation. In summary, the industrial estate areas to be developed are as shown in Table 1.3.1.

Table 1.3.1: Industrial Estate Areas to Be Developed by 2015 and 2025

2015	2025
130 ha	690 ha (+560 ha)

The need to develop the overall VIZ with a total area of 2,000 ha will be after year 2025.

1.3.2 Industrial Estate Development Framework

The development framework for the feasibility study area was determined based on the formulas shown in Table 1.3.2.

Table 1.3.2: Basis of the Development Framework for the Feasibility Study Area

Formula	Remarks
Factory Lot Area = 70% x Industrial Estate Area	Consideration of average of 30% is required for the common infrastructure, such as road and other facilities.
Working Population = Factory Lot Area x 81.7 persons/ha	Based on "Japanese Guideline for Industrial Estate Planning (JGIEP)"
Living Population = 80% x Working population	Considering the financial problem on commuting and comfort of laborer's life, the living population, unmarried workers who prefer to stay in the surrounding area, is estimated to be 80%. The remainder was assumed to be occupied by the management class who can afford to have their own vehicle. Priority should be given to the family life in the urban area.

Based on the formulas above, the working population and living population are calculated below:

Factory Lot Area = 70% x 130 ha = 91 ha

Working Population = 91 ha x 81.7 persons/ha = 7,435 persons; rounded to 7,500 persons

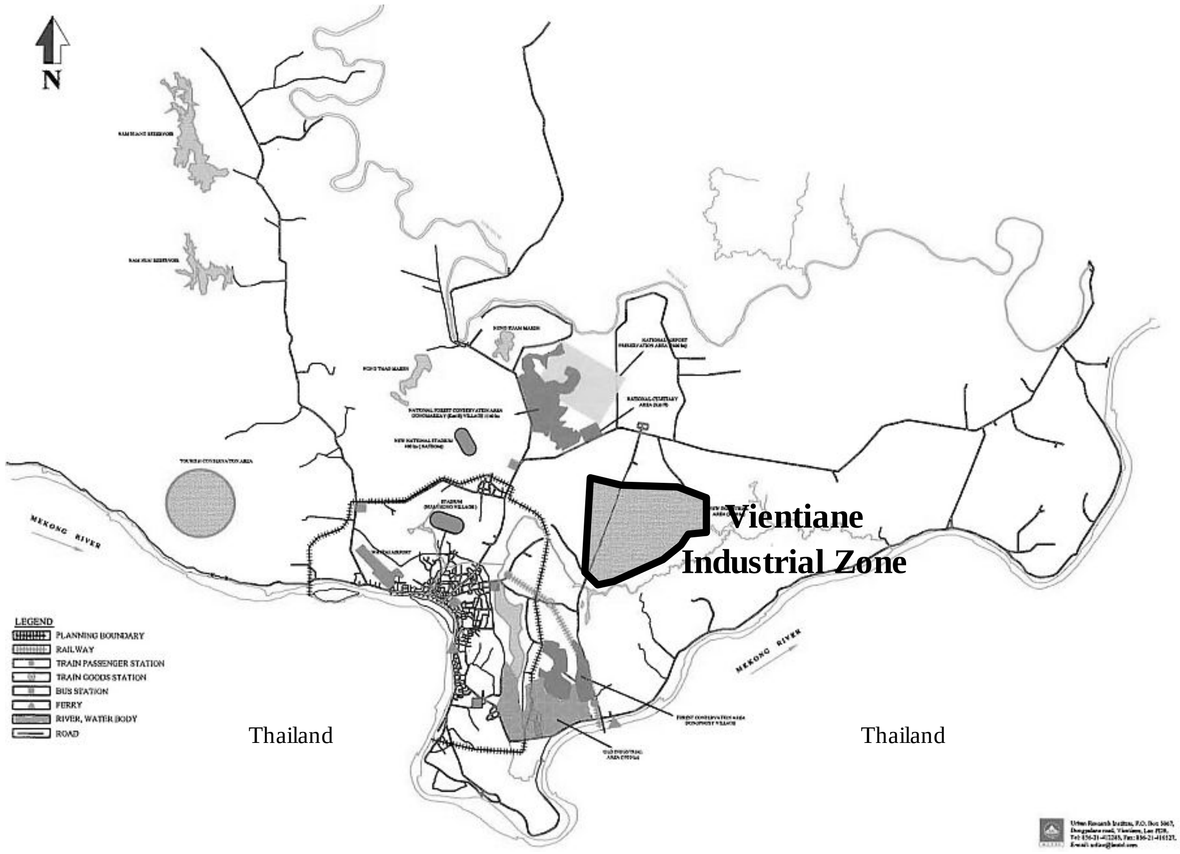
Living Population = 80% x 7,500 persons = 6,000 persons

Therefore, it is necessary to prepare a development plan to support both industrial activities for 130 ha and 6,000 lives.

1.4 Development Strategy of Vientiane Industrial Park

1.4.1 Location of VIZ

The location of VIZ which has an area of 2,000 ha is as shown in Figure 1.4.1. It was declared officially as an industrial zone by the Government of the Lao PDR, when the Vientiane Master Plan for 2010 was elaborated.



Source: JICA Survey Team

Figure 1.4.1: Location of VIZ

1.4.2 Vientiane Industrial Park Site Selection

(1) Candidate sites: Site A and Site B

A comparison between two candidate sites, namely, Site A and Site B, was made to determine the most appropriate location for the Vientiane Industrial Park.

- Site A: A part of the huge land totally designated as industrial zone in "Urban Development Plan (2000-2010)" which is located at the east of Central Vientiane
- Site B: A part of the existing industrial area at the southeast of Central Vientiane

The location of Site A and Site B is shown in Figure 1.4.2.

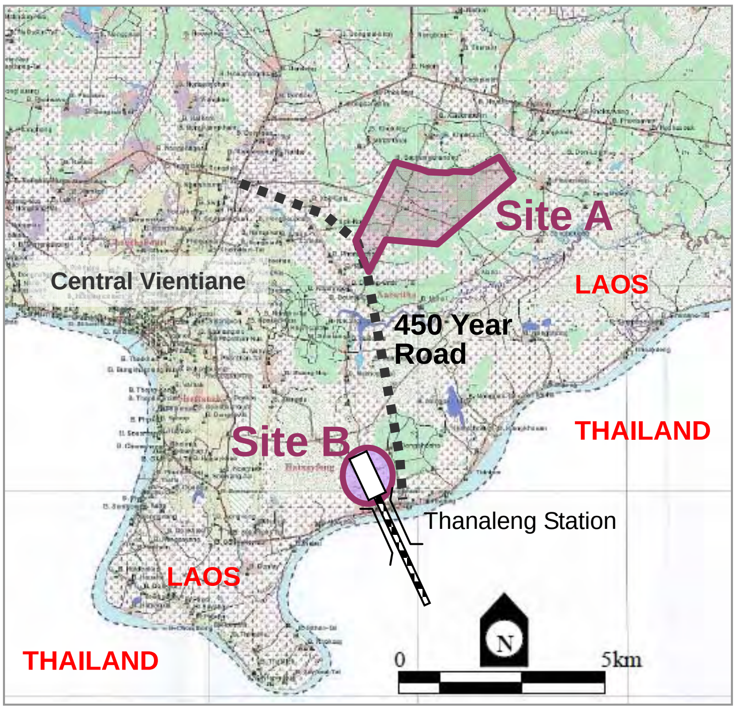


Figure 1.4.2: Location of Site A and Site B

(2) Comparison between Site A and Site B

Table 1.4.1 shows the comparison between Site A and Site B from the viewpoint of suitability for an industrial park development.

Table 1.4.1: Suitability Comparison between Site A and Site B

	Valuation Basis	Advantage	Site A	Site B
1*	Intention of the Lao PDR.	Site A	Lao PDR has only one option regarding land for large scale industrial development in Vientiane, which is Site A. The land has been reserved for future industrial development since 1990s, of which development responsibility rests with the Ministry of Industry and Commerce (MoIC). Moreover, Site A was identified as industrial zone as per "Urban Development Plan (2000-2010)"	Both the Ministry of Industry and Commerce (MoIC) and Vientiane Capital have no intention to implement an industrial park in Site B. In other words, Site B is not an option for the Lao PDR government.
2*	Land Availability	Site A	Site A has an area of no less than 2,000 ha, which is large enough for an industrial park development. As the land has been reserved for future industrial development, most it is still vacant, and there are much less land use restrictions compared with Site B.	Adjoining areas have been recognized as "Old Industrial Zone" for years in Vientiane. However, land availability for new development is quite limited. There is a vacant land with an area of 100 ha at the west of Thanaleng Station, which is too small for new industrial development. The distorted land shape and hilly conditions are also disadvantages for industrial development. There is another land covering an area of 120 ha at the east of the station, but is not large enough either.

	Valuation Basis	Advantage	Site A	Site B
3*	Attractive Functions for Investors	Even	[3.1] Customs Customs services could be available in an industrial park in cooperation with the Lao PDR authorities in charge.	[3.1] Customs Customs services could be available in an industrial park in cooperation with the Lao PDR authorities in charge.
		Site B	[3.2] Logistics Center There is little possibility that a logistics center will be developed in the vicinity.	[3.2] Logistics Center There is a clear possibility that a logistics center will be developed and integrated with the industrial park. If an integrated development is implemented, this would be a great advantage as different logistics services would be provided for investors inside the industrial park.
		Even	[3.3] Supporting Functions A large scale industrial park needs residential and commercial functions in the vicinity. Site A, which has a large scale of land, can meet the demand for such support functions. In addition, it is probable that residential and commercial functions will be supported at a large scale in the adjoining areas, following the SEA Game/ Su Zhou Univ. development.	[3.3] Supporting Functions A large scale industrial park needs residential and commercial functions in the vicinity. Site B with limited land availability will not meet the additional land demand for such support functions. However, this can be compensated considering that there are some existing commercial facilities around the nearby immigration center of Thailand.
4*	Land Price	Site A	The land prices along 450 Year Road adjacent to Site A are as follows: State price: 0.9 USD/m^2 Market price: 4.9 USD/m^2 Sale price: 2.2 USD/m^2	The land prices along 450 Year Road adjacent to Site B are as follows: State price: 2.7 USD/m^2 Market price: 6.0 USD/m^2
5*	Investment Demand	Site A	According to the result of the investment demand survey conducted as a part of this study, an area of 130 ha will be needed for industrial use. Site A has enough space to meet said demand.	According to the result of an investment demand survey conducted as a part of this study, an area of 130 ha will be needed for industrial use. Site B does not have enough space to meet said demand.
6	Urbanization Control	Site A	As an industrial park development would be of great impact to the urbanization trend, it is important to consider the location of the park. From the viewpoint of urban development, Site A would have an advantage because it would promote multipolarization of Vientiane urban functions in the north where balanced development is required, together with other development projects (SEA Game Stadium / Su Zhou Univ.).	As an industrial park development would be of great impact to the urbanization trend, it is important to consider the location of the park. From the viewpoint of urban development, Site B is not recommendable because it would enhance the urbanization of the southeastern part of Vientiane where many factories and warehouses already exist, without considering the urban functions positioning at the whole city level.
7	Infrastructure	Site B	[7.1] Present Power/ Telecommunication infrastructure is provided. Water/ Road infrastructure is being improved through the adjoining development.	[7.1] Present Power/ Telecommunication/ water/ Road infrastructure are provided since the adjoining area is already urbanized.
		Even	[7.2] Future Water: A pipeline is being extended to Site A, in line with a series of SEA Game developments. Road: 450 Year Road will be completed in 2010. Other principal roads will also be rehabilitated gradually in line with a series of SEA Game developments. and establishment of Su Zhou Univ.	[7.2] Future Further water infrastructure development could not be executed unless Site B is developed.

	Valuation Basis	Advantage	Site A	Site B
8	Accessibility	Site B	[8.1] Proximity to Thailand About 10 minutes drive by car compared with Site B	[8.1] Proximity to Thailand Nearer by 10 minutes by car (compared with Site A)
		Site A	[8.2] Proximity to China/ Vietnam Nearer compared with Site B	[8.2] Proximity to China/ Vietnam Farther (compared with Site A)
		Site A	[8.3] Proximity to other main Lao cities Nearer (compared with Site B)	[8.3] Proximity to other main Lao cities Farther (compared with Site A)
9	Labor Force Vicinity	Site B	[9.1] Present It appears difficult to acquire labor force since the adjoining areas are less populated.	[9.1] Present Difficulty in sourcing labor force is lesser since the adjoining areas are already urbanized and more populated.
		Even	[9.2] Future It would be more possible to acquire more labor force than it is now because the adjoining areas will be developed at a high pace. Su Zhou Univ. can be expected as a human resource.	[9.2] Future It would be possible to provide a constant labor force volume. However, the area could not meet larger labor force needs because there are few potential lands to be developed in the vicinity.

Note: *numbers with an asterisk sign are the most critical valuation bases.
Source: JICA Survey Team

(3) Evaluation for site selection of Vientiane Industrial Park

Table 1.4.2 shows the evaluation summary of the suitability comparison between Site A and site B.

Considering critical valuation bases 1 to 5 as well as all the valuation bases, Site A scores higher than Site B. There are some bases where Site B has advantage against Site A at present. However, Site A is now catching up with Site B at a high pace due to the ongoing development projects in the adjoining areas. Especially, it should be emphasized that the Government of the Lao PDR has a strong intention of implementing the industrial park at Site A which has been declared as industrial zone since 1990s for future development.

In conclusion, based on all the detailed analysis described above, Site A was selected as the location of the Vientiane Industrial Park, as the first priority project.

Table 1.4.2: Evaluation Summary of the Suitability Comparison between Site A and site B

	Valuation Basis	No.	Site A	Site B
1	Critical valuation bases	1-5	6 points	3 points
2	All valuation bases	1-9	11 points	8 points
Evaluation			Site A has an advantage.	

Source: JICA Survey Team

1.4.3 Position of a Feasibility Study Site

(1) Main evaluation bases for positioning the feasibility study site

The "priority area" for the feasibility study (Stage-1 development) was positioned in the southwestern corner of Site A through the following steps:

- Step 1: Preconditions
- Step 2: Other conditions to be considered for the comparison between North Side and South Side are as follows:

- Advertising effect appealing to investors
- Influence of the existing factories
- Accessibility to the south (especially after the completion of 450Year Road in 2010)
- Accessibility to the north (toward National Road No. 13)
- Advantage of infrastructure (Water supply)
- Advantage of infrastructure (Power supply)
- Advantage of infrastructure (Wastewater drainage)
- Adjoining land availability for extension in the future
- Land price
- Intention of the Lao PDR.

The F/S site positioning process is as detailed below:

(2) F/S site positioning process

1) Step 1: Preconditions

Two conditions are necessary for the development of the area for Stage-1. Firstly, the area should face a main or a sub-main road. Secondly, the area should be positioned on a more appropriate side of the main (or the sub-main) road, judging from the current land use.

The present conditions in Site A are as follows:

There is only one sub-main road that runs north to south, which is District Road No. 108.

450 Year Road, which will be a significant arterial route for logistics movement in the near future, edges the southernmost side line of the westernmost part of Site A.

There are 16 factories mainly on the western side of District Road No. 108. As Vientiane Industrial Park will be divided into different zones including residential and commercial, it is recommended to avoid intermixed land use in said park. That is, the western side of District Road No. 108 will be an industrial area, while the eastern side is mainly a residential area.

Considering the present conditions described above, it is obviously reasonable to position the main land for Stage-1 on the western side of District Road No 108.

2) Step 2: Comparison between North Side and South Side

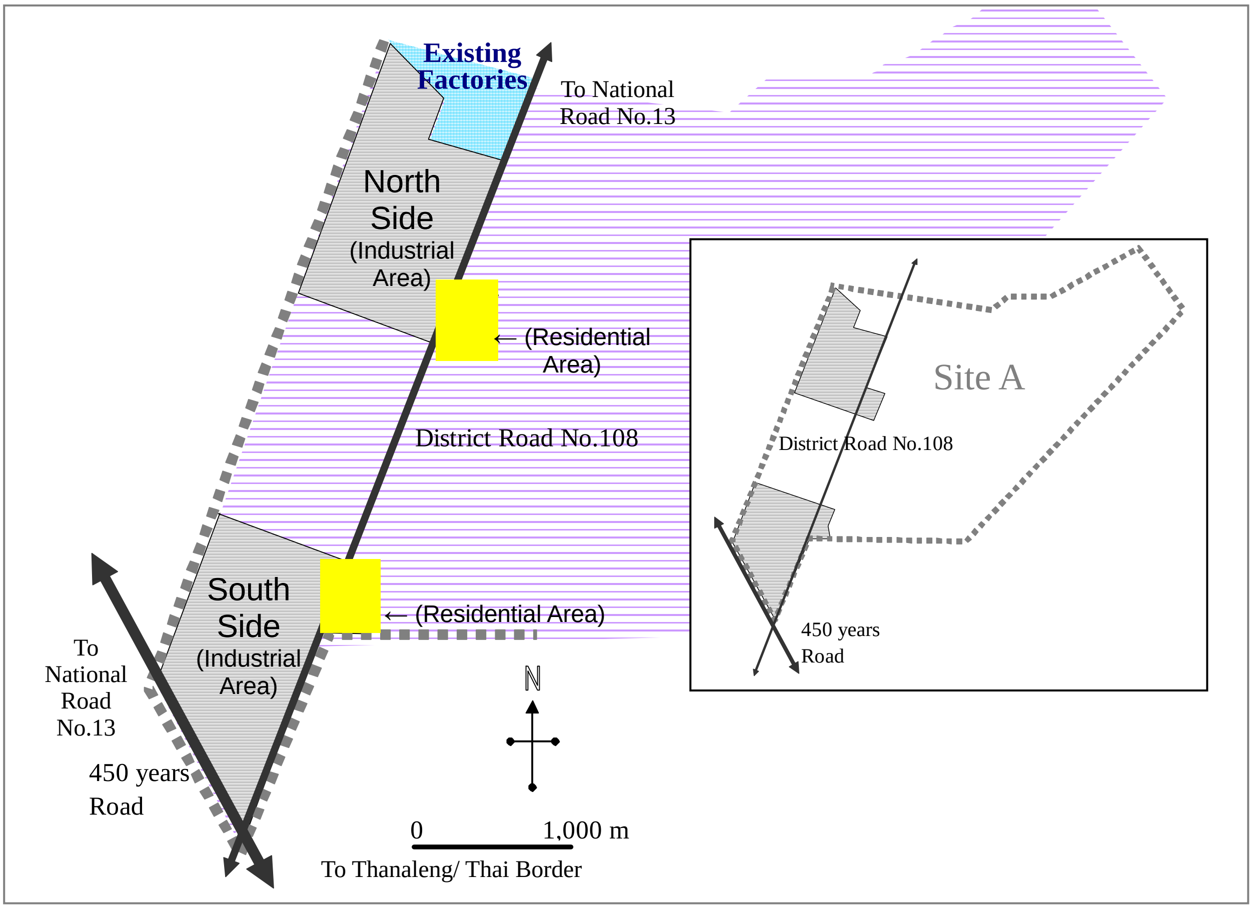
The land located on the western side of District Road No. 108 has an area of about 460 ha, which is too large for Stage-1 (Only an area of 130 ha is needed for industrial use). Therefore, it is necessary to decide which side (north or south) will be more appropriate for Stage-1.

- North side has an area adjacent to the exiting 16 factories.
- South side is located at the southernmost part of Site A, and faces traffic and logistics arterial road, the 450 Year Road, which is now under construction and will be completed no later than 2010.

The location of north side and south side is shown in Figure 1.4.3.

The western part of District Road No 108 is declared as an industrial zone while the eastern part, which is much smaller than the western, is declared as residential zone at both north and south sides.

The south side faces 450 Year Road. This location will contribute in strongly attracting initial investors that regard the vicinity, being adjacent to a main traffic route and logistics arterial road, as important and indispensable. A comparison between the north and south sides from different viewpoints is shown in Table 1.4.3.



Source: JICA Survey Team

Figure 1.4.3: Location of North Side and South Side

Table 1.4.3: Comparison between North and South Sides from Different Viewpoints

Weight	No.	Valuation Basis	North Side	South Side
***	1	Appeal to investors	C Inner part not facing arterial roads which link Vientiane to Thailand or other foreign countries/ domestic cities.	A Since it is facing 450 Year Road which will be an important traffic and logistics arterial route, the location would appeal to potential investors for the initial development stage. Advertising effect can be largely expected to benefit both investors and the industrial park developer.
***	2	Influence of the existing factories	C There are more than ten existing factories in the adjoining area which would make new infrastructure development complicated and costly.	A No factories nearby.
***	3	Accessibility to the south (especially after the completion of 450 Year Road in 2010)	B Farther away compared with South Side.	A As it faces 450 Year Road which will be an important traffic and logistics arterial route, provision of a main gate for VIP is convenient. The 450 Year Road leads to a future logistics center near the Thai border. Judging from the importance of the trade with Thailand, this location could be a great advantage.
**	4	Accessibility to the north (toward National Route No.13)	B Not facing National Road No.13, which is an arterial route to Vietnam or other Lao main cities, but much nearer compared with South Side.	C
**	5	Advantage on infrastructure (Water supply)	A Considering the nearby new development, access water point is nearer compared with South Side.	B
**	6	Advantage on infrastructure (Power supply)	A There is a substation nearby.	B
**	7	Advantage on infrastructure (Wastewater drainage)	C No existing infrastructure.	C No existing infrastructure.
**	8	Adjoining land availability for extension in the future (Future provision is uncertain; however, what is presently recognized as future risk is compared here.)	C There are some factories and lands for sale nearby, which could be among the spatial restrictions when the industrial park is extended.	B There are some houses, but much less lands are occupied or apparently for sale.
**	9	Land price	Land price is lower in South Side (80,000 kip/m^2) than in North Side (150,000 kip/m^2) presently. However, future land price provision depends on different factors, which are quite uncertain at the moment. Therefore, it is concluded that the land price comparison will not make sense.	
*	10	Intention of the Lao PDR.	C	A MoIC expressed intention to execute a feasibility study for the south side.

Source: JICA Survey Team

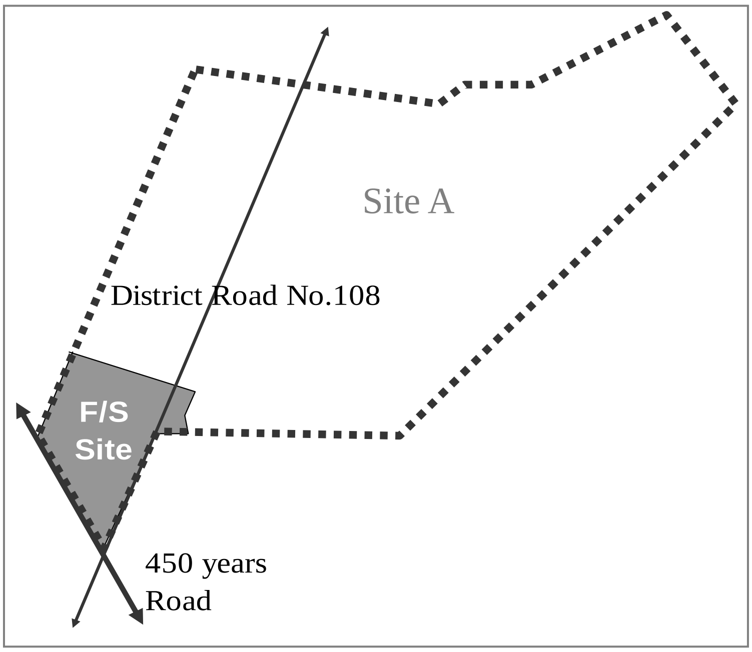
Table 1.4.4 shows the total evaluation scores for both north and south sides. Comparing the total score between the two, south side leads by 12 points more than north side.

Table 1.4.4: Scoring of North and South Sides from Different Viewpoints

Weight	No.	Evaluation Basis	North Side	South Side
***	1	Appeal to investors	0	6
***	2	Influence of the existing factories	0	6
***	3	Accessibility to the south (especially after the completion of 450 Year Road in 2010)	3	6
**	4	Accessibility to the north (toward National Road No.13)	2	0
**	5	Advantage on infrastructure (Water supply)	4	2
**	6	Advantage on infrastructure (Power supply)	4	2
**	7	Advantage on infrastructure (Wastewater drainage)	0	0
**	8	Adjoining land availability for extension in the future Land price	0	2
**	9	Land price	0	0
*	10	Intention of the Lao PDR.	0	1
Total score			13	25

Note: Weight: *** = to triple, ** = to double, * = not to be multiplied, Evaluation Score: A= 3 points, B= 2 points, C= 1 point
Source: JICA Survey Team

According to the evaluation process described above, it is concluded that South Side as shown in Figure 1.4.4 was selected as the site for Stage-1, where a feasibility study will be carried out.



Source: JICA Survey Team

Figure 1.4.4: Location of Feasibility Study Site

A 50-m Right of Way (ROW) is reserved at either side of 450 Year Road. The ROW is a zone to be taken by the government together with the road area and to be resold posterior to the completion of the construction work. The feasibility study site therefore, is 50 m behind the edge of the 450 Year Road.

CHAPTER 2 BASIC CONCEPT OF VIP DEVELOPMENT

2.1 Key to Success

Beneficial effects such as employment creation and industrialization are not realized by only designating the land as an industrial estate. Unless the industrial estate is attractive to manufacturers, it has a little chance of success.

The key to successful industrial estate projects is customer satisfaction. Customer satisfaction requires a lot of efforts to be exerted by the project implementation body. In order to achieve customer satisfaction, it is essential that the industrial estate meet the five conditions illustrated in Figure 2.1.1.

Source: JICA Survey Team

Figure 2.1.1: Keys to Success of VIP

2.1.1 Location

Good location is the most important condition for the industrial estate development.

Vientiane Capital has been selected as the industrial estate site for the feasibility study, in consideration of good access to fresh air, good living environment for foreign experts, and proximity to the central government for facilitating procedures.

2.1.2 Incentive

The government needs to grant incentives for encouraging manufacturing sectors to invest to the industrial estate. Such incentives, which include profit tax, import customs duty, various subsidies, and preferential treatment for various procedures, should be better than those offered by the neighboring countries. It is crucially important for the government to stipulate the concrete incentives in the decree for the specific industrial estate.

2.1.3 Infrastructure

Manufacturers need different infrastructure such as roads, power supply, water supply, sewerage, drainage and solid waste facilities. Industrial estate needs to provide the whole required infrastructure, although important infrastructure depends on the tenants. Such infrastructure in the industrial estate needs to be connected with public infrastructure. Public infrastructure is required to be developed together with the internal infrastructure in the case of VIP, because it is not available in its adjacent area.

2.1.4 Labor Force

Manufacturers emphasize the existence of labor force satisfying quality, quantity, and labor cost conditions.

In the case of VIP, a considerable labor force is needed to be employed from outside the commuting distance. It is recommended that the project implementation body should develop a residential site and invite investors to build apartments for laborers traveling from outside the commuting distance.

It is also recommended that the project implementation body should build and operate a training center to educate laborers regarding the way of living in the city, factory rules, and skills at the tenants' request.

2.1.5 Organization of Project Implementation

The investors, especially foreign investors, face many problems in order to construct factories and keep them in operation. Management organization of industrial estate needs to satisfy the investors by providing guidance and assistance to keep the investors' business running smoothly.

Besides, the management organization needs to conduct overseas marketing actively, because they cannot draw so much FDI by just waiting for foreign investors' site visit.

2.2 Zoning of VIP

VIP consists of two areas that have different functions, as illustrated in the next Figure 2.2.1.

Source: JICA Survey Team

Figure 2.2.1: Zoning of VIP

2.2.1 Manufacturing Area

Land allotted for the manufacturing area will be leased to manufacturers or the service industry supporting the manufacturers such as forwarders and warehousing business. An administration building will be built to provide office for the management organization of VIP, customs branch office, spaces for common facilities such as conference rooms and rental rooms. The type of manufacturing area has been investigated and recommended in the next section since it has a decisive influence on incentives for encouraging investment as well as characteristics.

2.2.2 Residential and Training Area

Since labor training is vital to the success of the VIP development as mentioned in the previous section, a workforce training center should be developed as part of the VIP development project. Besides, the residential site should be reclaimed as part of the VIP development project to attract service industries to build and lease apartments for laborers.

2.3 Recommended Type of VIP

2.3.1 Recommended Type of VIP

The following scheme is recommended for VIP based on the outcomes of comparative study of alternatives concerning the type of VIP. Details of the comparative study are given in Appendix III.1.

1) Specific Economic Zone with Bonded Area

The manufacturing area of VIP should be a specific economic zone designated as the bonded area.

2) Equal Incentives for All Investors in VIP

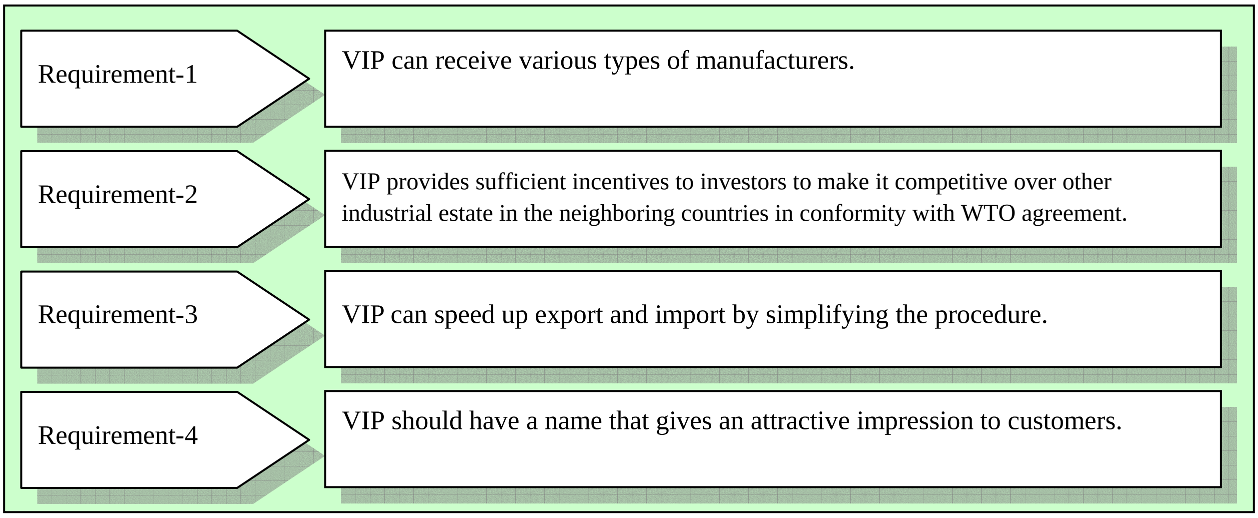
All the investors in VIP should equally be able to enjoy exemption from import customs duties to be imposed on materials and machines imported for manufacturing; and enjoy other incentives to be stipulated under the decree so that VIP could have a competitive edge over other industrial estates in the neighboring countries.

3) Naming for Giving Attractive Impression

VIP should have a name that gives an attractive impression to customers.

2.3.2 Reasons for the Recommendation

Figure 2.3.1 shows the extremely important requirements to attract a lot of investors to VIP. With the recommended scheme mentioned above, a specific economic zone satisfies all of the four requirements, as explained in Table 2.3.1. Based on this, the specific economic zone scheme was recommended for VIP.



Source: JICA Survey Team

Figure 2.3.1: Four Requirements to Attract Investors

Table 2.3.1: Expected Effects of the Recommended Scheme of VIP

Four Requirements	Expected Effects of the Recommended Scheme of VIP
【Requirement-1】 VIP can receive various types of manufacturers.	Because the specific economic zone can accommodate all kinds of manufacturers including those engaged in exports and domestic market, as well as foreign and local investors, various types of investment opportunities are available.
【Requirement-2】 VIP provides sufficient incentives to investors to make it competitive over other industrial estate in the neighboring countries in conformity with WTO agreement.	Preferential treatment of profit tax has no advantage over preferential corporate income tax in Thailand or Vietnam according to the draft law on investment promotion as of September 2009. Special incentive on profit tax is needed for the investors in VIP. However, subsidies for export or local content are not allowed, and countervailing measures are stipulated under the Agreement on Subsidies and Countervailing Measures of WTO. In VIP, manufacturers are not limited to the export industry or the industry utilizing local content. Therefore, it is possible to provide preferential treatment of profit tax to manufacturers in VIP, even in compliance with the WTO agreement.
【Requirement-3】 VIP can speed up export and import by simplifying the procedure.	Because all investors can enjoy the same incentives in VIP, it is not necessary to apply procedures different from each other. Therefore the export and import procedures are simplified. As a result, rapid export and import progress could be realized.
【Requirement-4】 VIP should have a name that gives an attractive impression to customers.	Attractive name for VIP is recommended.

Source: JICA Survey Team

2.4 Functions and Zoning Policy for VIP

Judging from the fact that VIP is planned to cover an area of no less than 845 ha by 2025, different functions will be needed to support investors' activities and the park operation on a daily basis, as shown in Table 2.4.1.

Table 2.4.1: Zoning Categories Necessary for VIP

Zoning Category	Function	Permitted Buildings/ Uses
1. Industrial Area	"Industrial" is the main function of VIP. Investors will construct factories and/or warehouses together with their offices in "Industrial Area".	Factory Infrastructure that will be commonly used by investors' factories/ warehouses Industrial Park Management office
2. Residential Area	"Residential" is the second important function after "Industrial", as more and more workers are expected to live within the industrial park in the future. "Residential Area" will provide those who live in the industrial park with good living environment together with necessary social services.	House Apartment Social infrastructure (clinics, schools, etc.) Limited number of small stores
3. Commercial Area	"Commercial" is a function that meets the shopping demand of those who live inside and outside the industrial park. Office buildings and research and development institutions can also be constructed in the "Commercial Area".	Commercial building (Stores, Shopping centers, Restaurants, etc.) Office Research and development institution Conference hall
4. Logistics Area	"Logistics" is a function necessary for shipment of products that are manufactured in the industrial park. A bus terminal can also be constructed in this area for commuters' or residents' convenience.	Logistics center Bus terminal
5. Amenity Area	"Amenity" is a function necessary to promote comfortable living conditions to those who work and/or live within the industrial park. "Amenity areas" which include parks, waterways, greenery, etc. will be properly positioned within or between other zoning areas. A part of the amenity areas can be reserved for internal main road extension in the future.	Park Water surface Buffer greenery

Source: JICA Survey Team

2.5 Stage-wise VIP Development Plan

The development phasing and framework for VIP are as shown in Table 2.5.1.

The first and the second target years are set to be 2015 and 2025, respectively. The development area for each target year was figured out based on the result of the investment demand survey, i.e.: 140.0 ha for 2015, and 705.0 ha for 2025. In other words, an area of 845.0 ha will be developed by 2025.

For Stage-1, only industrial area and residential area will be developed. For Stage-2, however, other uses such as commercial, amenity and logistics will be introduced gradually to meet the needs of those who will be living and working in or around the industrial park.

"Final Figure" is a definitive situation of VIP in the distant future. An area of 1,155 ha which consists of industrial and other different uses will be gradually developed after 2025.

Table 2.5.1: Development Phasing and Framework for VIP

STAGE - 1 (2015)

Function		Net Area (ha)			
		Stage1 (2015)		Total	
1	Industrial Area	130.0	94%	130.0	94%
2	Residential Area	10.0	6%	10.0	6%
3	Commercial Area				
4	Amenity Area				
5	Logistic Area				
TOTAL		140.0	100%	140.0	100%

STAGE - 2 (2025)

Function		Net Area (ha)					
		Stage1 (2015)		Stage2 (2025)		Total	
1	Industrial Area	130.0	94%	560.0	79%	690.0	82%
2	Residential Area	10.0	6%	97.0	14%	107.0	13%
3	Commercial Area			19.0	3%	19.0	2%
4	Amenity Area			19.0	3%	19.0	2%
5	Logistic Area			10.0	1%	10.0	1%
TOTAL		140.0	100%	705.0	100%	845.0	100%

FINAL FIGURE (After 2025)

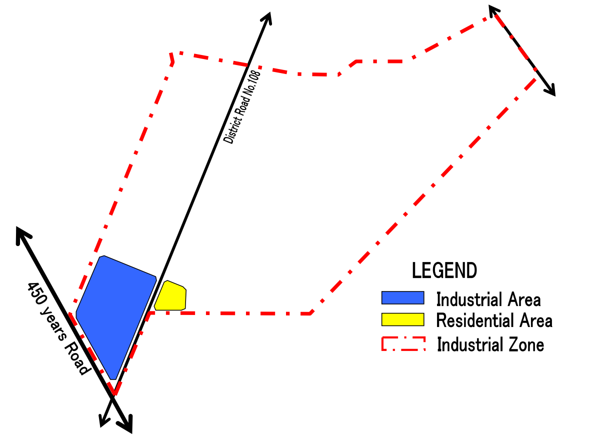
Function		Net Area (ha)							
		Stage1 (2015)		Stage2 (2025)		Stage3 (after 2025)		Total	
1	Industrial Area	130.0	94%	560.0	79%	850.0	74%	1,540.0	77%
2	Residential Area	10.0	6%	97.0	14%	179.0	15%	286.0	14%
3	Commercial Area			19.0	3%	53.0	5%	72.0	4%
4	Amenity Area			19.0	3%	53.0	5%	72.0	4%
5	Logistic Area			10.0	1%	20.0	2%	30.0	2%
TOTAL		140.0	100%	705.0	100%	1,155.0	100%	2,000.0	100%

Source: JICA Survey Team

A zoning plan for each stage (2015, 2025, and Final Figure) is shown in Figure 2.5.1.

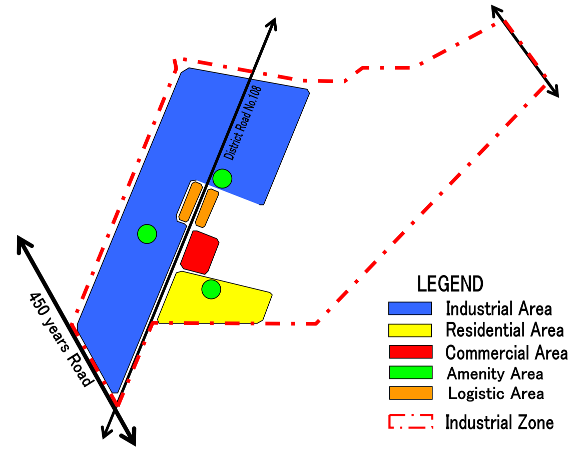
Stage-1 (2015)

- Stage-1 will start with the development of an area of 140 ha facing 450 Year Road which is currently under construction to be completed in 2010.
- An area of 130 ha will be developed for industrial use. The industrial area will be placed along 450 Year Road and District Road No.108.
- An area of 10 ha will be developed for residential use. The residential area will be placed at the east of District Road No.108.



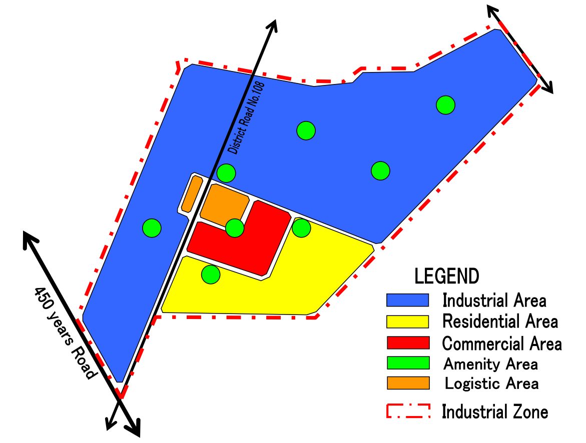
Stage-2 (2025)

- Stage-2 will cover an area of 705 ha of which 560 ha will be an industrial area.
- The industrial zone developed during Stage-1 will expand first to the north, and then to the east, crossing District Road No. 108.
- The residential zone developed during Stage-1 will expand to the east to have a total area of 107 ha.
- The central part on the both sides of District Road No. 108 will be declared as logistics zone with an area of 10 ha.
- The land located between the residential area and the commercial area will be zoned as commercial covering an area of 19 ha.
- Amenity function will be properly positioned in the industrial area and residential area, covering an area of 19 ha in total.



Final Figure (after 2025)

- An area of 1,155 ha will be gradually developed after 2025, so that Vientiane Industrial Park will cover a total area of 2,000 ha.
- The industrial area will expand to the east to have a total area of 1,540 ha.
- The residential area will expand to the east to have a total area of 286 ha.
- Both the logistics area and commercial area will also expand toward east, off District Road No. 108, to have a total area of 30 ha and 72 ha, respectively.
- Amenity function will be positioned in the industrial, residential, logistics and commercial areas, covering a total area of 72 ha.



Source: JICA Survey Team

Figure 2.5.1: Zoning Plan for Each Development Stage (2015, 2025, and Final Figure)

2.6 Investment to be Encouraged in VIP

2.6.1 Manufacturers to be Encouraged to Invest

The following manufacturers should be encouraged to establish in the VIP:

- Manufacturers which generate employment in the nation and contribute to the industrialization of the country.
- Manufacturers taken in by VIP without regard to capital structure (foreign, domestic or joint venture), product market (export or domestic market), and raw material supply (imported or local materials).

Among other potential industries in Vientiane Capital, the following manufacturing industries expressed interest as tenants of VIP, as described in Part II, Section 2.4.2.

- Manufacture parts of electrical and electronic machines and apparatus
- Metal works and non-ferrous metals
- Food and miscellaneous daily goods
- Textiles and apparels

In fact, according to the interview survey conducted by the JST, Japanese manufacturers of these categories showed interests in VIP as described in Appendix III.5

2.6.2 Service Industries to be Encouraged to Invest

Service industries that should be encouraged are those that provide support to the manufacturers.

2.6.3 Prohibited Business

The following businesses are prohibited in VIP:

- Manufacture of weapons or gunpowder
- Manufacture and sales of illegal drugs
- Other businesses prohibited by the law of the Lao PDR

2.6.4 Limitation of Foreign Workers Employment

According to Article 25 of the Labor Law (No.06/NA, December 7, 2006), employment of foreign workers are limited to the following:

- In terms of blue-collar worker, the number of foreign workers is limited up to 10% of the total number of workers in each establishment.
- In terms of white-collar worker, the number of foreign workers is limited up to 20% of the total number of workers in each establishment.

Because VIP is established for the purpose of creating employment for the Lao people, limitation of foreign workers employment should strictly be followed by establishments in VIP.

CHAPTER 3 VIP DEVELOPMENT PLAN

3.1 Site Conditions and Field Surveys

3.1.1 Topographic Conditions

The topographic survey was conducted by the JICA Survey Team (JST), sublet to a local consultant, from June 17 to October 25, 2009. The result of the survey is summarized below.

(1) Outline of Topographic Survey

The topographic survey covered the area including 450 Year Road and the entire development area of VIP with an area of about 200 ha. The survey was conducted as per the outline shown in Table 3.1.1.

Table 3.1.1: Outline of Topographic Survey

Work Item	Targeted Area	Work Schedule
• Collection and analysis of required data and maps, such as benchmark data, information of GPS. • Topographic survey covering about 200 ha, 1:2,000 scale. • Inventory survey for the existing buildings, electric line, telecommunication towers and underground facilities. • Survey report with topographic maps.	F/S area with 200 ha (1st phase of development)	• Site reconnaissance and kick-off meeting with DoIC on June 17, 2009. • Preparatory work was conducted. • Field works were completed on August 2, 2009. • Draft final report was submitted on August 31, 2009. • Final report was submitted on October 25, 2009.

Source: JICA Survey Team

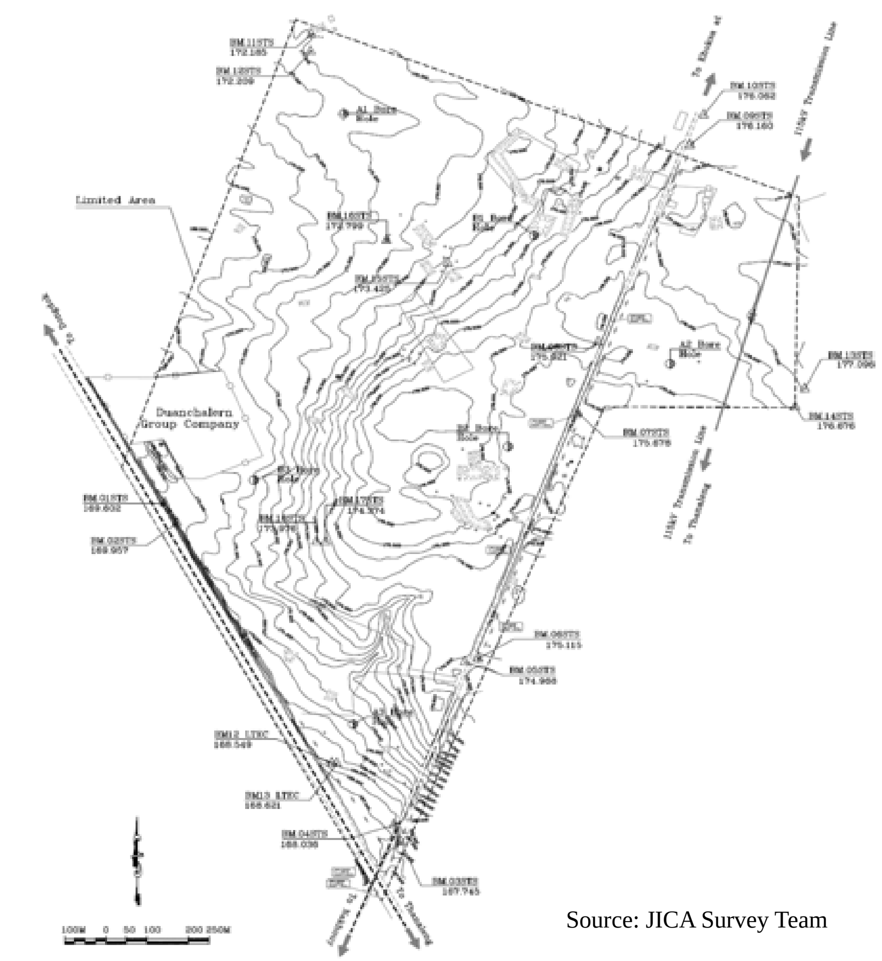
(2) Result of Topographic Survey

The feasibility study area is wedged between 450 Year Road and District Road No. 108 as shown in Figure 3.1.1. The surveyed area on the west side of District Road No.108 has a form of a flat dome with elevation varying from EL.176.989 m to EL.167.575 m above the mean sea level (AMSL). The hill with the highest elevation of EL.176.989 m is located about 480 meters from District Road No, 108 and 749 meters from 450 Year Road. The point of lowest elevation with EL.167.575 m is located at the cross road between 450 Year Road and District Road No. 108. The area along the east side of the latter road is much flatter than the western area and has higher elevation varying from about EL.176 m to EL. 177 m.

The area along District Road No. 108 is relatively higher than other areas. The area with lowest elevation is along 450 Year Road. The gradient of the terrain slopes from east to west with 1%. Slope of 450 Year Road is about 1% while that of District Road No. 108 has a gentle descent with less than 0.1% to the south.

Within the feasibility study area, there are 46 fish ponds with size varying from 100 m^2 to 5,600 m^2, and one small stream flowing towards 450 Year Road. This stream does not flow during most of the dry season. The counted numbers of houses/buildings in the area were approximately 33 structures.

On the basis of analysis and the results of the topographic survey, the infrastructure for the VIP is planned and designed.



Source: JICA Survey Team

Figure 3.1.1: Topographic Map and Location of Core-Boring Site

(3) Inventory Survey for the Existing Facilities

The existing facilities are summarized in Table 3.1.2 (as for the location of each facility, refer to Figure 3.1.1).

Table 3.1.2: Existing Facilities

No.	Facilities	Unit	Quantity
1	Electricity Concrete Pole 22kv	Unit	74
2	Transmission Tower 115kv	Unit	1
3	Pipe Culvert		
	- Pipe Culvert 2 Ø 80	Set	1
	- Pipe Culvert 2 Ø 100	Set	1
	- Pipe Culvert Ø 80	Set	5
4	Local Well	Number	5
5	Fish Pond	Number	46

Source: Topographic Survey Report for VIP

(4) Survey for the Existing Houses and Buildings

Detailed description of 33 houses/buildings in VIP area is summarized in Table 3.1.3.

Table 3.1.3: Housing and Buildings

No.	Location (Village)	Type of Houses/Buildings				
		Size (m)	Number of Floor	Wall	Roof	Column
1	Xoknoy	6.0x7.0	One floor	Brick Masonry	Galvanized Iron Sheet	Precast Reinforce Concrete
2	Xoknoy	3.0x4.0	Temporary hut	Bamboo	Galvanized Iron Sheet	Wood
3	Xoknoy	4.0x6.0	Temporary hut	None	Galvanized Iron Sheet	Precast Reinforce Concrete
4	Xoknoy	8.0x10.0	One floor with 40cm base	Brick masonry (Partially)	Galvanized Iron Sheet	Precast Reinforce Concrete
5	Xoknoy	3.0x4.0	One floor with 50cm base	Old conjugated sheet plate + wood	Old Galvanized Iron Sheet	Wood
6	Xoknoy	3.0x3.0	One floor (temporary type)	Plastic	Straw	Bamboo
7	Xoknoy	4.0x5.0	One floor Stilt House	Bamboo (Partially)	Old Galvanized Iron Sheet	wood
8	Xoknoy	5.0x6.0	One floor Stilt House	Bamboo	Galvanized Iron Sheet	Wood
9	Xoknoy	8.0x12.0	One floor	Unplastered Brick Masonry (Partially)	Fiber cement roofing tile	Precast Reinforce Concrete
10	Nabian	7.0x8.0	One floor with 30cm base	Brick Masonry	Fiber cement roofing tile	Precast Reinforce Concrete
11	Nabian	4.0x5.0	One floor Stilt House	Bamboo (Partially completed)	Galvanized Iron Sheet	Wood
12	Nabian	9.0x12.0	One floor Stilt House	Bamboo	Fiber cement roofing tile	Steel
13	Nabian	8.0x9.0	Incompleted	None	None	Reinforce Concrete
14	Phonthong	7.0x9.0	One floor	Brick Masonry (windows incomplete)	Galvanized Iron Sheet	Precast Reinforce Concrete
15	Phonthong	4.0x5.0	One floor Stilt House	Bamboo (Partially completed)	Galvanized Iron Sheet	Wood
16	Phonthong	5.0x7.0	One floor Stilt House	Bamboo (Partially completed)	Galvanized Iron Sheet	Wood
17	Phonthong	3.0x4.0	One floor Stilt House	Bamboo	Galvanized Iron Sheet	Wood
18	Phonthong	4.0x5.0	One floor Stilt House	Bamboo (Partially completed)	Straw (lony leaves grass)	Wood
19	Phonthong	4.0x5.0	One floor Stilt House	Bamboo	Galvanized Iron Sheet + Straw	Wood
20	Phonthong	4.0x6.0	Temporary hut	None	Galvanized Iron Sheet	Wood
21	Phonthong	8.0x12.0	Two floor	Wood (first floor is no wall)	Fiber cement roofing tile	Precast Reinforce Concrete
22	Phonthong	24.0x15.0	One floor	Brick Masonry (windows incomplete)	Fiber cement roofing tile	Precast Reinforce Concrete
23	Phonthong	20.0x20.0	One floor under construction	Brick Masonry	No	Reinforce Concrete
24	Phonthong	7.0x8.0	One floor with 40cm base	Unplastered Brick Masonry	Fiber cement roofing tile	Reinforce Concrete
25	Phonthong	8.0x9.0	One floor with 30cm base	Brick Masonry	Fiber cement roofing tile	Reinforce Concrete
26	Phonthong	4.0x6.0	One floor Stilt House	None	Old Galvanized Iron Sheet	Wood
27	Phonthong	4.0x6.0	Incomplete	None	Old Galvanized Iron Sheet	Wood
28	Phonthong	8.0x9.0	Incomplete	None	None	Reinforce Concrete
29	Phonthong	4.0x6.0	One floor with 30cm base	Bamboo	Old Galvanized Iron Sheet	Wood
30	Phonthong	9.0x12.0	One floor with 30cm base	Wood	Galvanized Iron Sheet	Precast Reinforce Concrete
31	Phonthong	4.0x6.0	One floor Stilt House	Bamboo (Partially completed)	Straw	Wood
32	Phonthong	3.0x4.0	One floor Stilt House	Straw+Plastic	Straw	Wood
33	Phonthong	3.0x4.0	One floor Stilt House	Straw+Old conjugated sheet plate	Straw	Wood

Source: Topographic Survey Report for VIP

3.1.2 Geological Conditions

Geological survey was conducted in Vientiane Capital from June 17 to October 5, 2009. Results of survey works are described in the following sub-sections.

(1) Outline of Geological Survey

The geological survey was conducted at six sites as shown in Figure 3.1.1. The work covers the items and schedule shown in Table 3.1.4.

Table 3.1.4: Outline of Geological Survey

Work Item	Targeted Area	Work Schedule
a) Six locations b) Core Boring: Depth of 50 meters for Type A and 30 meters for Type B. c) Standard Penetration Test (SPT): 2 m in each bore hole. d) In-situ permeability test: One place in each bore hole. e) Laboratory Tests - Density of soil particles - Moisture content test - Grain size analysis - Wet density test - Permeability test - Unconfined compression test - Consolidation test - California Bearing Ratio(CBR) test - Survey report	Sites to be selected are areas where large facilities are expected; wastewater treatment plant, sub-station, water tank, within F/S area with 140 ha (1st phase of development)	• Site reconnaissance and kick-off meeting with DoIC on June 17, 2009. • On-site investigations were conducted in June. • Field works were completed on July 11, 2009. • Draft final report was submitted on August 24, 2009. • Final report was submitted on September 7, 2009.

Source: JICA Survey Team

(2) Result of the Sub-Surface Soil Condition Survey

The geological features of Vientiane Capital are described as talus terraces with alluvial deposits from the Mesozoic Cretaceous period. Alluvial deposits consist of mostly unconsolidated clay, transported by the Mekong River flooding. The urban area is covered with alluvial soil, while the area further from the Mekong River is mostly covered with laterite.

Form the result of soil investigation of six boreholes, the soil strata at the feasibility study area are classified into two layers as mentioned below:

Layer 1: very stiff, red, reddish yellow and reddish grey, clayey sand including laterite

Layer 2: very hard, reddish brown, clay stone

The clayey sand including laterite of layer 1 is found at the ground surface of boreholes A1, A2, A3, B2 and B3, with an average layer thickness of 1.8 m. The thickness of clayey sand including laterite varies from 1.0 m (A2) to 2.0 m (A1, A2, B2 and B3). The composition of this layer is not homogeneous. Soil color varies from red, reddish yellow and reddish grey and has stiff to very stiff consistency.

(3) Result of Geological Survey

Through the results obtained from the geotechnical investigation, the top soil is recommended to be scraped away since its depth of 50 cm consists of cultivated soil. The soil of layer 1 was found to be with high bearing capacity, but its thickness is lesser. This layer is suitable for laying the foundation for light structure, such as box culvert, pipe installation and manholes. Layer 2 meanwhile consists of bed rock, with soft rock materials and is significantly thicker. This layer is suitable to bear heavy loads. In other words, this layer is suitable for laying the foundation for heavy industries or high rise buildings.

(4) Summary and Recommendations

Layers with high bearing capacity are summarized in Table 3.1.5.

Table 3.1.5: Summary of Soil Layers with N-Value >30

Boreholes	Number of Layers	Distributed Depth		Thickness (m) with SPT>30
		Top (m)	Bottom (m)	
A1	2	2	30	28
A2	2	3	30	27
A3	2	5	30	25
B1	2	2.1	20	17.9
B2	1 and 2	0	20	20
B3	2	2	20	18

Source: Geological Survey Report for VIP

According to the field and laboratory test results, it is concluded that the soil condition at the project area consists of cohesive materials which range from stiff to very stiff properties, and consistent hard rock materials. Since such analysis and findings are very useful prior to building any structures or foundation at any location, it is important to consider the results of the geological survey.

3.2 Land Use Plan and Strategy for VIP Development

3.2.1 Planning Basis

Land use plan was prepared based on the concepts below:

1) To prepare the plan based on the framework described in the industrial development plan as summarized below:

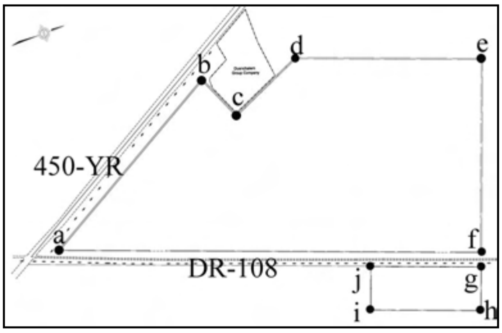
   a. Industrial estate development target by 2015: 130 ha

   b. Estimated number of employees (factory workers) at 100% operation: 7,500

   c. Estimated required residential area to accommodate 80% of the total employees: 10 ha

   d. Land development boundary authorized by the MoIC and Vientiane Capital

	North	East
a.	1990356.757	258340.146
b.	1991242.864	257848.184
c.	1991329.477	258055.185
d.	1991668.707	257909.367
e.	1992455.757	258217.997
f.	1992134.495	259037.259
g.	1992111.313	259096.376
h.	1992038.300	259282.572
i.	1991572.809	259100.038
j.	1991645.823	258913.842



Source: JICA Survey Team

Figure 3.2.1: Authorized Land Development Boundary

2) To consider the future development plan of the VIZ and expansion of District Road No.108.

3) To keep necessary land area for common functions, such as road, green/park and other infrastructure, for carrying out related industrial activities with better atmosphere.

4) To maximize the land area for the factory lot and raise its land value and cost return.

5) To consider internal traffic flows for ensuring safety and escape traffic congestion.

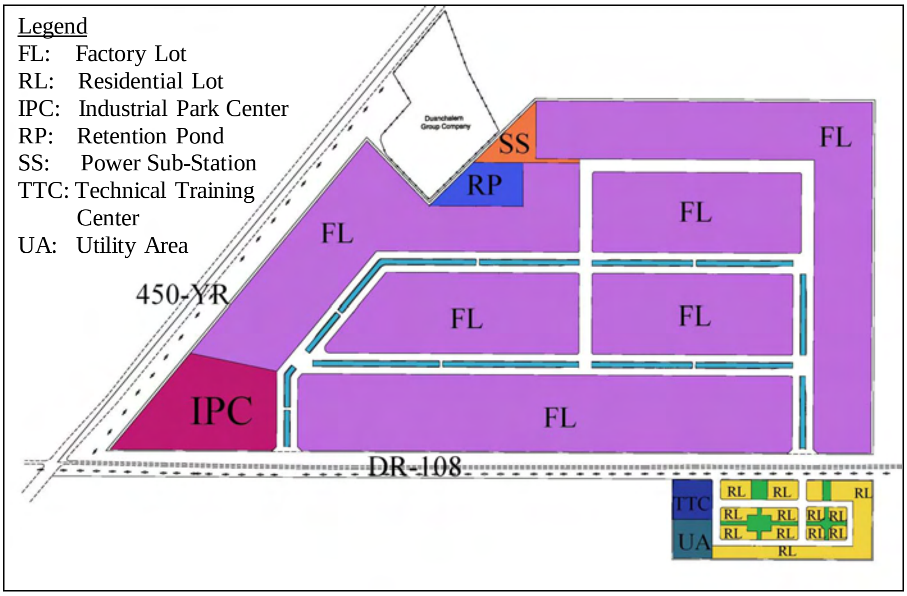
6) To utilize the land, unsuitable as factory lot, for common infrastructure facilities.

7) To consider the landscape and amenity of the park.

8) To consider the factory lot size to meet investors' needs.

3.2.2 Land Use Plan

The total land area for VIP is 140.14 ha, which is calculated based on the authorized land boundary. Land use plan is shown in Figure 3.2.2 and Table 3.2.1.



Source: JICA Survey Team

Figure 3.2.2: Land Use Plan for the VIP

Table 3.2.1: Numerical Land Scales by Use

Industrial Area	Area (ha)		Residencial Area	Area (ha)	
Factory Lot	96.50	*74.15%*	Residence Lot	5.04	0.50
Industrial Park Center, incl. retention pond	7.11	*5.46%*	Park and Amenity	0.90	0.09
Retention Pond	1.93	*1.48%*	Technical Training Center (TTC)	0.95	0.10
Power Sub-Station	1.30	*1.00%*	Utility Area	0.94	0.09
Road, incl. channel	20.79	*15.98%*	Road	1.82	0.18
Slope/Buffer Green	2.51	*1.93%*	Slope/Buffer Green	0.35	0.04
Total	**130.14**	***100.00%***	**Total**	**10.00**	***100.00%***

Source: JICA Survey Team

As a result, factory lot area can be kept over 70%, which has better land performance based on the average in Japan (70% as a common/average target).

3.2.3 Lot Allocation Plan

The lot allocation plan for the VIP is shown in Figure 3.2.3. To meet different needs of lot area from different types of industry or investors, small lots are allocated in the same block. Therefore, if an investor requires a larger area, several small lots can be combined to increase the saleable lot size.

Furthermore, large lots are allocated in front or beside the main road for traffic convenience and better appearance of the park.

Source: JICA Survey Team

Figure 3.2.3: Lot Allocation Plan for the VIP

The factory lots sum up to 59 in total as shown in Table 3.2.2. Considering the aims and management requirements, 1 ha is adopted as the smallest lot size.

Table 3.2.2: Summary of Lot Allocation Plan

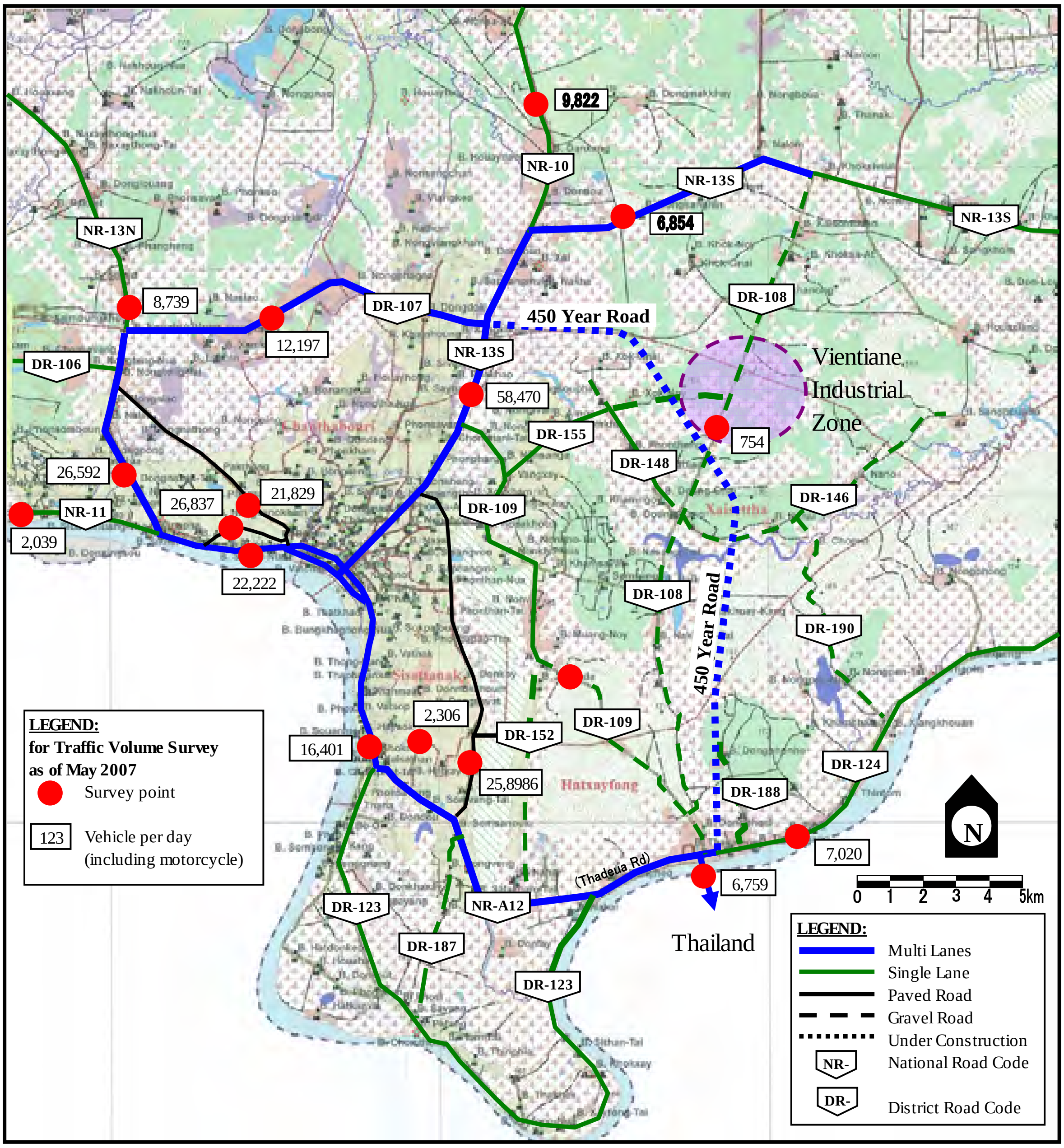
Industrial Area		
Total Factory Area (ha)	96.50	
Total Factory Lot Nos.	59	100.0%
Factory Lot 1.0ha and less	27	45.8%
Factory Lot 2.0ha and less	19	32.2%
Factory Lot 3.0ha and less	9	15.3%
Factory Lot over 3.0ha	4	6.8%

Source: JICA Survey Team

3.3 Traffic Network Analysis

3.3.1 Present Vientiane Road Network

Figure 3.3.1 shows the present network in Vientiane and the result of actual traffic volume count based on the survey conducted under the "The Study of Master Plan on Comprehensive Urban Transport in Vientiane (JICA, 2008)" (hereinafter called the Transport MP).



Source: JICA Survey Team

Figure 3.3.1: Major Road Network and Result of Traffic Volume Survey

VIP is located at the northwest part of the junction between 450 Year Road (under construction as of April 2010) and District Road No. 108 (under expansion as of April 2010). The traffic volume around VIP is as follows:

- National Road No.13 South: 6,854 vehicles/day.
- District Road No.108: 754 vehicles/day.

Currently, there is no significant traffic around the VIP site.

3.3.2 On-going Road Construction Projects in Vientiane

(1) 450 Year Road Construction Project

The 450 Year Road is being constructed and is planned to be completed by October 2010.

1) Outline of the Project

This road construction project includes the Vientiane Capital's outside ring road, which connects National Road No.13 South to the Friendship Bridge.

a) Width: 33.0 m (4 lanes and expandable to a total of 6 lanes in the future)

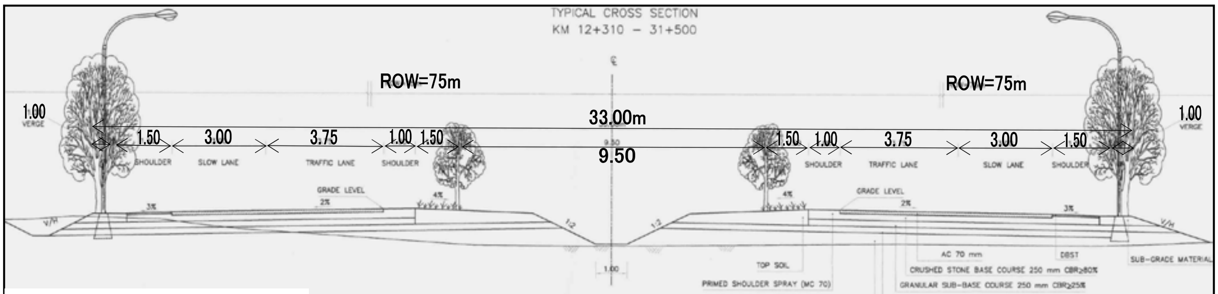
b) Length: 20.30 km (section: Dong Pho Si to Dong Dok)

c) Pavement: mainly asphalt pavement; concrete pavement will be at intersections only

d) Work components: earthworks, pavement, drainage, sidewalk, street lighting and plantation

2) Implementation Schedule

Construction work started on April 25, 2008 with a duration of 28 months.



Source: Vientiane capital

Figure 3.3.2: Typical Section of 450 Year Road

(2) 25th SEA Games Linking Roads Construction Projects

This is a road construction project initiated by the Ministry of Public Works and Transport (MPWT). The ring road around the stadium where the SEA Games was held in December 2009 was developed.

1) Outline of the Project

[Project No.1] New Road linking SEA Game Stadium and 450 Year Road

a) Width: 9.0 m (2 lanes)

b) Length: 6.23 km (section: Khok-Gnai to Xok-Noy)

c) Pavement: asphalt pavement and concrete pavement

d) Work Components: earthworks, pavement, drainage and street lighting

[Project No.2] Improvement and Expansion of National Road No.13 South

a) Width: 29.5 m (Four lanes) in front of Stadium and 22.0m (Four lanes) for the other section

b) Length: 4.725 km (section: SEA Game Stadium to Junction No. 3)

c) Pavement: asphalt pavement and concrete pavement

d) Work Components: earthworks, pavement, drainage, street lights and plantation

[Project No.3] Expansion and Pavement of District Road No. 108

District Road No. 108 (gravel pavement) connects from its junction with National Road No.13 South up to B. Nakhoay-Tai across 450 Year Road.

a) Width: 17.0 m (4 lanes)

b) Length: 14.077 km (section: National Road No.13 South junction to Nakhoay Tai or 450 Year Road junction)

c) Pavement: asphalt pavement and concrete pavement

d) Work Components: earthworks, pavement, drainage, and street lighting

2) Implementation Schedule

Project No. 1 and No. 2 were completed before December 9, 2009 (opening date of SEA Games). Construction of Project No. 3 has already started and is planned to be completed by December 31, 2010.

3.3.3 Review on Existing Vientiane Traffic Network Analysis

(1) Review of Relevant Existing Study

The transport networks studied in the Transport MP conducted by JICA in 2008 formed the basis for this updating work.

1) Traffic Flow Direction

According to the result of the Transport MP, traffic flow direction in Vientiane is as shown in Figure 3.3.3.

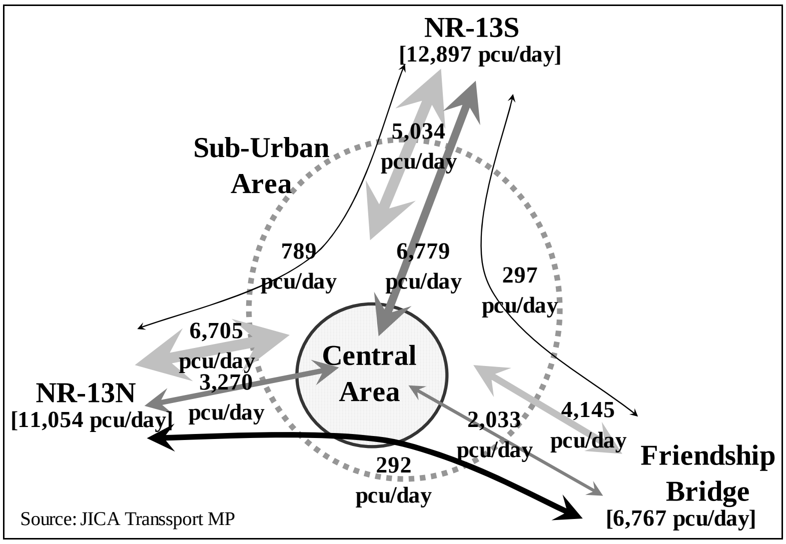


Figure 3.3.3: Traffic Flow Direction in Vientiane

Traffic volume at Friendship Bridge is 6,767 pcu/day where 34% goes to the central area.

2) Future Traffic Volume

According to the Transport MP, trip number and vehicle ownership will be more than double from 2007 to 2025. The estimation results are shown in Figure 3.3.4 below.

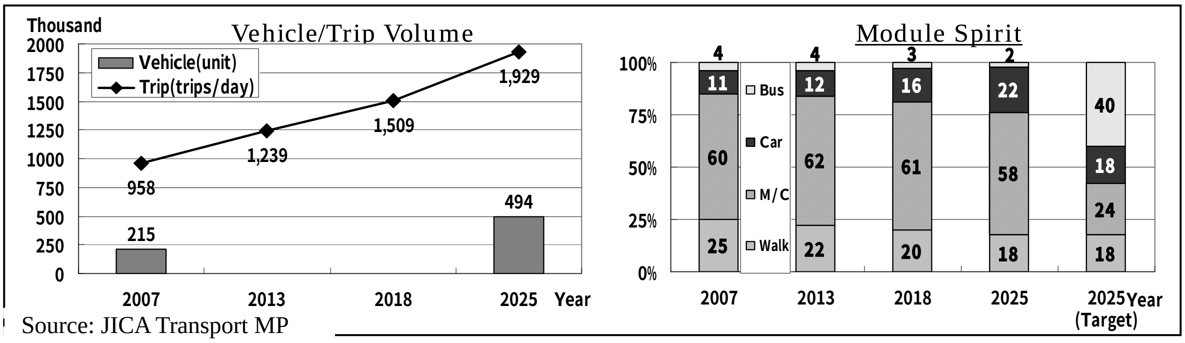
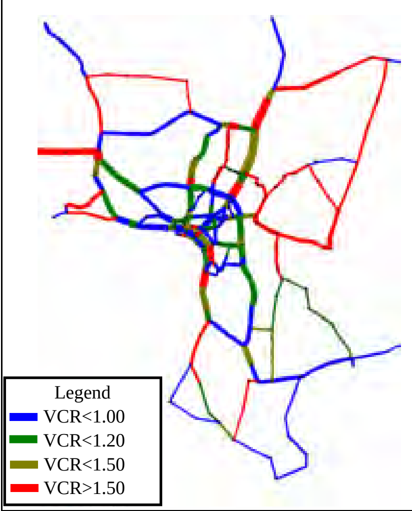
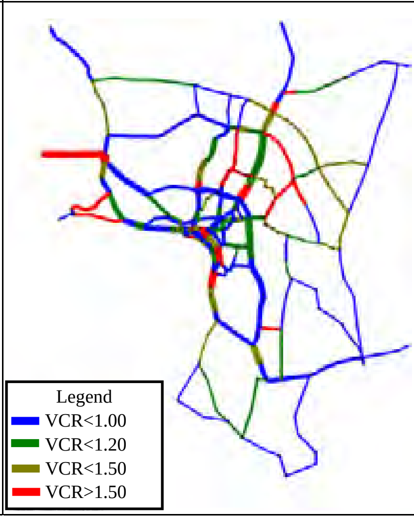
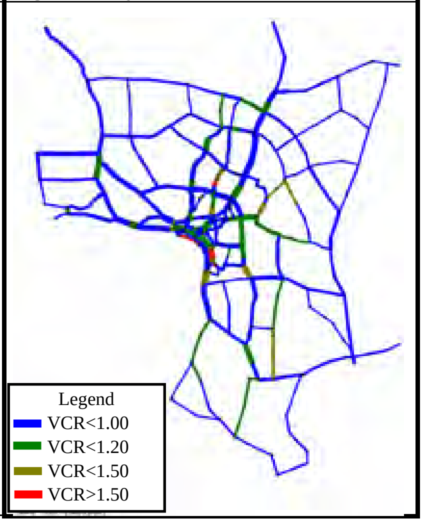


Figure 3.3.4: Estimated Trip, Number of Vehicles and Modal Split

3) Development Scenario for the Road Network

Three development scenarios for the road network were examined as summarized in Table 3.3.1 below. Consequently, Scenario-3 was selected.

Table 3.3.1: Outline of Planned Scenarios

Scenario-1 Urgent Improvement Scenario	**Scenario-2** Missing Link Construction Scenario	**Scenario-3** Completion of Road Network Scenario
This scenario assumes that only urgent road improvement projects are implemented, which aim to reduce traffic congestion expected in the near future. These improvement projects are listed as follows: - Extension of the Inner Ring Road up to the northeastern side of the airport, and connects to the road between Nongtengtai Village and Pakthan Village. - Widening of the existing sections of Inner Ring Road to proposed four lanes. - Widening of the road connecting Dongdok – Saynamngeun – Chommani – Hongseng to proposed four lanes from the existing 1.5 lanes in each direction.	In addition to the urgent improvement scenario, the following projects are to be implemented, which aim to complete the basic road network with minimum improvement of existing roads in view of the future urban structure proposed in the Study: - Missing links are to be connected with two-lane pavement road. - The unpaved existing roads with two lanes are to be paved. - The narrow road sections are to be widened to two-lane widths.	This scenario assumes that functional road network is to be provided to accommodate traffic demand in the target year of 2025 and to apply the road design standards corresponding to the functional street systems described in the preceding section. Local roads are excluded in the traffic assignment of the Study as it considers a broad-based traffic flow. - The cross sections are the primary arterial streets. Arterial street and collector street are established taking into account the future modal share and their roles in terms of their functions required. - The desirable road cross sections and right-of-way are shown.
		

Note: VCR= Volume Capacity Ratio
Source: JICA Transport MP

(2) Required Updating Works

The Transport MP was conducted in 2008. However, road construction projects that have commenced unexpectedly, such as 450 Year Road, are not taken into consideration in the plan. Therefore, updating work is curried out with consideration of the additional roads below:

1) 450 Year Road, which will be expanded to six lanes by 2025,

2) 25th SEA Games Linking Roads, and

3) Traffic generation with the development of VIZ.

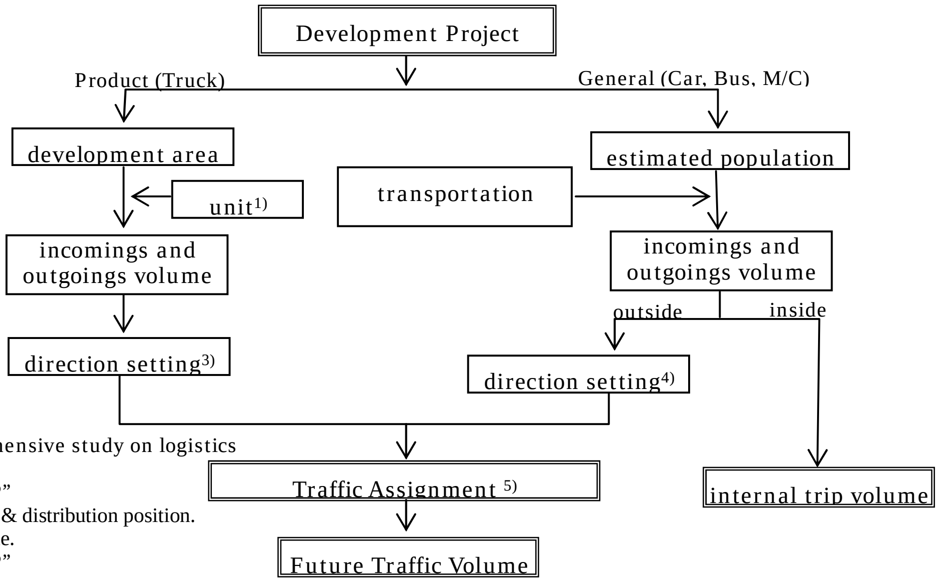
The plan was prepared based on the target year of 2025. Target year for the updating is set in line with the VIP development plans, which are 2015 as the short term target year, and 2025 as the mid-long term target year.

3.3.4 Traffic Volume Projection related to VIZ

(1) Estimation Basis

1) Traffic Volume Estimation Flow

Traffic Volume is re-estimated based on the workflow shown in Figure 3.3.5. The conditions in the updating work are applied for the Transport MP.



1) From " The comprehensive study on logistics system" 's survey
2) From "Transport M/P"
3) Distributes to a logistics & distribution position.
4) Distributes to OD volume.
5) From "Transport M/P"

Source: JICA Survey Team

Figure 3.3.5: Traffic Volume Estimation Flow

2) Estimation of Unit Traffic Volume

The unit volume of industrial vehicle (truck) is examined based on survey results done under "The Comprehensive Study on Logistics System in the Lao PDR" (hereinafter called as the Logistics Study) and demand survey results conducted by the Study.

The establishment conditions are as follows:

a) Utilization of the result of incoming and outgoing traffic count survey done under the Logistics Study.

b) Categorizing the results above by type of industrial sector.

c) Adoption of the above results to the assumed industrial sectors to be located in VIP based on the demand survey results.

Consequently, VIP's standard unit traffic volume by factory area is estimated at 70 vehicles/ha/day and the traffic volume for the logistics center was estimated at 55 vehicles/ha/day.

Number of trips of general types of vehicle (motorcycle, car and public transport) will be calculated based on the population.

3) Modal Split

In the Transport MP, modal split for the year 2013, 2018, 2025 and 2025 Target was estimated as shown in Table 3.3.2.

Table 3.3.2: Modal Split

	2007	2013[1)]	2018[1)]	2025[1)]	2025 Target[2)]
Walk & Bicycle	25.0%	22.0%	20.0%	18.0%	18.0%
Motorcycle	60.0%	62.0%	61.0%	58.0%	24.0%
Car	11.0%	12.0%	16.0%	22.0%	18.0%
Public Transport	4.0%	4.0%	3.0%	2.0%	40.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
			Stage-1	Stage-2	Stage-3

Note: 1) Present condition trend of Transport M/P
2) Target of Transport M/P
Source: JICA Transport M/P

Considering a safe figure for the Study, the 2018 prediction is adopted for Stage 1 (2015), 2025 for Stage 2 (2025), and 2025 Target for Stage 3 (after 2025).

The actual occupancy ratio measured under the Transport MP shown in Table 3.3.3 will be used. The average ratios for pick-up and sedan are applied for the occupancy ratio for sedan, while that of mini bus, large bus and tuk-tuk were applied for bus as the major public transportation.

Table 3.3.3: Occupancy Ratio by Type of Vehicle

	Average Occupancy	Occupancy Ratio to be used in the Study			Remarks
Motorcycle	1.3	1.3			
Pick-Up	2.7	2.4			Use for sedan
Sedan	2.1				
Tuk-Tuk	4.0	6.1	13.5		Use for public trans. Stage 1
Mini Bus	8.1			18.2	Use for public trans. Stage 2
Large Bus	28.3				Use for public trans. Stage 3
Light Truck	2.5				
Heavy Truck	1.6				
Trailer	1.7				

Source: JICA Transport M/P

(2) Estimation of Traffic Volume of VIZ in the Study

The result of incoming and outgoing traffic volume count is shown in Table 3.3.4. The external trip is defined as the incoming and outgoing traffic volume to and from VIZ, respectively, while internal trip is traffic volume within the vicinity of VIZ. It is noted that external trip of the residents is estimated as part of the commercial trip.

Table 3.3.4: Estimated Traffic Volume at VIZ

Category		Stage 1 2015	Stage 2 2025	Stage 3 After 2025	Remarks
1	**Development Area**				Based on the land use plan
a	Factory Lot (ha)	96.4	483.0	1,078.0	
b	Residential Lot (ha)	5.0	50.0	140.0	
c	Commercial Lot (ha)	0.0	10.0	37.5	
d	Logistic Lot (ha)	0.0	7.0	21.0	
2	**Factory Floor Area**				
a	Factory Floor Ratio (%)	30%	30%	30%	
b	Ave. floor	1	1	1	
c	Factory Floor Area (ha)	28.9	144.9	323.4	= [1a]x[2a]x[2b]
3	**Population**				Based on development framework
a	Industrial Worker	7,500	39,700	88,700	
b	Worker (living in VIP)	6,000	35,730	88,700	
c	Worker (from outside)	1,500	3,970	0	
d	Residents	6,000	92,800	239,600	
e	Admin worker	30	50	50	
f	Commercial	0	11,600	32,300	
4	**[External] Industrial Vehicle Volume**				
a	Unit (trip/ha/d)	70	70	70	
b	Cargo (Factory) (trip/d)	2,023	10,143	22,638	= [2c]x[4a]
c	Unit (trip/ha/d)	55	55	55	
d	Cargo(Logistic) (trip/d)	0	385	1,155	= [1d]x[4c]
e	**Total Truck Volume (trip/d)**	**2,023**	**10,528**	**23,793**	= [4b]+[4d]
5	**[External] General Vehicle Volume**				
a	Population (from outside)	1,530	15,620	32,350	= [3c]+[3e]+[3f]
b	Overall Trip Rate	2.0	2.0	2.0	incoming-outgoing
c	**Overall Trip Volume (trip)**	**3,060**	**31,240**	**64,700**	=[5a]x[5b]
d	Walk/Bicycle Sharing Ratio	20.0%	18.0%	18.0%	
e	Walk/Bicycle Occupancy Ratio	1.0	1.0	1.0	
f	**Walk/Bicycle Trip Volume (trip/d)**	**612**	**5,623**	**11,646**	=[5c]x[5d]/[5e]
g	Motorcycle Sharing Ratio	61.0%	58.0%	24.0%	
h	Motorcycle Occupancy Ratio	1.3	1.3	1.3	
i	**Motorcycle Trip Volume (trip/d)**	**1,436**	**13,938**	**11,945**	=[5c]x[5g]/[5h]
j	Sedan Sharing Ratio	16.0%	22.0%	18.0%	
k	Sedan Occupancy Ratio	2.4	2.4	2.4	
l	**Sedan Trip Volume (trip/d)**	**204**	**2,864**	**4,853**	=[5c]x[5j]/[5k]
m	Public Transport Sharing Ratio	3.0%	2.0%	40.0%	
n	Public Transport Occupancy Ratio	6.1	13.5	18.2	
o	**Public Transport Trip Vol. (trip/d)**	**15**	**46**	**1,422**	=[5c]x[5m]/[5o]
6	**[Internal] General Trip Volume**				
a	Workers living in VIP	6,000	35,730	88,700	=[3b]
b	Trip rate	2.0	2.0	2.0	incoming-outgoing
c	**Workers Trip Volume (trip/d)**	**12,000**	**71,460**	**177,400**	=[6a]x[6b]
d	Residents (except workers)	0	57,070	150,900	=[3d]-[3b]
e	Trip rate	1.0	1.0	1.0	assumed that as a daily average, 50% of residents are moving.
f	**Residents Trip Volume (trip/d)**	**0**	**57,070**	**150,900**	=[6d]x[6e]
g	**Total Trip Volume**	**12,000**	**128,530**	**328,300**	=[6c]+[6f]

Source: JICA Survey Team

To identify the required road types and number of lanes, it is necessary to convert the trip volume above into passenger car unit (pcu) by multiplying the number of trips to the pcu unit. The conversion ratio (pcu unit) for each trip type, which is described in the previous section, is applied. The results of conversion are summarized in Table 3.3.5.

Table 3.3.5: Estimated External Traffic Volume in pcu

Type	External Traffic			pcu unit	Internal Traffic		
	Stage 1	Stage 2	Stage 3		Stage 1	Stage 2	Stage 3
	2015	2025	after 2025		2018	2025	After2025
Truck (vehicle/d)	2,023	10,528	23,793	2.00	-	-	-
Walk/Bicycle (trip/d)	612	5,623	11,646	0.00	12,000	128,530	328,300
Motorcycle (vehicle/d)	1,436	13,938	11,945	0.33	-	-	-
Sedan (vehicle/d)	204	2,864	4,853	1.13	-	-	-
Public transport (vehicle/d)	15	46	1,422	2.00	-	-	-
Total Traffic Volume (pcu/d)	4,780	28,984	59,856		0	0	0

Source: JICA Survey Team

It is noted that a huge number of pedestrians or walking trips under internal traffic are not estimated as a vehicle/car trip. Thus, it is necessary to provide sufficient sidewalk and pedestrian lanes inside the VIZ as well as VIP as part of the Stage 1 VIZ development project.

Moreover, it is necessary for the initial stage of stage-wise development to consider enough future expansion space to accommodate the estimated final traffic volume. Therefore, District Road No. 108 as an internal arterial road is required to provide sufficient buffer space for the future expansion.

(3) Traffic Flow Direction

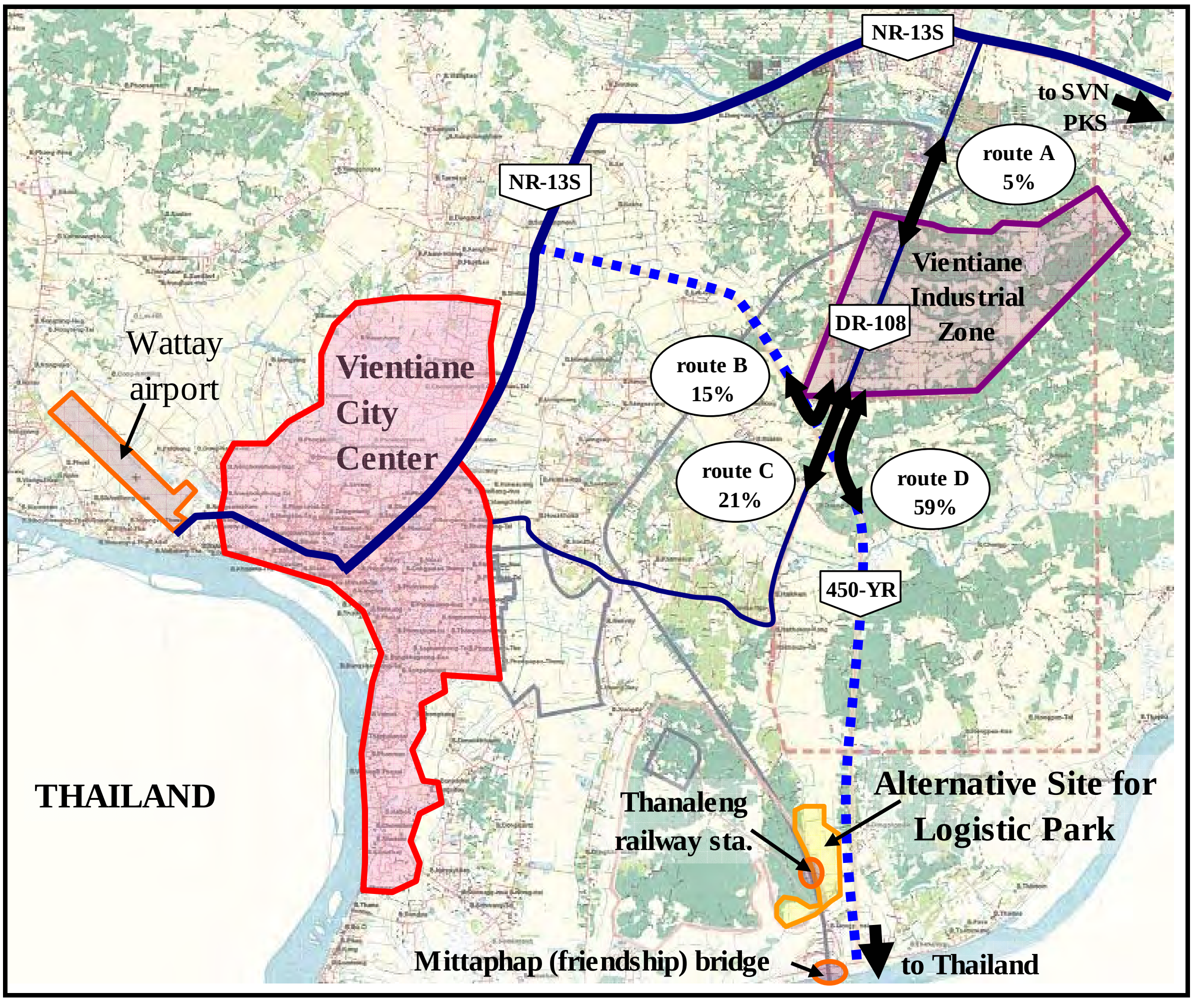
There are four major traffic flow directions from VIZ as shown in Figure 3.3.6. The distribution ratio presented in Figure 3.3.6 is assumed based on the conditions below:

1) Route A: Leads to the southern part of Lao, such as Savannakhet and Pakse.
Considering no large residential area and/or village exist currently, major traffic to this direction will be industrial trucks.

2) Route B: Leads to the airport through 450 Year Road and National Road No.13 South.
Some residential area exists along National Road No.13 South, therefore, traffic to this direction will mainly consist of industrial trucks to the airport and motorcycles.

3) Route C: Leads to the city center.
Major commuters such as motorcycles, sedans, bus/public transports will come and go through this direction.

4) Route D: Leads to Thanaleng and Thailand Border through 450 Year Road.
Some residential area exists around Thanaleng, therefore, traffic to this direction will mainly consist of industrial trucks traveling to Thailand and some motorcycles.



Source: JICA Survey Team

Figure 3.3.6: Assumed Traffic Flow Directions

The assumed traffic flow distribution ratio should not be changed during the whole stage of the VIZ development.

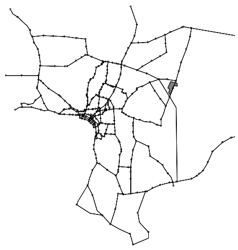
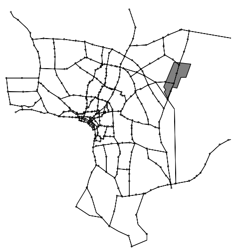
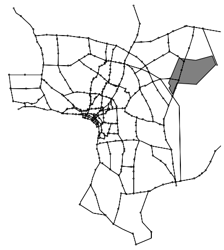
3.3.5 Traffic Distribution Analysis

(1) Impact of the Road Network

Traffic distribution analysis is updated based on the new road network which includes new projects and traffic volume incidence due to the VIZ development and revised OD (added traffic generation related to VIP development).

Impact of VIZ development to the traffic network is analyzed based on the conditions summarized in Table 3.3.6.

Table 3.3.6: Conditions Related to VIZ Development

<table>
<tr><td colspan="2" rowspan="2"></td><td>Stage 1</td><td>Stage 2</td><td>Stage 3</td></tr>
<tr><td>2015</td><td>2025</td><td>after 2025</td></tr>
<tr><td colspan="2">road network</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">OD
(based on Transport MP)</td><td>2015</td><td>2025</td><td>2025</td></tr>
<tr><td rowspan="4">traffic volume of VIZ (vehicle/d)</td><td>Truck</td><td>2,023</td><td>10,528</td><td>23,793</td></tr>
<tr><td>Motorcycle</td><td>1,436</td><td>13,938</td><td>11,945</td></tr>
<tr><td>Sedan</td><td>204</td><td>2,864</td><td>4,853</td></tr>
<tr><td>Public transport</td><td>15</td><td>46</td><td>1,422</td></tr>
<tr><td rowspan="2">direction setting</td><td>Industrial Traffic</td><td colspan="3">70% for Thanaleng/Thailand boundary, 10% for Airport, 20% to Southern region through National Roads No.13S.</td></tr>
<tr><td>Other Traffic</td><td colspan="3">Distributes to OD pattern volume as stated in the Transport MP.</td></tr>
</table>

Source: JICA Survey Team

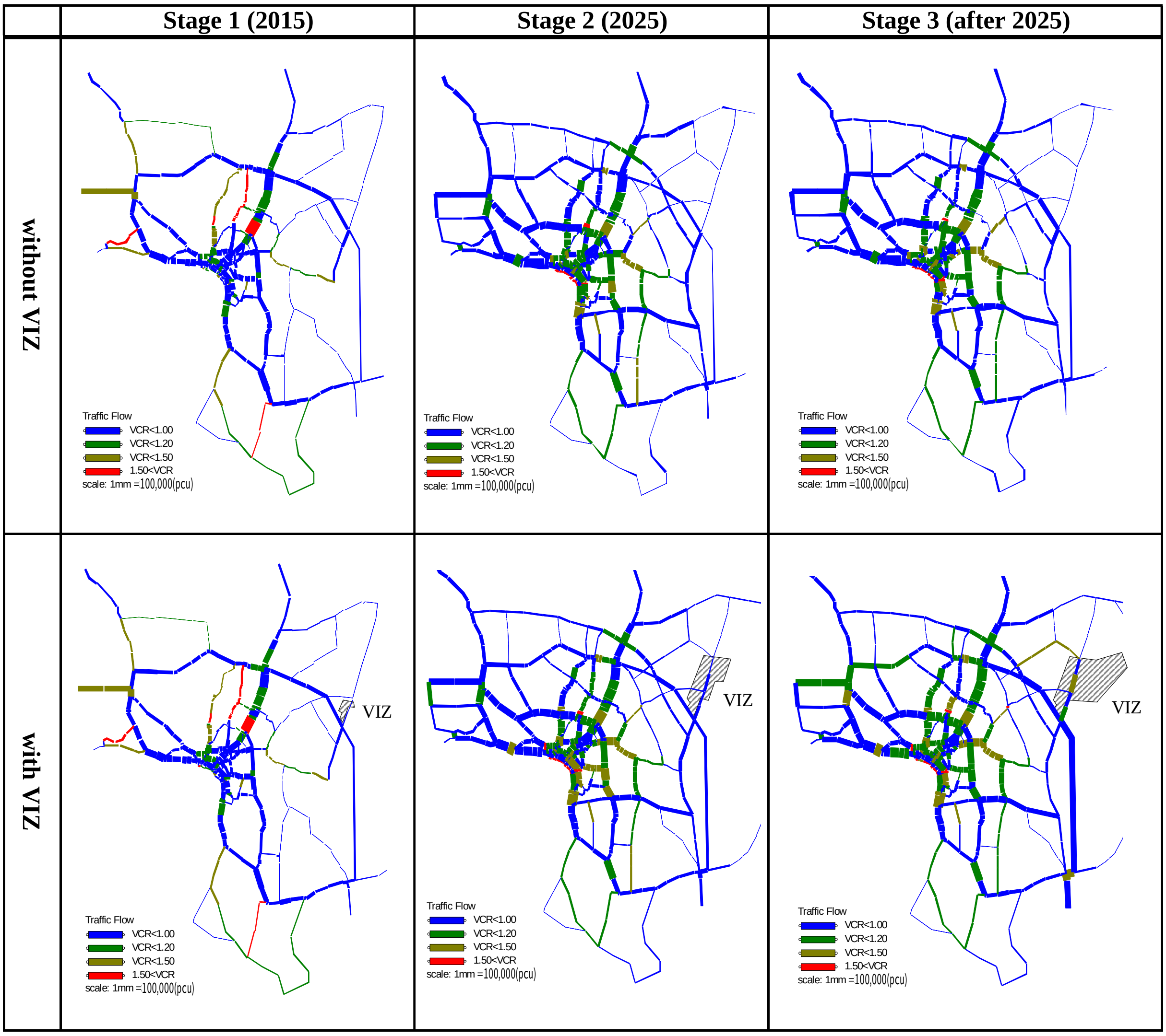
The traffic distribution is analyzed by utilizing the JICA-STRADA software. The results of the analysis are summarized below as well as shown in Figure 3.3.7 and Table 3.3.7.

1) The ratio of traffic volume of VIZ is too small compared to the overall traffic volume of Vientiane Capital.

2) After the Stage 1 development, no influence on average Volume Capacity Ratio (VCR) and average travel speed is realized. It means that it has no effect to the traffic flow.

3) After the Stage 2 and Stage 3 developments, some influence on average VRC can be identified. On the other hand, average travel speed is reduced. It means that the VIZ development slightly increases traffic congestion without providing a new congested section as can be shown in the Figure 3.3.6.

4) Throughout all development stages, no serious effects are generated by the VIZ development to the traffic flow in Vientiane.



Source: JICA Survey Team

Figure 3.3.7: Result of Traffic Flow Analysis

Table 3.3.7: Result of Traffic Estimation

With-Without VIZ Conditions		Stage 1 (2015)			Stage 2 (2025)			Stage 3 (after 2025)		
		Value	Difference	Rate	Value	Difference	Rate	Value	Difference	Rate
Total Volume (pcu-km)	Without	4,504,790	—	—	7,773,340	—	—	7,990,050	—	—
	With	4,574,740	69,950	1.6%	8,267,700	494,360	6.4%	9,115,380	1,125,330	14.1%
Hour Volume (pcu-km-h)	Without	122,098	—	—	195,260	—	—	198,660	—	—
	With	123,938	1,840	1.5%	208,150	12,890	6.6%	230,600	31,940	16.1%
Ave. VCR	Without	0.63	—	—	0.69	—	—	0.68	—	—
	With	0.64	0.01	1.6%	0.74	0.05	7.2%	0.78	0.10	14.7%
Ave. Travel Speed (km/h)	Without	36.9	—	—	39.8	—	—	40.2	—	—
	With	36.9	0.0	0.0%	39.7	-0.1	-0.3%	39.5	-0.7	-1.7%

Note: pcu=Passenger Car Unit, VCR=Volume Capacity Ratio
Source: JICA Survey Team

3.4 Land Reclamation Plan

3.4.1 Planning Concept

Land reclamation plan is prepared based on the following concepts:

1) Not exceeding site boundary as determined in the land use plan.

2) Smooth connection with District Road No.108 (DR-108) and drainage connection point.

2) Secure land from flood with 25 years return period.

3) Secure land inclination for traffic safety for heavily loaded vehicles.

4) Minimize land reclamation work volume.

5) Secure soil strength for relevant construction works.

3.4.2 Land Elevation Plan

As for the design concept above, the following criteria is adopted:

1) Minimum land elevation of 164.10 m (above sea water level) to avoid flood.

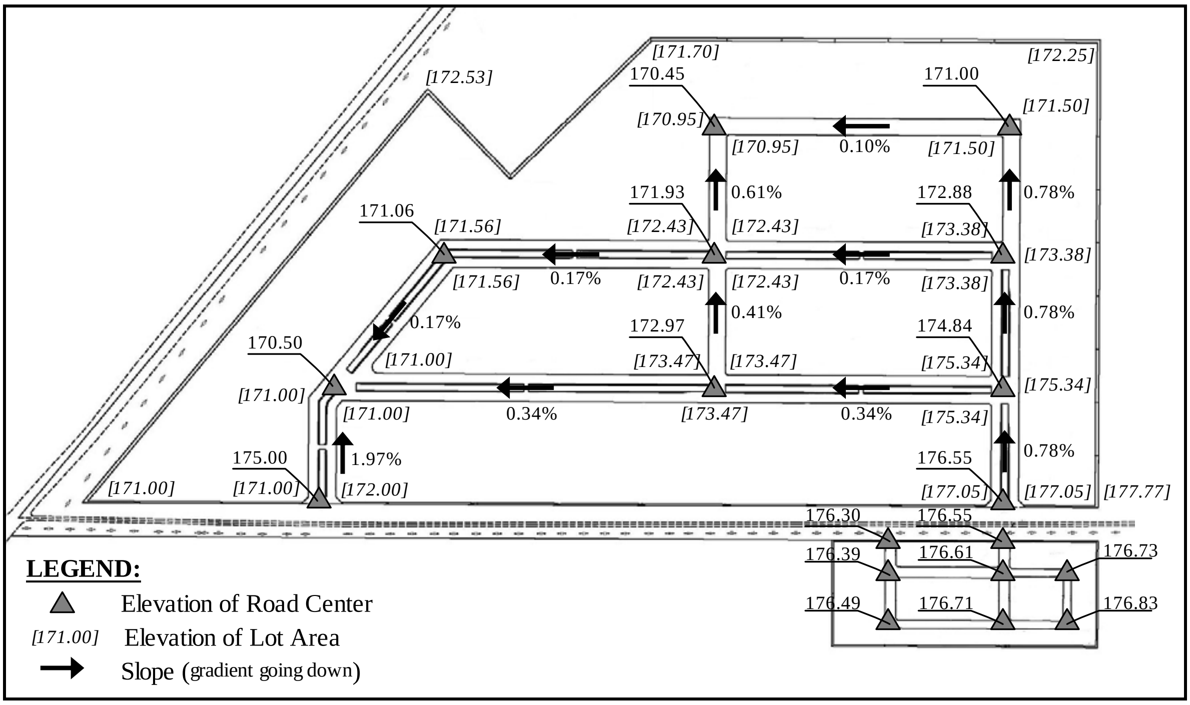
2) Connecting Road A1 and Road A8 to existing District Road No.108 with elevations of 175.00 m and 176.55m, respectively.

3) Minimum road slope of 0.1% to drain the rainwater and maximum road slope of 4.0% for traffic safety for heavily loaded vehicles.

4) Additional average heights of 0.5m and 0.3m for rainwater discharge from factories and residences, respectively.

5) Secure existing land elevation as much as possible.

As a result, land elevation as shown in Figure 3.4.1 is determined.



Source: JICA Survey Team

Figure 3.4.1: Land Elevation Plan

Table 3.4.1: Summary of Land Elevation Plan

Lot Elevation	Minimum: 171.00 m (6.90 m above the target) Maximum: 177.77 m
Road Elevation	minimum: 170.50 m (6.40 m above the target) maximum: 176.55 m
Road Slope	minimum: 0.10% maximum: 1.97%

Source: JICA Survey Team

3.4.3 Estimation of Land Subsidence

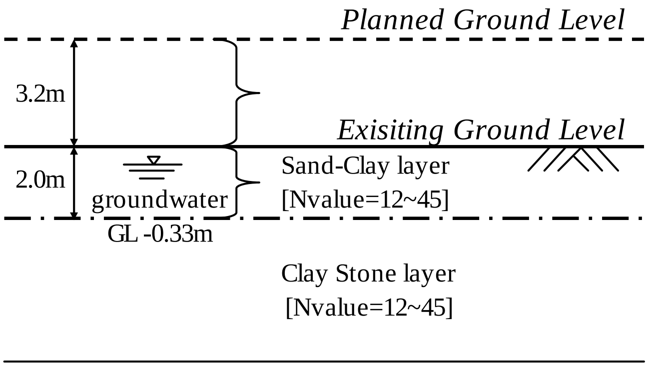
Generally, soil strata in the VIP site are hard enough for construction works. However, concerning detailed estimation on the earthworks volume and required cost, land subsidence for the weakest strata of Sand-Clay (SC) layer is examined.

Land subsidence is estimated based on the following considerations:

1) Geographic and soil data from the actual survey result on the site.

2) Maximum filling height of 3.2 m determined by elevation plan is adopted for the whole project site.

3) Estimated condition as shown in Figure 3.4.2.



Source: JICA Survey Team

Figure 3.4.2: Estimated Condition

Estimation formula used is as shown below.

$$S = \frac{e_0 - e_1}{1 + e_0} \, xH$$

where; *S is subsidence volume (m)*
e_0 is void ratio before filling work = 0.71
e_1 is void ratio after filling work =0.65
H is filling height (m)=3.2 m

As a result, **subsidence volume of 0.07 m** or 7 cm is calculated.

3.4.4 Earthworks Volume

Earthworks volume was calculated for the items below.

1) Earthworks volume, which consists of cutting and filling volumes, is calculated based on existing and planned elevations by using a common engineering software named "Land Development Desktop (Autodesk Co., Ltd.)".

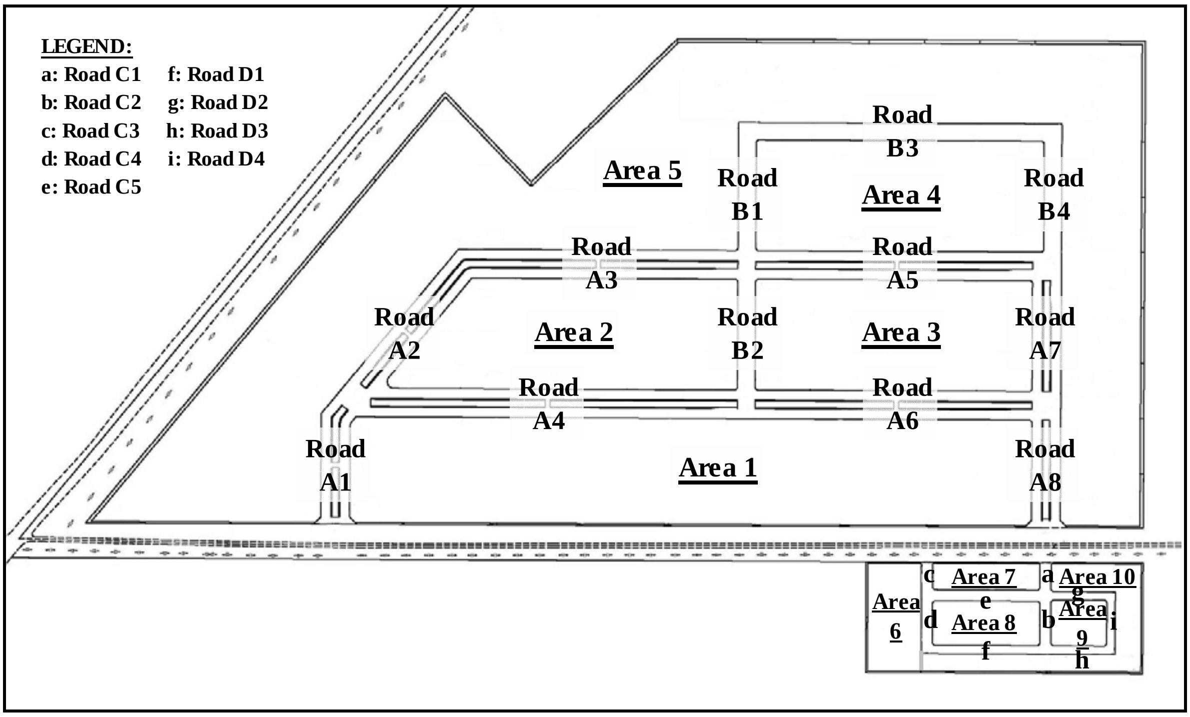
2) Additional filling volume required because of the estimated subsidence of 0.07 m.

3) Stripping of existing surface to secure soil strength, which is commonly done for 30 to 50 cm on agricultural land.

(1) Earthworks Volume

The project site is divided into several areas as shown in Figure 3.4.3. Table 3.4.2 shows the calculation result and Figure 3.4.4 shows the area required for cutting and filling works.

In total, **cutting work volume is 1,315,615 m^3** and **filling work volume is 658,297 m^3**. Therefore, the **surplus balance is 657,318 m^3**.



Source: JICA Survey Team

Figure 3.4.3: Calculation Area Plan

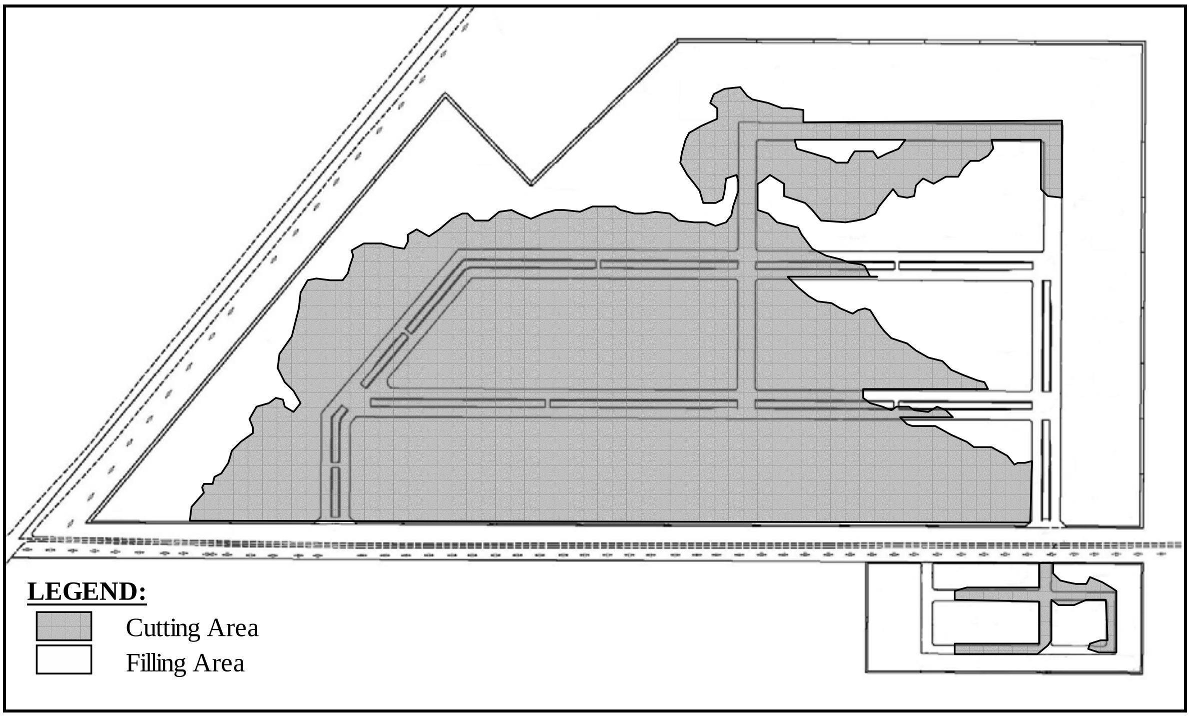
Table 3.4.2: Earthworks Volume Calculation Result

No.	volume (m³) cutting	volume (m³) filling
Area 1	404,829	2,688
Area 2	399,556	0
Area 3	49,309	48,511
Area 4	6,068	45,855
Area 5	102,346	479,236
Area 6	0	16,108
Area 7	7	3,215
Area 8	2	3,828
Area 9	47	2,723
Area 10	203	12,166
Total	**962,367**	**614,330**

No.	volume (m³) cutting	volume (m³) filling	No.	volume (m³) cutting	volume (m³) filling
Road A1	2,354	525	Road B4	668	43
Road A2	55,197	0	Road C1	483	5,810
Road A3	70,604	0	Road C2	263	0
Road A4	138,446	0	Road C3	0	527
Road A5	9,329	7,829	Road C4	0	811
Road A6	35,363	2,510	Road C5	518	267
Road A7	0	15,862	Road D1	309	256
Road A8	0	8,948	Road D2	706	0
Road B1	9,416	0	Road D3	4	357
Road B2	23,554	0	Road D4	143	8
Road B3	5,891	214	**Total**	**353,248**	**43,967**

No.	volume (m³) cutting	volume (m³) filling
Lot Area	962,367	614,330
Road	353,248	43,967
Total	**1,315,615**	**658,297**
balance	657,318	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.4.4: Cutting and Filling Area

(2) Additional Earth Volume for Land Subsidence

Additional filling height of 0.07 m or 7 cm is necessary to cover land subsidence for the whole project site of 140.14 ha. The required volume is calculated at **98,098 m^3**.

(3) Additional Earth Volume for Stripped Surface Soil

The surface of paddy fields or agricultural land is usually covered by organic soil, which is not suitable for build-up area and required to be stripped. Table 3.4.3 shows the several earthworks cases with different stripping depths.

Table 3.4.3: Earthworks Volume Comparison by Different Depth of Stripping Work

condition	Case 1	Case 2	Case 3
stripping depth	0.3 m	0.4 m	0.5 m
project area	140.14 ha	140.14 ha	140.14 ha
earth volume (m^3)			
cutting	1,315,615	1,315,615	1,315,615
filling	658,297	658,297	658,297
land subsidence	98,098	98,098	98,098
stripping	**420,420**	**560,560**	**700,700**
balance	138,800	**-1,340**	**-141,480**

Source: JICA Survey Team

Technically, all cases have no problem. Concerning the cost and environmental impacts during soil stripping and transportation, it is recommended to minimize the balance. Therefore, Case 2 with 0.4 m stripping is appropriate for the project.

(4) Total Earthworks Volume

The required earthworks and its volume are summarized in Table 3.4.4.

Table 3.4.4: Summary of Required Earthworks Volume

work item		volume (m^3)
1.	Cutting Volume	1,315,615
2.	Total Filling Volume	1,316,955
	a. for leveling	*658,297*
	b. for land subsidence	*98,098*
	c. for stripping	*560,560*
Balance		**-1,340**

Source: JICA Survey Team

Stripped soil (total volume of 560,560 m^3) is necessary to be removed from the project site, and it is recommended to fill the existing borrow pits located within the VIZ.

Source: JICA Survey Team

Figure 3.4.5: Existing Borrow Pits in VIZ

3.5 Road Plan

3.5.1 Framework of Road Development Plan

(1) Missions, Strategies, and Goals of the VIP Sector Development

Missions, strategies, and goals for the VIP road sector development are determined as seen in Table 3.5.1.

Table 3.5.1: Missions, Strategies and Goals for Road and Transportation Sector

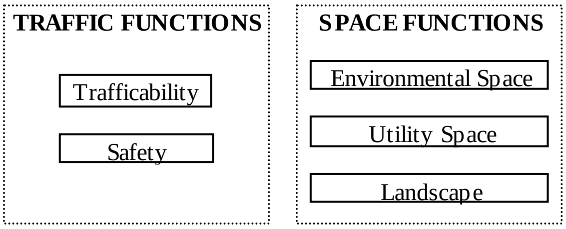
Missions	To provide transportation functions to support various kinds of activities in the VIP.	To provide spatial functions for other infrastructure including water supply, sewerage, drainage, power supply, and communication.
Strategies	To design roads and lanes leaving enough space and flexibility for later adjustment and redevelopment. To separate traffic flow of different types of users for safer and more comfortable transportation.	To provide enough space for utilities leaving flexibility for future development and maintenance. To develop some important zonal roads along with the internal roads for reasonable and comprehensive utility infrastructure networks.
Goals	To complete the development of roads as the most basic infrastructure in the VIP.	

Source: JICA Survey Team

(2) Planning Principle of the VIP Internal Roads

Since the VIP internal roads are categorized as urban roads (categories 3 and 4), appropriate consideration should be given to the road functions. Figure 3.5.1 shows the expected road function for urban roads.

The following principles are applied to examine appropriate road functions for the VIP internal roads and set the planning concept:



Source: JICA Survey Team

Figure 3.5.1: Road Functions

<u>Traffic Functions (Trafficability, Safety)</u>

- Adequate vehicle lane widths shall be provided for heavy vehicle passage, especially at road intersections.
- Adequate additional lanes shall be provided at the intersections that connect to the circumferential roads of the VIP.
- Facilities to formulate a safe pedestrian network such as sidewalks, pedestrian crossings, and pedestrian traffic signs shall be provided.

<u>Space Functions (Environmental Space, Utility Space, Landscape)</u>

- A buffer zone shall be provided to create a hospitable roadside environment.
- Adequate utility accomodation space shall be provided to support various utilities.

3.5.2 Proposed Road Plan

(1) Design Standard

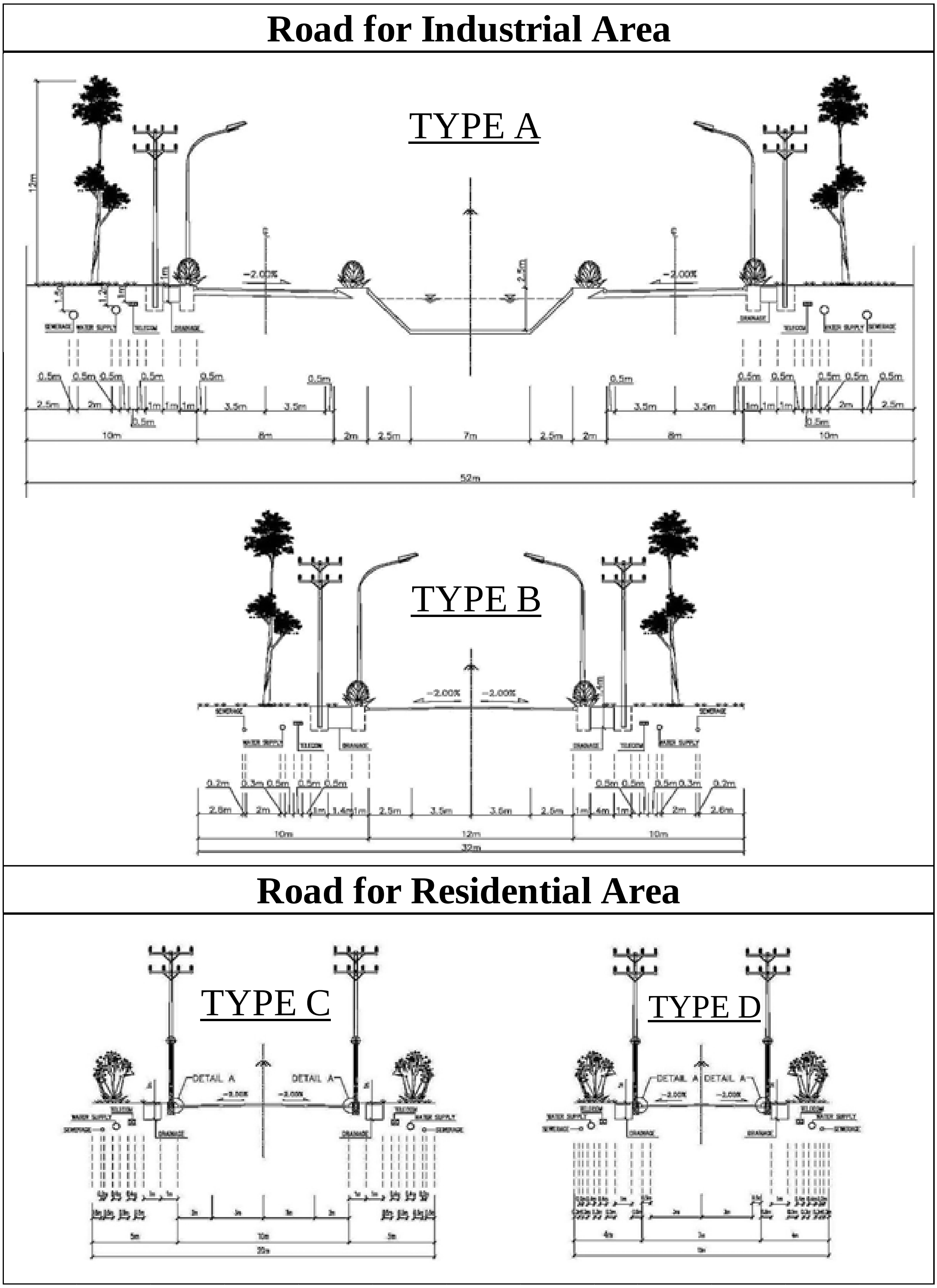
Road design is mainly based on the 1996 Road Design Manual issued by the Ministry of Communication, Transport, Post, and Construction of the Lao PDR.

(2) Typical Road Cross Section

Typical road cross section is planned based on the following conditions:

1) Considering traffic purpose and vehicle load, roads are separated mainly into two types: (i) road for industrial area, and (ii) road for residential area.
2) Considering construction and maintenance issues, number of typical road cross section was minimized.
3) Right of Way (ROW) is based on the estimated traffic volume.
4) Required space for the necessary infrastructure, such as lighting, drainage ditch/channel and water supply pipeline, was considered.

As a result, four typical road cross sections are proposed. Detailed cross sections are shown in Figure 3.5.2:

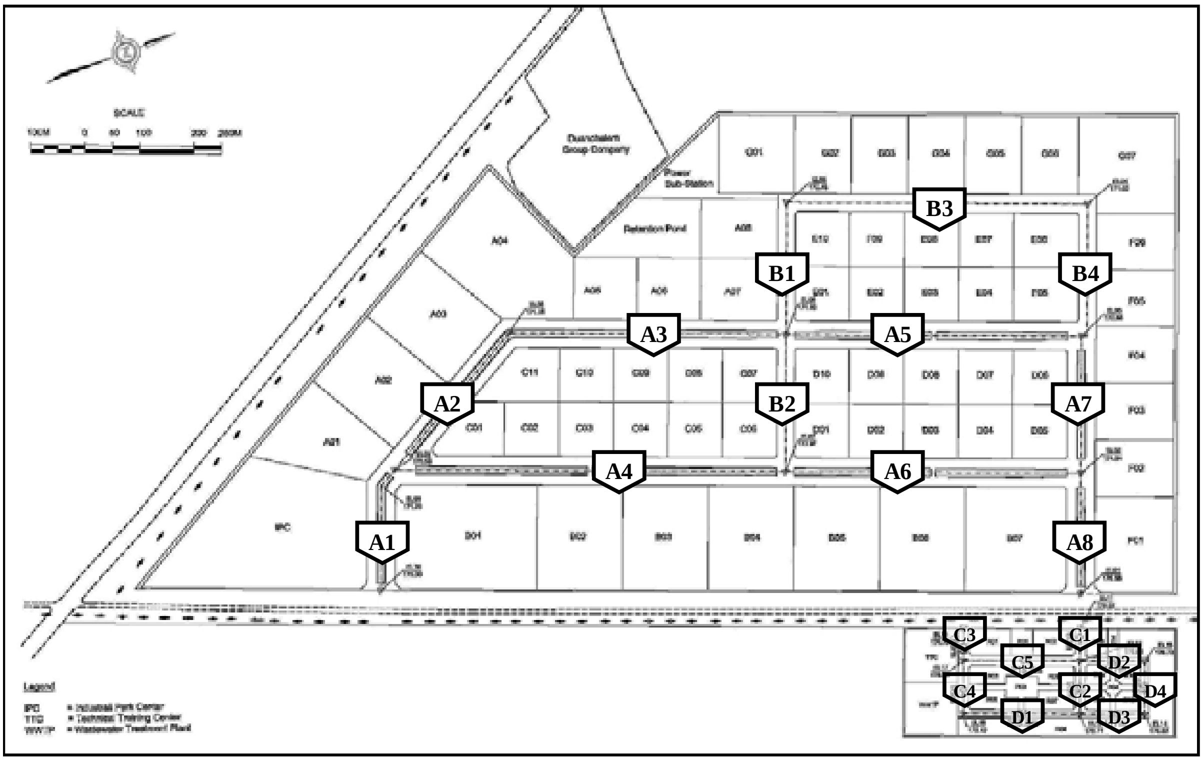


Source: JICA Survey Team

Figure 3.5.2: Typical Road Cross Sections

(3) Proposed Road Alignment

The proposed road alignment based on the factory layout plan is shown in Figure 3.5.3 and the total road length by type is shown in Table 3.5.2.



Source: JICA Survey Team

Figure 3.5.3: Proposed Road Alignment

Based on traffic volume, routes A7 and A8 can be covered by road cross section Type B. However, considering traffic management, such as emergency case and landscape as an entrance road for North Gate, it is proposed to adopt road cross section Type A.

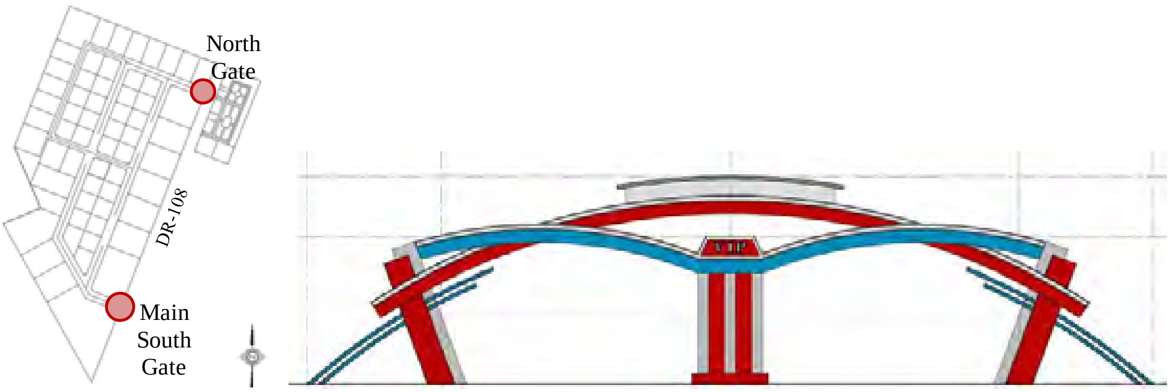
Table 3.5.2: Summary of the Road Plan

TYPE A		TYPE B		TYPE C		TYPE D	
ROW=52m		ROW=32m		ROW=20m		ROW=15m	
Road	Length (m)	Road	Length (m)	Road	Length (m)	Road	Length (m)
A1	191	B1	242	C1	60	D1	216
A2	367	B2	252	C2	95	D2	117
A3	508	B3	552	C3	60	D3	117
A4	717	B4	242	C4	95	D4	95
A5	542			C5	216		
A6	542						
A7	252						
A8	220						
total	3,339	total	1,288	total	526	total	545
				ground total			**5,698**

Source: JICA Survey Team

(4) Traffic Controls

To control traffic, especially for an industrial area, it is proposed to have a gate and control station for traffic in and out of the VIP. The proposed location of the gate is shown in Figure 3.5.4.



Source: JICA Survey Team

Figure 3.5.4: Location and Elevation Plan of the Gate

Source: JICA Survey Team

Figure 3.5.5: Perspective of Main South Gate

The control stations/posts are necessary to be settled in each road direction, and are recommended to be located at both sides of the center pier.

(5) Operation and Maintenance (O&M) Plan

Figure 3.5.6 shows the proposed structure for O&M organization under the Vientiane Industrial Park Authority (VIPA) to reinforce the project implementation of road, landscape, drainage, and wastewater systems.

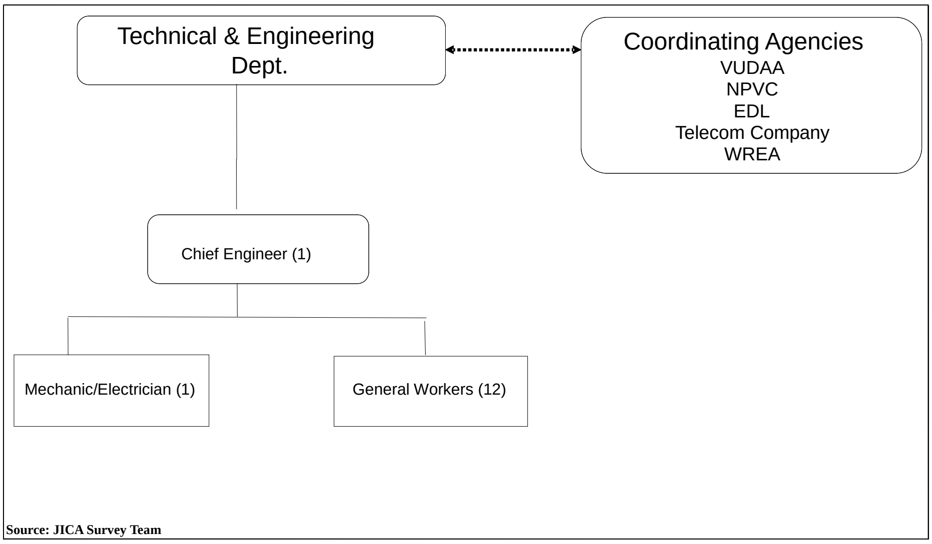
O&M works for the road system and landscape will be conducted by the Technical Section. Main activities of the O&M works are the following:

1) Regular inspection, patrolling, and sweeping of road and buffer green.

2) O&M of roads and VIP internal common lighting system.

3) Seasonal maintenance and rehabilitation of plantation.

4) Management of rehabilitation and preparation of sublet works, which cannot be handled by the Technical Section, such as pavement overlay, pothole preparation, and crack sealing.



Source: JICA Survey Team

Figure 3.5.6: Structure of Technical Section under Technical and Environmental Department of VIPA

The O&M of all facilities related to drainage and sewerage systems will require 14 staffs that include a chief engineer, a technician and 12 workers as shown in Table 3.5.3.

Table 3.5.3: Required Staff Members for O&M

Position	Number
Chief Engineer	1
Mechanic/Electrician	1
General Workers	12
Total	14

Source: JICA Survey Team

For the proposed road facilities, the ratio of annual O&M cost to the direct construction cost of road system is proposed to be 0.6%, including periodical maintenance work (e.g., pavement overlay every five years). Annual O&M cost of about LAK360 million (equivalent to JPY3.80 million) has been estimated and it will be recovered through the tenants' monthly and annual O&M fees.

(6) Conclusion and Recommendations

The following are the conclusions and recommendations for the road system:

1) To properly manage and operate the transportation within the VIP, it is recommended to have gate controls for the industrial area, both for the Main South Gate and North Gate.

2) Public bus should be prohibited to operate inside the VIP and will only be limited to the bus station, which is located inside the IPC lot, just beside the Main South Gate.

3) Major maintenance works, which will cause traffic congestion, are recommended to be conducted at night, during weekends and national holidays.

3.6 Storm Water Drainage Plan

3.6.1 Framework of Storm Water Drainage Development Plan

The hydrological factors for the drainage development plan are determined as shown below:

(1) Meteorology and Hydrology for Water Bodies

The meteorological data of Vientiane Capital in the past 30 years are presented in Figure 3.6.1 and Table 3.6.1. The annual total precipitation is about 1.67 m, on an average of 30 years in Vientiane Capital, where drought and flood occur almost every year.

Table 3.6.1: Meteorology in Vientiane Capital

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum Temperature	℃	28.3	30.4	33	34.3	32.9	31.8	31.3	30.9	30.9	30.8	29.8	28.1
Minimum Temperature	℃	16.3	18.5	21.5	23.8	24.6	24.9	24.8	24.6	24.1	22.9	19.9	16.5
Mean Temperature	℃	22.3	24.1	27.2	29	28.7	28.4	28.1	27.8	27.5	26.9	24.8	22.3
Average Temperature	℃	25.2				28.1					25.2		
Rainfall	mm	7.2	13.1	33.6	85.3	245	279	275	331	307	77.5	11.2	2.8
Ratio to Annual Precipitation	%	14				86					14		
Relative Humidity	%	75-80				65-70					75-80		

Source: National Statistics Center [2005], Statistics 1975-2005

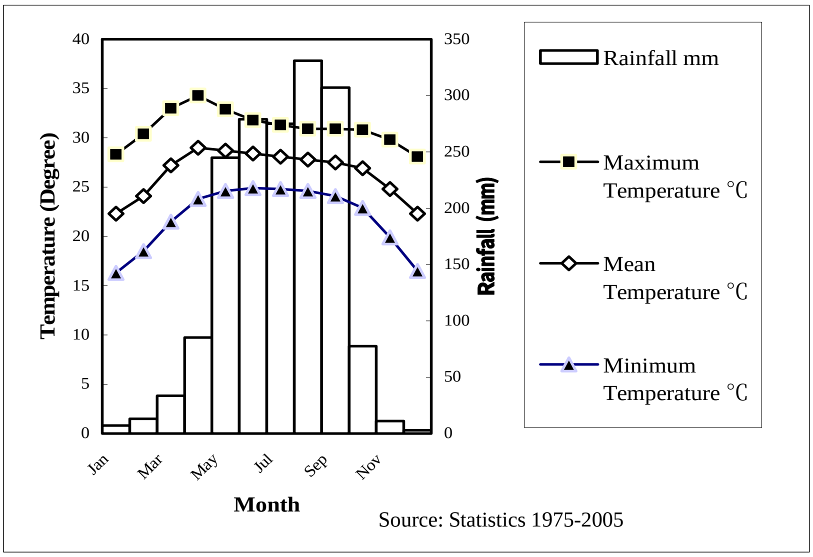


Figure 3.6.1: Climatology of Vientiane from 1975 to 2005

Vientiane Capital is situated on an alluvial plain, so called Vientiane plain, extending along the left bank of the Mekong River from east to west. In the Vientiane plain, the Nam Ngum River, with a length of 354 km from the north through the central part bending to the east side, flows into the Mekong River and forms vast lowland swamps around both banks. The Mak Hiao River with a length of 56 km and a slope of 1/3000, meanders from west through That Luang and Na Khay marshes to east and flows into the Mekong River. The area of the VIP belongs to the Mak Hiao River basin. The Mak Hiao River has a drainage area of 441 km^2 at the outlet to the Mekong. Highest water level (HWL) of the Mak Hiao River upstream of Na Khay marsh is 164.07 m above mean sea level (AMSL) and the lowest water level (LWL) is 162.93 m AMSL as shown in Table 3.6.2.

HWL of the Mak Hiao River at its confluence with the Mekong River is 165.21 m AMSL, which was recorded in 1978, and HWL of the Mekong River at Km 4 Vientiane monitoring station is 170.74 m, which was recorded in 1966 according to daily water level records of the Department of Meteorology. The annual maximum water levels at the confluence of the Mekong River with the Mak Hiao River and Vientiane are well correlated. In case that the water level of the Mekong River is higher than that of the Mak Hiao River, water of the latter flows backward to its downstream. The Mak Hiao River has two gates at the confluence with the Mekong to prevent backward flow from Mekong. From previous observations, the estimated minimum flow of the Mak Hiao River upstream of Na Khay marsh is 0.112 m^3/s and its maximum flow is 21.0 m^3/s.

Table 3.6.2: Hydrological Data of Mak Hiao River and Mekong River

Description	Thut Luang Marsh	Mak Hiao upstream of Na Khay Marsh	Mak Hiao downstream of Na Khay Marsh	Mak Hiao at confluence with Mekong	Mekong at Km 4 Vientiane Station
Drainage Area (km^2)*1				441	299,000
Highest Water Level (m) *1	165.20	164.37		165.21	170.74
Lowest Water Level (m) *1	164.44	163.39			
Gauge Zero level (m) *1	163.97	162.93		154.64	158.04
EL of 10 years Return Period (m)*1	166.00	165.50		165.40	170.60
Flow observed on Sep-30 1961 (m^3/s) *1		21.000			
Flow observed on May-25 1989 (m^3/s) *1		0.295			
Flow observed on June-02 1989 (m^3/s) *1		2.534			
Flow observed on Sep-07 1989 (m^3/s) *1		19.270			
Flow observed on Jan-05 2009 (m^3/s)*2		0.410	0.753	0.163	
Flow observed on Feb-05 2009 (m^3/s) *2		0.112	0.349	0.190	
Flow observed on May-05 2009 (m^3/s) *2		11.688	23.706	28.935	

Source: *1 F/S on Improvement of Drainage System in Vientiane, JICA 1990

Source: *2 Progress Report for the Study on Improvement of Water Environment in Vientiane City, JICA 2009

(2) Basic Concept for Planning

The basic concepts for the drainage development plan in the VIP are briefly described below.

Target year	: 2015
Planning area	: 140 ha of Vientiane Industrial Park consisting of an industrial area of 130 ha and residential area of 10 ha
Drainage basin	: Mak Hiao River Basin with a catchment area of 441 km^2
Collection system	: Separate system with open channel/ditch and culvert
Design storm water flow	: 2 years return period for collection system
Storm water reservoir for flood control	: 2 retention ponds for retaining and regulating 10 years flood
Receiving water bodies	: Mak Hiao River upstream of Nathrough through the existing culverts of 450 Year Road

(3) Design Storm Water Flow

The drainage development plan was carried out for two sub-basins of the Mak Hiao River basin. The design for storm water flow is described below:

1) Rainfall Intensity

The following rainfall intensity formula for Vientiane was formulated in the JICA F/S on Improvement of Drainage System in Vientiane, 1990, from the past rainfall data. Based on the probable rainfall estimated by previous studies, the Talbot's formula, as given below, is applied in the analysis of storm rainfall intensities for varying durations.

$$I = \frac{a}{t^n + b}$$

where, I : Rainfall intensity (mm/hour)

t : Duration (minutes)

n, a, b : Constants to be determined for each return period as follows:

Return Period	N	A	b
2 years	1.0	5,835	65.40
5 years	1.0	8,171	63.90
10 years	1.0	9,629	62.15
20 years	1.0	10,983	60.43
50 years	1.0	12,685	58.31

Source: F/S on Improvement of Drainage System in Vientiane, JICA 1990

2) Design Storm Water Flow

The design storm water flow shall be calculated using the rational formula given below, with the rainfall intensity calculated from the formula developed by JICA F/S on Drainage in Vientiane.

$Q = C \cdot q \cdot A/360$

Where, Q: Design storm water flow (m^3/s)

C: Runoff coefficient

q: Rainfall intensity (mm/hour/ha)

A: Drainage area (ha)

3) Runoff Coefficient

The runoff coefficient shall be the overall coefficient for the drainage basin as calculated considering the runoff coefficients based on the surface characteristics of areas as shown in Table 3.6.3.

Table 3.6.3: Overall Runoff Coefficient

Land Use Type	VIP Before Development				VIP After Development			
	Classification of Area		Runoff Coefficient		Classification of Area		Runoff Coefficient	
	Area (ha)	Proportion	Base	Average	Area (ha)	Proportion	Base	Average
1 Residential Area		0.00 %	0.95	0.00	10.00	7.14 %	0.95	0.07
2 Industrial Area		0.00 %	0.85	0.00	98.90	70.64 %	0.85	0.60
3 Building		0.00 %	0.90	0.00	10.20	7.29 %	0.80	0.06
4 Agricultural Area	140.00	100.00 %	0.30	0.30		0.00 %	0.50	0.00
5 Road		0.00 %	0.85	0.00	20.90	14.93 %	0.85	0.13
Total	140.00	100.00 %	Overall	0.30	140.00	100.00 %	Overall	0.85

Source: JICA Survey Team

Thus, the overall runoff coefficient prior to and after the development of VIP has been estimated at 0.30 and 0.85, respectively.

(4) Hydrological Analysis

For the hydraulic analysis of the drainage development plan, the following conditions and formulas are adopted:

1) Design Rainfall Intensity and Water Levels

The following rainfall intensities are adopted for design flow calculation:

Table 3.6.4: Rainfall Intensity

Return Period	Rainfall Intensity (mm/hour)		Remarks
	Before Development	After Development	
2 years	46	65	Collection System
10 years	78	112	Flood Control

Source: JICA Survey Team

In order to formulate the drainage plan, water levels of water bodies related to VIP development are analyzed. High and low water levels for Mak Hiao and Mekong are assumed to be the level for 10 years return period and gage zero level, respectively. The water level for retention ponds of the VIP are to be designed properly to secure the correlation between ponds, culverts and Mak Hiao, as described below.

Table 3.6.5: Designed Water Levels

Water Bodies	High Water Level (m AMSL)	Low Water Level (m AMSL)
Retention Pond No. 1 of VIP*[1]	168.95	167.45
Retention Pond No. 2 of VIP*[1]	169.00	167.50
Curvert No. 1 of 450 Year Road (DN800x1) *[2]	167.42	166.62
Curvert No. 2 of 450 Year Road (DN1200*[2]) *[2]	167.57	166.37
Mak Hiao upstream of Na Khay Marsh*[3]	165.50	162.93
Mak Hiao at confluence of Mekong*[3]	165.40	154.64
Mekong at KM4 Vientiane Station*[3]	170.60	158.04

Source: *[1]JICA Survey Team, *[2]450 Year Road Project, *[3]F/S on Improvement of Drainage System in Vientiane, JICA 1990

2) Design Flow

Design flow for the design storm water flow (DSF) has been calculated using the rational formula.

3) Hydraulic Design of Storm Water Collection System

The hydraulic design of storm water collection system is based on Manning's formula, which is given below.

$Q = A \cdot V$
$V = (1/n) \cdot R^{2/3} \cdot I^{1/2}$
Where, Q: Storm water discharge (m^3/s)
A: Sectional area of pipe/culvert/channel (m^2)
V: Mean velocity (m/s)
n : Roughness coefficient
R: Hydraulic radius (m)
I : Hydraulic gradient

4) Retention Ponds

Retention ponds shall be designed to cope with flood with a return period of 10 years. The allowable return period of the Mak Hiao River via the existing culverts is assumed to be 10 years. Such design will not only protect VIP against flood but also protect the downstream area. Capacity of retention ponds has been estimated using the following formula:

$Q = [Q_{10} – Q_a/2] \cdot T \cdot 60$
Where, Q: Design capacity of retention pond (m^3)
Q_{10}: Design storm water flow (m^3/s)
Q_a: Allowable discharge flow (m^3/s)
T: Concentration time (minute)
Volume of sedimentation is estimated as 1.5 m^3/ha/year for 10 years return period.

3.6.2 Proposed Storm Water Drainage Plan

(1) Design Policy and Standards

The proposed design standards for storm water drainage system within the area are as follows:

1) To apply the following regulations and standards:

- F/S on Improvement of Drainage System in Vientiane, JICA, 1990
- Road Design Manual, Department of Communication, MPWT, 1996
- Draft Agreement of National Standards of Environment in the Lao PDR, March 2009
- Ministerial Decree on The Management of Building Construction, Department of Housing and Urban Planning, Ministerial Decree, MPWT, 2005
- Sewerage Law in Japan, 1983
- Japan Sewerage Works Association Standards, 1984

2) To harmonize with existing infrastructure such as the 450 Year Road and District Road No. 108.

3) To adopt a separate system for storm water collection.

4) To take adequate measures in line with the local conditions so as to protect the landscape, water environment, and the entire site from natural disasters such as floods.

(2) Design Criteria

The design criteria for the storm water drainage system in VIP are summarized below.

1) Storm Water Collection Line

Design storm water flow	: Rational formula $Q = C \cdot q \cdot A$ Where, Q: Design storm water flow (m^3/s) C: Runoff coefficient q: Rainfall intensity (mm/s/ha) A: Drainage area (ha)
Rainfall intensity	: Intensity formulation of JICA F/S on Drainage
Return period	: 2 years for sewer
Overall runoff coefficient	: 0.30 before development, 0.85 after development
Hydraulic design of sewer	: Manning's formula $Q = A \cdot V$, $V = (1/n) \cdot R^{2/3} \cdot I^{1/2}$ Where, Q: Storm water discharge (m^3/s) A: Sectional area of pipe (m^2) V: Mean velocity (m/s) n : Roughness coefficient R: Hydraulic radius (m) I : Hydraulic gradient
Type of storm water collection sewers	: Pipes, box culverts, ditches and open channels
Allowable flow velocity	: 0.8 - 3.0 m/s
Minimum size of pipe	: 250 mm
Allowance of sewer capacity	: 10-20% of design storm water flow
Minimum earth covering	: 1.0 m
Maximum manhole interval	: 50 m for less than D300 mm of inlet pipe
Sewer connection method	: Sewer bottom connection or water surface connection
Material of inlet pipe	: Hume concrete pipe
Material of ditch and box culvert	: Reinforced concrete
Material of open channel	: Earth canal with sodding
Roughness coefficient	: 0.013
Hydraulic gradient	: 2.0% for less than D500 mm, 1.0% for box culvert, ditch and open channel

2) Retention Functions

Design return period for retention functions	: 10 years
Type of pond	: Digging type with gate and spillway
Capacity of retention pond	: $Q = [Q_{10} - Q_a/2] \cdot T \cdot 60$ Where, Q: Design capacity of retention pond (m^3) Q_{10}: Design storm water flow (m^3/s) Q_a: Allowable discharge flow (m^3/s) T: Concentration time (minute)
Volume of sedimentation	: 1.5 m^3/ha/year and 10 years period
Regulating Gate	: $Q_0 = C \cdot B \cdot d \cdot [2 \cdot g \cdot H_1]^{0.5}$ Where, Q_0: Discharge flow (m^3/s) C : Coefficient of correlation between H_1/d and H_2/d B : Width of gate (m) d : Opening height of gate (m) g : Gravitational constant (9.8 m/s^2) H_1: Upstream water height (m) H_2: Downstream water height (m)
Type of regulating gate	: Sluice gate

Spillway	: $Q_c = C \cdot L \cdot h^{0.5}$ Where, Q_c: Overflow (m^3/s) C : Overflow coefficient L : Width of trough (m) h: Water height of trough (m)

(3) Proposed Storm Water Drainage Plan

Storm water in VIP is discharged to the Mak Hiao River through the existing culverts installed at 450 Year Road after the development of the drainage system and finally discharged to the Mekong River. The proposed storm water drainage plan should cope well with the variety of public facilities and services, industrial lots and environmental requirements particular to the VIP. The overall storm water discharge flow diagram of VIP is presented in Figure 3.6.2.

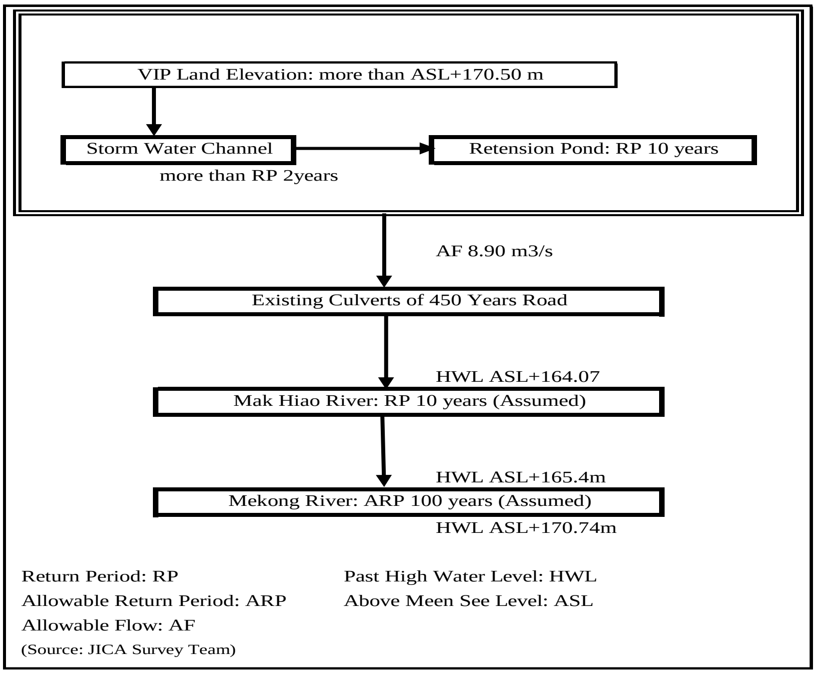
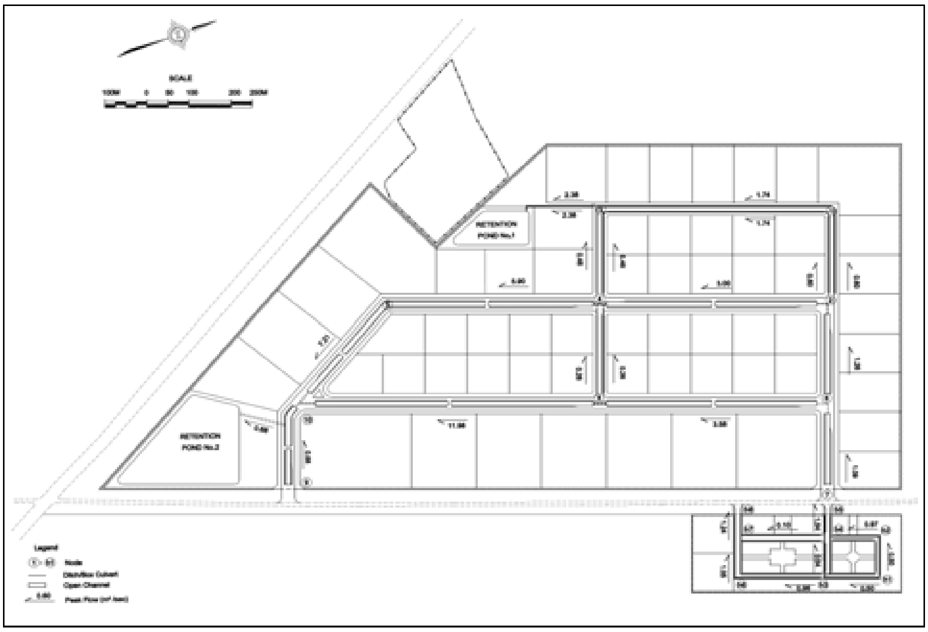


Figure 3.6.2: Storm Water Discharge Flow Diagram

Storm water collection system is hydraulically analyzed as shown in Figure 3.6.3.



Source: JICA Survey Team

Figure 3.6.3: Hydraulic Model of Storm Water Collection System

Results of the hydraulic analysis for retention ponds No. 1 and No. 2 are presented in Table 3.6.6.

Table 3.6.6: Hydraulic Analysis for Retention Ponds

VIP	Travaling Time (minutes)		Mean Velocity for Developed Area		Runoff Coefficient			
Before Development	t1: 5	t2: L/V/60	0.5 m/sec		0.30			
After Development	t1: 5	t2: L/V/60	1.5 m/sec		0.85			
Catchment Area	Accumu. Area (ha)	Length: L (m)	Con-Time t1+t2 (min)	Pi: Peak Flow (m3/s) P=2 years	P=10 years	Pc: Allowable Flow of Mak Hiao (m3/sec)	Pc/2 (m3/s)	Required Capacity (m3)
Pond No.2								
Before Development	97.5	1,679	60.97	3.75	6.36	6.36	3.18	32,001
After Development	97.5	1,679	23.66	15.02	25.72			
Pond No.1								
Before Development	32.5	1,074	40.80	1.49	2.53	2.53	1.27	8,152
After Development	32.5	1,074	16.93	5.41	9.29			

Source: JICA Survey Team

The capacity of retention ponds required for coping with 10 years flood return period is shown in Table 3.6.7.

Table 3.6.7: Required Capacity of Ponds

Retention Pond	Pond No. 1	Pond No. 2
Drainage Area (ha)	32.46	97.54
Required Capacity (m^3)	8,152	32,001
Sedimentation (m^3)	487	1,463
Required Total Capacity (m^3)	8,639	33,464
Required Depth (m)	1.500	1.500
Height Water Level (m AMSL)	168.95	169.00
Height of Freeboard (m)	2.000	2.000

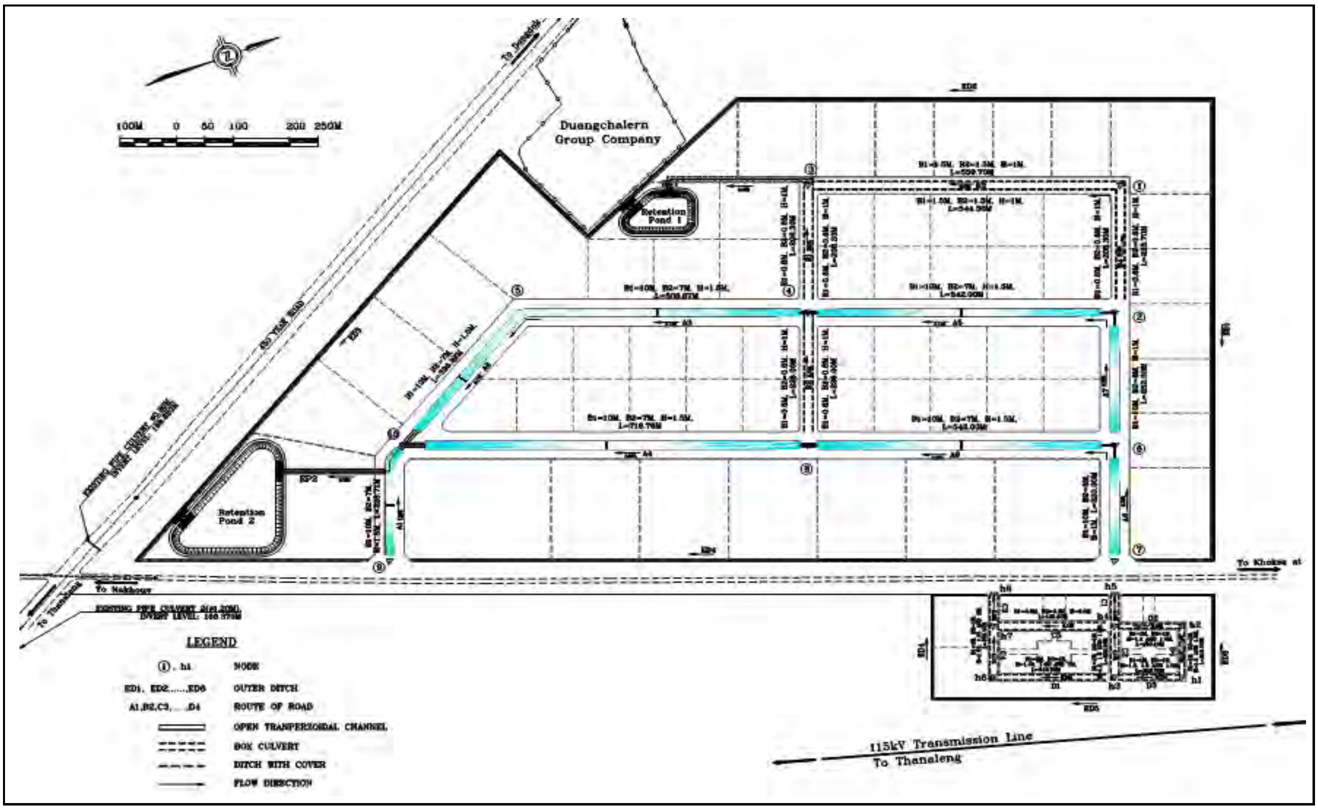
Source: JICA Survey Team

From the results of the hydraulic analysis for drainage system, the storm water drainage plan is proposed as shown in Figure 3.6.4 and Table 3.6.8. The storm water drainage plan consists of the following: i) storm water collection sewer for industrial area; ii) storm water collection sewer for residential area; iii) boundary ditch; and iv) flood control facilities, as shown in Table 3.6.8.

Table 3.6.8: Components of Proposed Storm Water Drainage Plan

	Work Item	Quantity	
1	**Storm water Collection Sewer for Industrial Area**		
a)	Open Channel (b1:10 m x b2:8 m x h: 1.0m) Wet Stone Masonry	472	m
	Open Channel (b1:10 m x b2:7 m x h:1.5 m) Wet Stone Masonry	2,877	m
b)	Ditch (b:0.6 m x h:1.0 m) with cover	1,472	m
	Ditch (b:1.5 m x h:1.0 m) with cover	1,104	m
c)	Box Culvert 1300 x 1000, single	52	m
	Box Culvert 2000 x 1000, single	104	m
	Box Culvert 1500 x 1000, twin	280	m
	Box Culvert 2000 x 1000, twin	52	m
	Box Culvert 2500 x 1000, twin	52	m
	Box Culvert 4000 x 1500, twin	250	m
	Inlet Pit & Outlet (Manhole 1.2 m x 1.2 m, H=2 m, D300 mm RC Pipe)	67	units
2	**Storm water Collection Sewer for Residential Area**		
a)	Ditch (b:0.8 m x h:0.8 m - b:1.0 m x h:2.0 m) with cover	2,140	m
b)	Box Culvert (1000 x 1300 – 1000 x 2000), single	140	m
3	**Boundary Ditch**		
	Open Ditch (b:0.8 m x h:0.8 m - b:1.5 m x h:1.0 m)	7,060	m
4	**Flood Control Facilities**		
a)	Retention Pond No. 1	24,200	m^3
	Flood Gate, 2 m wide x 1.5 m high	1	units
	Overflow & Spillway: B=2 m, h=1.5 m, L=10 m	1	units
b)	Retention Pond No. 2	86,600	m^3
	Flood Gate, 2.0 m wide x 1.5 m high	2	unit
	Overflow & Spillway: B=3.5 m, h=1.5 m, L=10 m	1	unit
c)	External Box Culvert connected with existing culvert: B x H=1.5 m x 1.5 m	600	m

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.6.4: Overall Storm Water Drainage Plan

(4) O&M Plan

The following institutional aspects are taken into account to reinforce the project implementation organization and establish the O&M mechanism for the storm water drainage system in the VIP. Main activities of the technical section are:

- Operation of the retention ponds with spillways, flood gates, and their maintenance;
- Regular patrolling and sweeping of road networks, sewers, drainage channels, and retention ponds;
- Seasonal maintenance and rehabilitation of levees, revetments, etc.; and
- Measurement and monitoring of water level and flow discharge.

The O&M of the drainage and sewerage system is recommended to be executed together with the road network system in the VIP. For the O&M of all facilities related to drainage and sewerage system, 14 staffs, which include a chief engineer, a technician and 12 workers, will be required as described in the proposed structure of the O&M organization for road networks.

For the proposed drainage and sewerage facilities, the ratio of annual O&M cost to the direct construction cost of drainage and sewerage system is proposed to be 0.5%. Annual O&M cost of about LAK294 million per year (equivalent to JPY3.1 million) has been estimated for drainage and sewerage system. In most developed countries, the O&M cost for drainage and sewerage system is recovered through beneficiaries. Thus, in order to secure the O&M cost, a levy-based system shall be established prior to implementation of the drainage and sewerage system. It is recommended that charge for sewerage systems should be collected by means of prorating the O&M cost to the development area of each tenant.

(5) Conclusion and Recommendations

The overall storm water drainage plan in the VIP is presented as shown in Figure 3.6.4. Required facilities for the proposed storm water drainage plan are summarized in Table 3.6.9. The total length of the sewerage system, which consists of sewers and box culverts, is around 16.1 km including an open channel with a length of 3.3 km. Boundary ditch with a length of 7.1 km shall be constructed around the VIP area for catchment of storm water flowing to the area from its northern area. Flood retention function consists of Pond Nos. 1 and 2 with capacities of 24,200 m^3 and 86,600 m^3, respectively. External box culvert with a length of 0.6 km is required to discharge storm water with more than 10 years flood to the existing culverts of 450 Year Road.

Table 3.6.9: Summary of Storm Water Drainage Facilities

Work Item		Quantity	
1	**Storm water Collection Sewer**	16.1	km
a)	Open Channel	3.3	km
b)	Ditch with cover	4.7	km
c)	Box Culvert	0.9	km
d)	Boundary Ditch	7.1	km
2	**Inlet Pit & Outlet**	67	units
3	**Retention Ponds**	110,800	m^3
a)	Retention Pond No. 1	24,200	m^3
b)	Retention Pond No. 2	86,600	m^3
4	**External Box Culvert**	0.6	km

Source: JICA Survey Team

For the implementation of the storm water drainage plan, the following measures are recommended from both structural and non-structural aspects.

1) Structural Measures

- The detailed design of drainage system should be prepared in consideration of the harmonization with District Road NO.108 and its infrastructure to be improved by Vientiane Capital.
- The retention ponds are required to protect VIP against flood and also protect its downstream area.
- The 0.6 km long external box culvert is required to divert the present flow of storm water from the VIP to the drainage system of 450 Year Road.

2) Non-Structural Measures

- The organization of O&M for the sewerage and drainage system including the retention ponds will be established together with road network system in VIP.
- In order to secure the O&M cost, the levy-based system should be established prior to the implementation of the drainage and sewerage system.

3.7 Water Supply Plan

3.7.1 Framework of Water Supply Development Plan

(1) Water Source and Dongbang Water Supply Project

The Mekong River and the Nam Ngum River are used mainly for water supply and irrigation in Vientiane Capital. Nam Papa Vientiane Capital (NPVC) supplies potable water to Vientiane Capital with a service coverage ratio of 45%. At the VIP area, there is no water supply from NPVC and the main water source is underground water. Although the existing tenants and residents possess individual boreholes, it is reported that underground water in this area is contaminated and water quality indicates a high concentration of salinity.

NPVC has a plan to construct the Dongbang Water Treatment Plant (WTP) with a capacity of 20,000 m^3/d at the riverside of the Nam Ngum and expand the pipeline to supply the northeast area of the city center in Vientiane Capital. Phase I of the Dongbang Water Supply Project has commenced through PFI to construct Dongbang WTP and install a distribution main up to the SEA-Game Stadium. Phase II aims to install a distribution main with DN400 mm along District Road No. 108 from National Road No. 13S to the Xamkhe Reservoir and distribution main with DN300 mm along District Road No. 108 to Doungkang Village as shown in Table 3.7.1. Based on the results of discussion with NPVC, Dongbang WTP has enough capacity to supply water to VIP and NPVC intends to expand the existing distribution network. However, finance for Phase II has not yet been determined officially. It is possible that VIP can get sufficient water from Dongbang WTP in case the installation of distribution main along District Road No. 108 is conducted.

Table 3.7.1: Outline of Dongbang Water Supply Project

	Node	EL	Diameter	P (mH_2O)	Flow (L/s)	Demand	Length (m)	Material
Phase I								
WTP (20,000 m^3/d)	1	175.0	500	54.91	219.67	0		GFPP
Junction of Thadindeang R & National Road No. 13 South	12	176.0	500	40.33	141.83	77.84	7,778	GFPP
Phase II								
Junction of National Road No. 13S & DR-108	30	176.0	400	35.19	139.35	2.48	1,942	DIP
DR-108	37	177.0	400	18.18	133.31	6.04	6,422	DIP
Point to Xamkhe Reservoir	38	177.4	400	14.02	132.58	0.73	1,575	DIP
DR-108: VIP Reservoir*	R	171.0	400	7.16	132.58	0	1,857	DIP
Total of Phase II							11,796	

Source: NPVC
(Note) *: Assumed by JST, GFPP: Glass Fiber Polyester Pipe, DIP: Ductile Iron Pipe

(2) Basic Concept for Planning

The basic concepts for the water supply plan in the VIP area are briefly described below:

Target year	: 2015
Planning area	: 140 ha of Vientiane Industrial Park consisting of the industrial area of 130 ha and residential area of 10 ha
Demand projection area	: 101.5 ha consisting of the industrial area of 96.5 ha and residential area of 5.0 ha
Design population	: 6,000
Water source	: Dongbang WTP of 20,000 m^3/d obtained from Nam Ngum River
Distribution main from Dongbang WTP	: 12 km long with D400 mm of DIP
Water flow and pressure from Dongbang WTP	: 66 L/sec and 7 mH_2O at minimum
Internal distribution system of VIP	: Distribution Network (Reticulated pipeline)

(3) Water Demand Projection

1) Unit Water Consumption

Industrial unit water consumption is calculated using the result from the investment demand survey conducted by JST and the unit demand per tenant recommended by the Design Standard for Core Industrial Estate (Japan) as shown in Table 3.7.2

Table 3.7.2: Industrial Unit Water Consumption of VIP

Type of Industry	Number of Investors*[1]	Unit Area*[2] (ha/tenant)	Total Area (ha)	Unit Demand*[2] (m^3/ha/tenant/d)	Demand (m^3/d)
Food Manufacturing	6	0.6	3.6	178	641
Garment & Sewn Product	8	0.4	3.2	34	109
Chemical	3	3.1	9.3	197	1,832
Rubber Manufacturing	1	2.2	2.2	172	378
Iron & Steel	2	3.5	7	115	805
Nonferrous Metal	2	4.8	9.6	135	1,296
General Machinery Apparatus	4	1.9	7.6	40	304
Electric Machinery Apparatus	10	1.3	13	100	1,300
Transport Machinery Apparatus	4	2.1	8.4	74	622
Precision Machinery Apparatus	2	0.9	1.8	75	135
Total	42		65.7		7,422
Industrial Unit Water Consumption (m^3/ha/d): rounded up					115

Source: JICA Survey Team
(Note) *[1]: Data of Investment Demand Survey conducted by JICA Survey Team
*[2]: Design Standard for Core Industrial Estate, Japan Development Corporation

Domestic unit water demand of 150 liter per capita per day (lpcd) is adopted considering the past trend of domestic water consumption of around 100 lpcd on average in Vientiane Capital and Building Standard of Japan.

2) Required Water Supply

Based on the unit water consumption, the water demand projection for VIP was estimated as shown in Table 3.7.3. Total water supply is 12,000 m^3/d based on daily average.

Table 3.7.3: Water Demand Projection of VIP

	Lot Area (ha)	Population	Unit Demand		Water Demand (m^3/d)
Factory Lot	96.5		115	m^3/ha/d	11,100
Residential Lot	5.0	6,000	150	lpcd	900
Total	101.5	6,000			12,000

Source: JICA Survey Team

(4) Design Water Flow

In this Study, three types of water volumes are used in designing various water supply facilities:

- Daily Average Water flow (DAWF): Generally applied to base data for designing water treatment plant, reservoir and water tower
- Daily Maximum Water flow (DMWF): Generally applied to designing water treatment plant which can retain the maximum inflow throughout the year
- Hourly Maximum Water flow (HMWF): Generally applied to designing water supply pipeline network

The design water flows are estimated as shown in Table 3.7.4.

Table 3.7.4: Design Water Flow

Type of Design Flow	Volume (m^3/d)	Factor
Daily Ave. Water Flow: DAWF	12,000	1.00
Daily Max. Water Flow: DMWF	15,000	1.25
Hourly Max. Water Flow: HMWF	24,000	2.00

Source: JICA Survey Team

3.7.2 Water Supply Plan

(1) Design Policy and Standards

The proposed design standards for water supply within the area are as follows:

1) To apply the following regulations and standards:

- Water Supply Low in the Lao PDR, MPWT, May 2009
- Management and Technical Guidelines Water Supply-VOLUME C: Detailed Design and Technical Specifications, Water Supply Division, Department of Housing and Urban Planning, MPWT, February 2009
- Design Criteria for Water Works Facilities, Japan Water Works Association and JICA, 1990
- Ministerial Decree on The Management of Building Construction, Department of Housing and Urban Planning, Ministerial Decree, MPWT, 2005
- Design Standard for Core Industrial Estate, Japan Development Corporation

2) To coordinate and harmonize with Dongbang WTP project, especially on Phase II of the project.

3) To secure a highly reliable water supply system for both external (supply from Dongbang WTP Project) and internal systems.

4) To take adequate measures in line with the local conditions so as to protect the landscape, water environment, and the entire site from natural disasters such as floods.

(2) Design Criteria

The following design criteria for the water supply facilities are applied for the VIP site:

1) *Pipeline*

- Water pressure at consuming points must be at least 15 m (1.5 kg/cm^2) for normal condition and at least 10 m (1.0 kg/cm^2) for fire fighting emergency.
- Ductile iron pipe will be used as water supply pipeline.

2) *Installation*

- Earth cover should be at least 0.6 m from the ground surface to the top of pipe.
- Pipe bends at valve connections will be composed of flanges, tees or bends. No welded pipes will be utilized.
- It is necessary to support pipes at tees and bends outside valve pits and that these pipelines are totally placed on stable tamped ground and have low pressure. In addition, supports are arranged inside the valve pits near the turning points.

3) *Accessories*

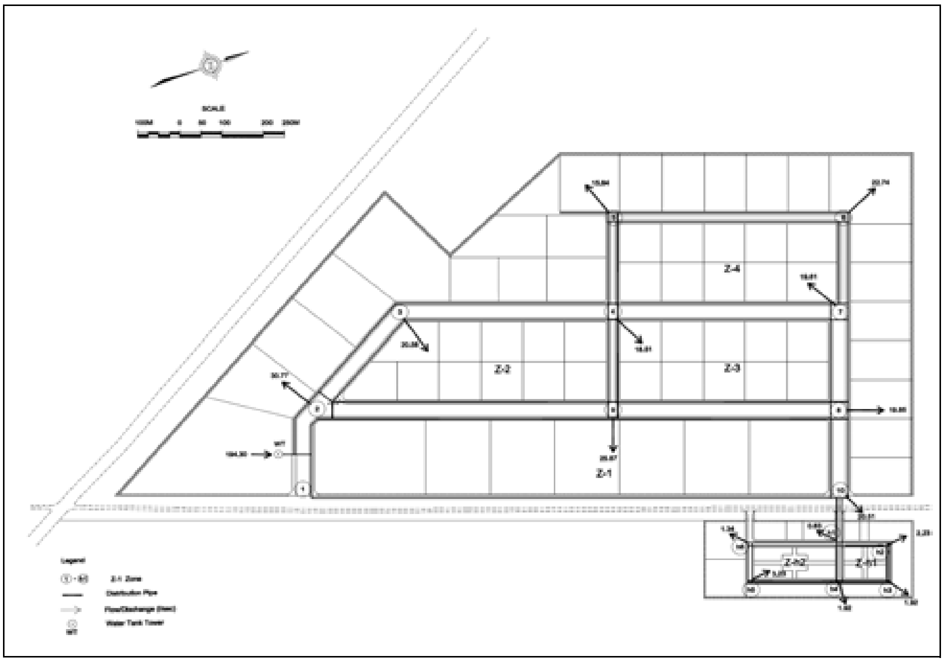
- T-branch with valve and end-cap will be installed at the planned connection point for future development area or distribution system unit with a minimum distance of 100 m.
- Air release valve will be installed at the high convex point of the pipeline.
- Drain valve will be installed at the low convex point of the pipeline.
- Gate valve with water meter will be installed at necessary junctions to monitor and identify water leakage in the future.

4) *Fire Fighting System*

- Maximum interval between fire hydrants with 2 connection points (flanges) along a pipeline is 300 m.
- Fire fighting emergency water is to be 4 m^3/min.
- Fire hydrants shall not be located along curve radius at street intersections but along roads at 1.6 m from fence lines ensuring a good view and convenience for fire emergency and installation of other systems.
- The diameter of fire hydrant connection socket should meet the mandatory requirements of Fire Fighting Department of Vientiane Police.
- There are two fire stations located at Chanthabouly and Sitattanak Districts in Vientiane Capital with 11 fire trucks in total.

(3) Network Modeling and Analysis

Distribution network analysis was conducted based on the reticulated pipeline as shown in Figure 3.7.1 and the result is presented in Table 3.7.5.



Source: JICA Survey Team

Figure 3.7.1: Distribution Network Model

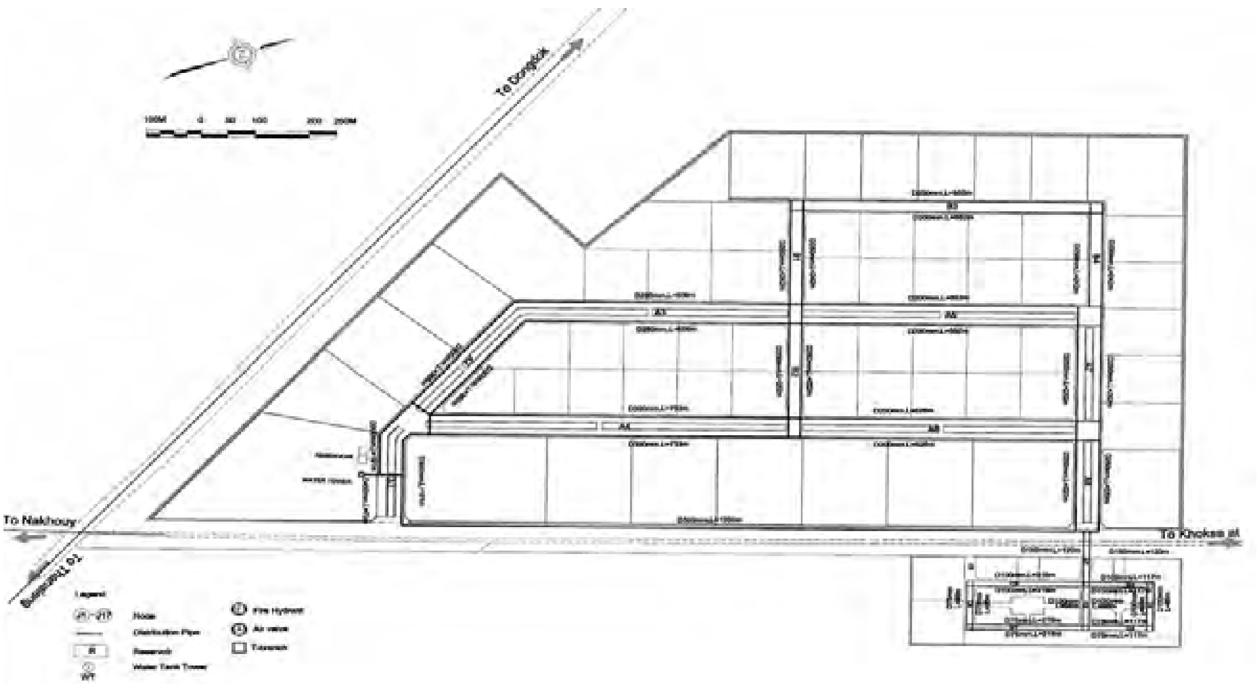
Table 3.7.5: Result of Network Analysis

Zone No.	Node No.	Length(m)	Dia.(m)	Q1(l/sec)	r	h1(m)	h1/Q1	@q(l/sec)	q(l/sec)	Q2(l/sec)
1	1-2	191	0.300	123.557	119.927	2.505	0.020		0.011	123.568
	2-9 (Z2)	733	0.200	30.372	3315.536	5.166	0.170		0.000	30.372
	9-8 (Z3)	526	0.200	-7.419	2379.225	-0.273	0.037		-0.001	-7.420
	8-10	220	0.250	-50.235	335.676	-1.327	0.026		0.011	-50.224
	10-1	1300	0.300	-70.744	816.260	-6.078	0.086		0.011	-70.733
	Total					-0.007	0.340	0.011		
2	2-3	365	0.250	62.412	556.917	3.289	0.053		0.011	62.423
	3-4	509	0.250	41.834	776.633	2.188	0.052		0.011	41.845
	4-9 (Z3)	254	0.200	-11.919	1148.903	-0.317	0.027		-0.001	-11.920
	9-2 (Z1)	733	0.200	-30.372	3315.536	-5.166	0.170		0.000	-30.372
	Total					-0.006	0.302	0.011		
3	4-7 (Z4)	536	0.250	-12.112	817.830	-0.233	0.019		0.009	-12.104
	7-8	254	0.250	-22.966	387.554	-0.360	0.016		0.012	-22.954
	8-9 (Z1)	526	0.200	7.419	2379.225	0.273	0.037		0.001	7.420
	9-4 (Z2)	254	0.200	11.919	1148.903	0.317	0.027		0.001	11.920
	Total					-0.002	0.098	0.012		
4	4-5	241	0.200	17.542	1090.101	0.615	0.035		0.003	17.546
	5-6	533	0.200	1.680	2410.888	0.018	0.011		0.003	1.684
	6-7	242	0.200	-21.060	1094.624	-0.866	0.041		0.003	-21.056
	7-4 (Z3)	536	0.250	12.112	817.830	0.233	0.019		-0.009	12.104
	Total					-0.001	0.106	0.003		
h1	h1-h2	117	0.100	3.486	15475.749	0.439	0.126		-0.011	3.475
	h2-h3	95	0.100	2.426	12565.779	0.182	0.075		-0.011	2.415
	h3-h4	117	0.075	1.325	62820.782	0.298	0.225		-0.011	1.315
	h4-h1 (Zh2)	95	0.100	-5.777	12565.779	-0.908	0.157		-0.005	-5.782
	Total					0.012	0.583	-0.011		
h2	h1-h4 (Zh1)	95	0.100	5.777	12565.779	0.908	0.157		0.005	5.782
	h4-h5	215.5	0.075	2.958	115708.363	2.426	0.820		-0.005	2.953
	h5-h6	95	0.075	-2.672	51008.327	-0.885	0.331		-0.005	-2.677
	h1-h6	215.5	0.100	-6.318	28504.479	-2.432	0.385		-0.005	-6.323
	Total					0.017	1.694	-0.005		

Source: JST

(4) Proposed Water Supply System

From the results of hydraulic analysis for water supply system, the water supply plan is proposed as shown in Figure 3.7.2. The water supply plan consists of the following: i) outer distribution main, ii) reservoir and water tower, iii) water supply pipeline for industrial area, and iv) water supply pipeline for residential area, as described below.



Source: JICA Survey Team

Figure 3.7.2: Overall Water Supply Plan

1) Outer Distribution Main

Distribution main of D400 mm is installed by VIP from the junction of National Road No. 13S and District Road No. 108 up to VIP along District Road No. 108 with a length of 1.2 km since the implementation plan for Phase II of Dongbang Water Supply project has not been determined. Components of the outer distribution main scheme are summarized below:

a)	DN400 Ductile Pipeline with Mechanical Joint	12,000	m
b)	DN400 T-branch with Butterfly Valve and Pipe Blind	4	unit
c)	Air Valve	5	unit
d)	DN400 Drain Valve	2	unit
e)	Manhole 1.8 m x 1.8 m , H = 2.4 m	11	unit
f)	Restoration of NR-13S (Width=22m)	1	L.S.

Source: JICA Survey Team

2) Reservoirs and Water Tower Station

Reservoirs and water tower are designed as shown in Table 3.7.6 in order to secure a reliable water supply system in VIP with adequate water flow and pressure from Dongbang WTP. This scheme is composed of two reservoirs with total capacity of 4,200 m^3, one water tower with a height of 26 m and a capacity of 268 m^3, and one operation house with booster pumps and control panel.

Table 3.7.6: Reservoirs and Water Tower

Item		Unit	Value	Item		Unit	Value
1.	**Reservoirs**			**2.**	**Water Tower**		
a)	Time Factor	hrs	8	a)	Time Factor	hrs	0.5
b)	Required Capacity	m^3	3,999	b)	Required Capacity of Tank	m^3	250
c)	Design Capacity per Reservoir	m^3	2,100	c)	Number of Tower	unit	1
d)	Number of Reservoirs	unit	2	d)	Design Capacity of Tank	m^3	268
e)	Design Capacity	m^3	4,200	e)	Height of Tower	m	26.0
f)	Size of Reservoir			f)	Size of Octagon-shaped Tank		
	- Effective Depth	m	3.0		- Effective Depth of Tank	m	4.0
	- Width	m	20.0		- Height of Tank	m	4.5
	- Length	m	35.0		- Width	m	9.0
	- Height	m	3.5				

Source: JICA Survey Team

3) *Water Supply Pipeline for Industrial Area inside VIP*

Water supply pipeline for industrial area is planned as shown in Figure 3.7.2 with components as presented in Table 3.7.7. The total length of distribution mains are estimated to be about 9.3 km and their diameters range from 200 to 450 mm. Manholes and hand-holes, 254 in total, are constructed for installing T-branches and valves. About 32 fire hydrants are allocated at proper intervals of less than 300 m.

Table 3.7.7: Component of Water Supply Pipeline for Industrial Area

Item		Quantity	
a)	Distribution Mains	9,342	m
	DN450 ductile pipeline with mechanical joint	70	m
	DN300 ductile pipeline with mechanical joint	382	m
	DN250 ductile pipeline with mechanical joint	3,796	m
	DN200 ductile pipeline with mechanical joint	5,094	m
b)	T-branch	28	unit
	DN450 T-branch with butterfly valve and pipe blind	2	unit
	DN300 T-branch with butterfly valve and pipe blind	4	unit
	DN250 T-branch with butterfly valve and pipe blind	15	unit
	DN200 T-branch with butterfly valve and pipe blind	7	unit
c)	Air Valve	27	unit
d)	Drain Valve	13	unit
	DN300 drain valve	2	unit
	DN250 drain valve	6	unit
	DN200 drain valve	5	unit
e)	Gate Valve & Water Meter	185	unit
	DN300 gate valve and water meter	8	unit
	DN250 gate valve and ater meter	105	unit
	DN200 gate valve and water meter	73	unit
f)	Fire Hydrant	32	unit
g)	Manhole/ Hand-hole	254	unit
	Manhole 1.8 m x 1.8 m , H = 2.4 m (for DN250 and more)	169	unit
	Hand-hole 1.2 m x 1.2 m, H = 1.5 m (for less than DN250)	85	unit

Source: JICA Survey Team

4) *Water Supply Pipeline for Residential Area inside VIP*

Table 3.7.8 presents the components of water supply pipeline for the residential area . Total length of distribution mains are estimated to be about 3.5 km with diameters varying from 80 to 300 mm. Manholes and hand-holes, 121 units in total, are constructed for installing T-branches and valves. About 8 fire hydrants are allocated at the 10 ha residential area.

Table 3.7.8: Components of Water Supply Pipeline for Residential Area

	Item	Quantity	
a)	Distribution Mains	3,444	m
	DN300 ductile pipeline with mechanical joint	1,300	m
	DN150 ductile pipeline with mechanical joint	240	m
	DN100 ductile pipeline with mechanical joint	1,048	m
	DN80 ductile pipeline with mechanical joint	856	m
b)	T-branch	23	unit
	DN300 T-branch with butterfly valve and pipe blind	3	unit
	DN150 T-branch with butterfly valve and pipe blind	4	unit
	DN100 T-branch with butterfly valve and pipe blind	8	unit
	DN80 T-branch with butterfly valve and pipe blind	8	unit
c)	Air Valve	6	unit
d)	Drain Valve	6	unit
	DN300 drain valve	2	unit
	DN150 drain valve	2	unit
	DN100 drain valve	1	unit
	DN80 drain valve	1	unit
e)	Gate Valve & Water Meter	86	unit
	DN150 gate valve and water meter	10	unit
	DN100 gate valve and water meter	42	unit
	DN80 gate valve and water meter	34	unit
f)	Fire Hydrant	8	unit
g)	Manhole/ Hand-hole	121	unit
	Manhole 1.8 m x 1.8 m , H = 2.4 m (for DN250 and more)	11	unit
	Hand-hole 1.2 m x 1.2 m, H = 1.5 m (for less than DN250)	110	unit

Source: JICA Survey Team

(5) O&M Plan

NPVC conducts the O&M for the water supply system in VIP as part of public services. Main activities for O&M are:

- O&M of reservoirs with booster pumps and water tower;
- Regular patrol and repair of water supply network;
- Collection of water rate from each tenant; and
- Coordination with Dongbang WTP.

Although the water supply system of VIP is planned to be fully automated, NPVC allocates permanent technicians in order to execute proper O&M of the facilities, especially for booster pumps at reservoir and water tower station. Operation house will be constructed at the reservoir and water tower station for the technicians. O&M cost will be recovered by levying water rate. In most developed countries, construction cost of water supply project is also recovered through water rates. Construction cost of water supply scheme for VIP shall be financed by the government agencies of the Lao PDR such as NPVC since water supply is under public services. Therefore, it is recommended that the construction cost of the water supply scheme should not reflect on the land lease fee of tenants in the VIP.

(5) Conclusion and Recommendations

The overall water supply plan in VIP is presented in Figure 3.7.2. The required facilities for the proposed water supply plan are summarized in Table 3.7.9. The total length of distribution mains is estimated at around 24.8 km, which consists of 12.8 km distribution main inside VIP and 12.0 km outer water distribution main. The 4,200 m^3 reservoirs shall be constructed to receive water supplied from Dongbang WTP and secure required water volume for VIP. The 26 m high water tower is necessary for sufficient water pressure in the whole area of VIP.

Table 3.7.9: Summary of Water Supply Facilities

Work Item		Quantity	
1	**Water Supply Pipeline inside VIP**		
a)	Distribution Mains	12.8	km
b)	T-branch with Butterfly valve and pipe blind	51	unit
c)	Air Valve	33	unit
d)	Drain Valve	19	unit
e)	Gate Valve & Water Meter	271	unit
f)	Manhole/Hand-hole	374	unit
g)	Fire Hydrant	21	unit
2	**Reservoir & Water Tower**		
a)	Reservoir (V=2100 m^3 x 2 units)	4,200	m^3
b)	Water Tower (H=26 m, V=254 m^3)	1	unit
c)	Operation House with Pumps & Control Panel	1	unit
3	**Outer Water Distribution Main**	12.0	km

Source: JICA Survey Team

For implementation of water supply plan, the following measures are recommended:

1) Structural Measures

- The detailed design of water supply system should be prepared in consideration of the harmonization with District Road No. 108 and its infrastructure to be improved by Vientiane Capital.
- Phase II of Dongbang Water Supply project should be reviewed and the outer water distribution main along District Road No. 108 should be appropriately designed.

2) Non-Structural Measures

- The O&M for the water supply system in VIP will be conducted by NPVC.
- Construction cost of water supply scheme for VIP shall be absorbed by government agencies of the Lao PDR since water supply for VIP is part of public services.
- The construction cost of the water supply scheme for VIP should not reflect on the land lease fee of tenants in VIP.

3.8 Sewerage Plan

3.8.1 Framework of Sewerage Development Plan

(1) Present Condition of Sewerage Sector

Public sewerage system with a finalized wastewater treatment plant (WWTP) is not established in the Lao PDR. In Vientiane Capital, gray water and commercial wastewater are discharged individually to ditches. Night soil is treated through individual septic tanks or pit latrines, or discharged directly to ditches without proper treatment, while industrial wastewater is treated individually by each tenant in accordance with the Industrial Wastewater Effluent Standard of MoIC. The MoIC collects fees for the issuance of certificates on discharging wastewater of tenants as presented in Table 3.8.1.

Table 3.8.1: Fee of Certificate for Discharge of Sewage and Industrial Wastewater

No	Discharged volume of sewage and process wastewater (m^3/d)	Amount of fee (LAK for three years)
1	3	50,000
2	4 – 5	75,000
3	6 – 15	150,000
4	16-30	300,000
5	31-50	450,000
6	51-70	600,000
7	71-90	800,000
8	91-110	1,200,000
9	111-200	1,500,000
10	201-400	3,000,000
11	401-600	6,000,000
12	601-900	8,500,000
13	901-1,000	9,500,000
14	> 1,000	10,000,000

Source: Effluent Standard Article 22, MoIC

Although the national strategy on urban sewerage management and investment draft plan for 2020 has been provided by MPWT, concrete issues, such as responsible agency of sewerage management, executive agencies for implementation and O&M, implementation schedule and finance, have yet to be determined.

(2) Sewerage Treatment System for VIP

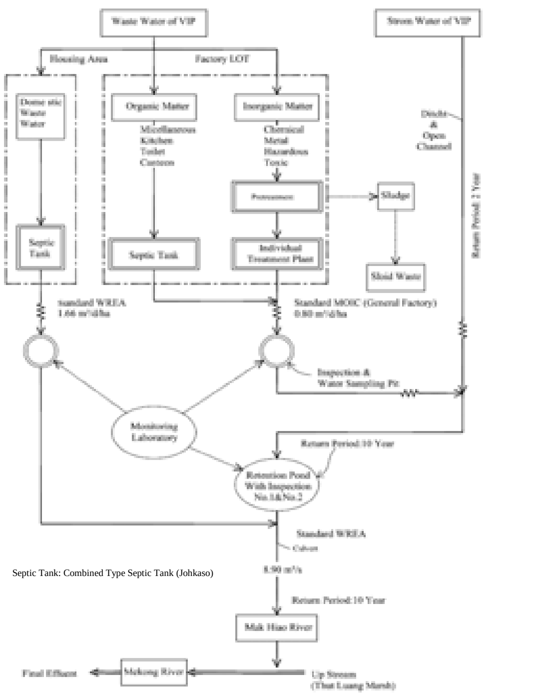
1) Basic Concept for Planning

The basic concept for the sewerage treatment system plan is summarized below. The sewerage treatment system is to be examined in order to adopt a system with appropriate technology to meet the present conditions of the Lao PDR.

Target year	:	2015
Planning area	:	140 ha of VIP consisting of the industrial area of 130 ha and residential area of 10 ha
Demand projection area	:	101.5 ha consisting of the industrial area of 96.5 ha and residential area of 5.0 ha
Design population	:	6,000
Wastewater yield ratio to water supply	:	70% for industrial water, 80% for domestic water
Collection system	:	Separate system with monitoring pit and sewer
Sewerage treatment system	:	Centralized treatment or individual treatment
Receiving water bodies	:	Mak Hiao River upstream of Nathrough through the existing culverts of 450 Year Road

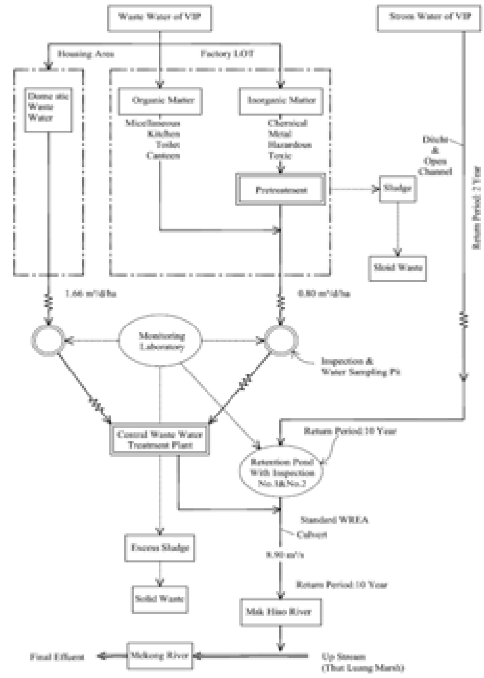
2) Alternative Examination of Sewerage Treatment Systems

Sewerage treatment systems are classified into two systems, namely, individual treatment and centralized treatment, as shown in Figures 3.8.1 and 3.8.2, respectively.



Source: JICA Survey Team

Figure 3.8.1: Flow Diagram of Individual Treatment System



Source: JICA Survey Team

Figure 3.8.2: Flow Diagram of Centralized Treatment System

The treatment system will be individually-managed consisting of industrial wastewater treatment plants with pretreatment schemes, combined septic tanks and effluent sewer with inspection pits. Treated wastewater is discharged to the planned storm water collection sewer as shown in Figure 3.8.1. Finally, treated wastewater is collected, together with storm water, and transported to retention ponds, which function both for flood control and water quality inspection. This system is generally suitable for tenants occupying a large area and for industrial estates with an undeveloped area for public sewerage system. VIP shall establish a monitoring system for treated wastewater quality to ensure the reliability of individual treatment systems of each tenant.

The centralized treatment system is composed of effluent sewer with inspection pit, separate collection sewers for wastewater and storm water, and WWTP as shown in Figure 3.8.2. As this system is similar to the public sewerage system, an O&M and monitoring system shall be set up properly and promptly. It is noted that the centralized WWTP will function for biological wastewater only while chemical wastewater will be treated by individual pretreatment facilities provided at each tenant. A centralized WWTP that also treats chemical wastewater will enormously increase construction and O&M costs for VIP since process wastewater contains various chemicals and qualities depending on the type of industry.

Characteristics of both treatment systems are compared and summarized in Table 3.8.2.

Table 3.8.2: Comparison of Centralized Treatment and Individual Treatment

Parameter		Centralized Treatment System	Individual Treatment System
1	Type of Collection Sewer (Number of Sewer Lines)	Drainage and sewerage sewers (2 Lines)	Drainage Sewer (1 Line)
2	Pretreatment	Required at tenant	Individual WWTP at tenant
3	Industrial Wastewater Treatment	Centralized WWTP	Individual WWTP at tenant
4	Domestic Wastewater Treatment	Centralized WWTP	Septic tank at tenant
5	Treatment Level	Biological treatment	Chemical and biological treatments
6	Construction of WWTP	By VIP project	By tenant
7	O&M of WWTP	Unknown	By tenant
8	Knowhow of O&M	None	Tenant
9	Inspection Pit	Required at tenant	Required at tenant
10	Inspection Pond	Not required	Required at point discharged from VIP
11	Volume of Excess Sludge	Low (estimated at 4 m^3/d)	High (depends on type of septic tank)
12	Excess Sludge Disposal	Conducted by VUDAA	Conducted by VUDAA
13	Area of WWTP	Required at public space (1.0 ha)	Required at tenant

Source: JICA Survey Team

3) Recommendation

For VIP, the individual sewerage treatment system is recommended based on the comparison of two treatment systems However, the centralized treatment and individual treatment systems are presented in this Study for further examination from various aspects of costs and O&M system as described later on.

(3) Wastewater Yield Projection and Design Flow

1) Wastewater Yield Projection

The unit wastewater volume was set based on the unit water supply volume. About 70% of the supplied industrial water volume and 80% of the domestic water volume are considered to be discharged to the sewerage system of VIP. The estimated daily average domestic and industrial wastewater yields are as follows:

Classification of Wastewater	Unit Yield	Wastewater Yield (m^3/d)
1. Domestic Wastewater in Residential Area	120 (lpcd)	720
2. Industrial Wastewater in Industrial Area	80.5 (m^3/ha/d)	7,768
Total		8,488

2) Groundwater Infiltration

Groundwater infiltration and unexpected surface water intrusion shall be considered when designing the capacity of the sewerage collection system. Groundwater infiltration including unexpected surface water intrusion is assumed to be 5% to 10% of daily average wastewater flow (DAWF). In this study, the proposed rate is 10% of DAWF, considering the geological conditions in VIP.

3) Design Wastewater Flow

In this study, three types of wastewater volumes are used for designing various sewerage facilities:

- Daily Average Wastewater flow (DAWF): Generally applied in designing sludge treatment process and basic data for tariff collections
- Daily Maximum Wastewater flow (DMWF): Generally applied in designing wastewater treatment process, which can retain the maximum inflow throughout a year
- Hourly Maximum Wastewater flow (HMWF): Generally applied in designing sewer pipes and pumping station, which can handle peak flow rates due to hourly fluctuation of wastewater inflow

The ratio of each factor (peak factor) was adopted by comparing existing cases from big cities in Asian countries and general practices. The ratios were set as follows:

DAWF : DMWF : HMWF = 1.0 : 1.15 : 1.44

However, as for groundwater infiltration, the volume calculated by DAWF was also applied to DMWF and HMWF. A summary of the Design Wastewater Yield is shown in Table 3.8.3.

Table 3.8.3: Design Wastewater Flow

Type of Design Flow	Volume (m^3/d)
Daily Ave. Wastewater Flow: DAWF	8,490
Daily Max. Wastewater Flow: DMWF	9,740
Hourly Max. Wastewater Flow: HMWF	12,340

Source: JICA Survey Team

(4) Planned Wastewater Quality

1) Unit Pollutant Load and Wastewater Quality

The wastewater discharged from polluters, such as houses and industries, always fluctuates in quality and quantity. In Vientiane Capital, not enough biochemical data of wastewater components discharged from polluters is available. As a result, it is difficult to analyze and conclude the acceptable BOD specific to VIP. Considering this, the planned wastewater quality is determined based on the results of previous studies in Japan and other Asian countries.

Table 3.8.4 presents the pollutant load per capita in hot and temperate countries in Asia. In addition, Japanese data was also analyzed for estimation purposes.

Table 3.8.4: Pollutant Load Per Capita in Hot/Temperate Countries

Name of Area	BOD (Unit: gpcd)	SS (Unit: gpcd)
Indonesia: Jakarta	30	-
India	30 – 45	67
S.E. Asia	43	-
JAPAN	50 – 60	40
Developing Countries (WHO)	40	-
Vietnam: Hanoi	40 – 100	-
(Data from Previous Study Reports)		

Source: Technical Guideline for Urban Drainage and Wastewater Disposal in Developing Countries, 1993 by IDI in Japan

The planned wastewater quality for VIP is determined as follows:

- Domestic wastewater: 40 gram per capita per day (gpcd) of BOD considering Table 3.8.4.
- Industrial wastewater: 200 mg/L of BOD based on the analyzed data of industrial wastewater in Japan.

2) Design Wastewater Quality

The design wastewater quality is estimated by applying unit pollutant loads to specific wastewater flow at DAWF condition. The total amount of wastewater and pollutant load in VIP is shown in Table 3.8.5.

Table 3.8.5: Summary of Design Wastewater Quality

Description	Value
1. Daily Ave. Wastewater Flow: DAWF (m^3/d)	8,490
a) Domestic Wastewater	720
b) Industrial Wastewater	7,770
2.Unit Pollutant Load	
a) Domestic (gpcd)	40
b) Industrial (mg/L of BOD)	200
3. Future Pollutant Load (kg/d)	1,792
a) Domestic	240
b) Industrial	1,552
4. Specific Unit	
a) Specific Yield (m^3/d/ha)	61
b) Specific Load (kg/d/ha)	13
5. Influent Wastewater Quality	
a) BOD (mg/L)	211
b) SS (mg/L)	264
6. Proposed Removal Ratio of Treatment (%)	90
7. Efficiency of Removal (%)	
a) BOD	86
b) SS	85
8. Treated Wastewater Quality	
a) BOD (mg/L)	30
b) SS (mg/L)	40
9. Excess Sludge (m^3/d)	5.0

Source: JICA Survey Team

By comparing the characteristics of sewerage with that in Japan, the average values of influent wastewater quality with 211 mg/L of BOD and 264 mg/L of SS, as mentioned above, have been considered reasonable for further planning and design purposes.

3) Proposed Influent and Effluent Wastewater Qualities

The influent and effluent wastewater qualities are proposed to be 211 mg/L and 30 mg/L at BOD level, respectively, as shown in Table 3.8.5. These were proposed to minimize the environmental impact on water bodies in VIP and meet the environmental quality and effluent standards in the Lao PDR.

3.8.2 Sewerage Plan

(1) Design Policy and Standards

The proposed design policy and standards for sewerage system within the area are as follows:

1) To apply the following regulations and standards:

- Standard for Discharge of Domestic Sewage and Process Wastewater from the Processing Industry Tenants, MoIC, 2006
- Standard for Wastewater Treatment from Public Areas to Environment, STEA, 1998
- National Strategy on Urban Sewerage Management and Investment Plan to the Year 2020, MPWT, 2009
- Draft Agreement of National Standards of Environment in the Lao PDR, March 2009
- Ministerial Decree on The Management of Building Construction, Department of Housing and Urban Planning, Ministerial Decree, MPWT, 2005
- Japan Sewerage Works Association Standards, 1984
- Guideline of Industrial Wastewater Treatment Method in Japan
- Domestic Wastewater Standard - JIS A3302, Japan, April 1988

2) To harmonize with the existing infrastructure, such as 450 Year Road and District Road No. 108.

3) To adopt a separate system with inspection pit and sewer for collecting treated wastewater.

4) For an individual sewerage system, to introduce a combined type septic tank (so called Gappei Johkaso in Japan) for domestic wastewater treatment and for MoIC to oblige the tenants to install the combined type septic tank, as stipulated in their respective contracts.

5) To propose the effluent standard and establish the monitoring system for treated wastewater quality in VIP.

6) To take adequate measures in line with the local conditions so as to protect the landscape, water, and living environment.

(2) Design Criteria

1) Sewerage Collection System

Separated sewer systems for all areas in the VIP shall be applied. In principle, the wastewater produced by industries will be treated prior to discharging into sewerage systems in order to meet the wastewater criteria in VIP. Highly loaded gray water and toxic/hazardous materials will be pretreated individually at the source.

Basically, VIP will be installed with gravity flow sewer system. However, pressure pipelines will also be used when the depth of the installed gravity pipe goes deeper than around 7 m or when pipes must cross rivers/channels to avoid difficult and dangerous construction work, as well as escalating construction cost.

2) *Materials of Sewer Pipes and Dimensions*

Reinforced Concrete (RC) pipe is to be used for gravity sewer lines and Ductile Cast Iron Pipe (DCIP) is to be adopted for pressure lines. The minimum dimensions of these pipes are set at 200 mm for RC pipe and 250 mm for DCIP.

3) *Hydraulic Calculation of Sewer Pipes*

For designing the gravity sewerage network, Manning's formula was applied to decide the proper dimensions for accepting the design flow rate from the area. This formula is given below:

$$Q = A \cdot V$$
$$V = (1/n) \cdot R^{2/3} \cdot I^{1/2}$$

Where, Q: Wastewater discharge (m^3/s)
A: Sectional area of pipe (m^2)
V: Mean velocity (m/s)
n : Roughness coefficient
R: Hydraulic radius (m)
I : Hydraulic gradient

The following relrated criteria were applied to the hydraulic design of sewers:

- Roughness Coefficient (n): 0.013
- Allowable flow velocity (V): 0.6-3.0 m/s
- Hydraulic gradient (I): Considered the same as the gradient of sewer pipe (in full capacity condition)
- Allowance of sewer capacity: 100% of design HMWF

4) *Minimum Earth Cover*

In this study, the minimum earth cover is set at 1.50 m to allow access to discharge pipes from industries and buildings. However, the minimum earth cover for pressure pipes, which will be buried in the sidewalk, is set at 0.6 m.

5) *Typical Interval of Manholes*

The typical interval of manholes is arranged at 50 m to reduce construction cost and actual work for daily maintenance.

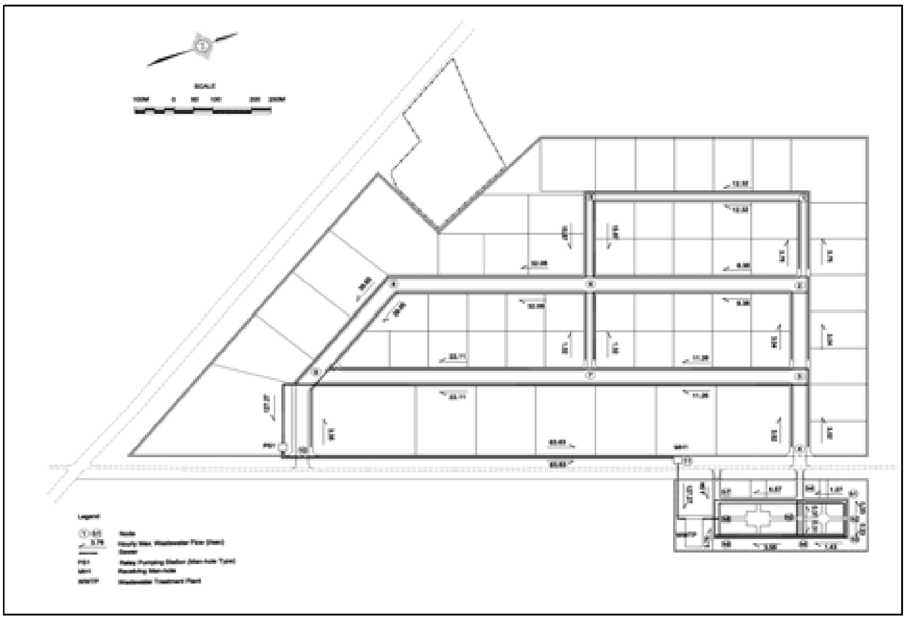
6) *Relay Pumping Station*

Relay pumping stations will be established to lift wastewater from deeper gravity sewers and send them to pressure lines. Stations will use submersible pumps and will be located underground along sidewalks and in green areas so as not to restrict land use or affect the landscape of VIP.

(3) Plan of Centralized Sewerage Treatment System

1) Hydraulic Analysis of Collection Sewer

Collection sewer of the centralized sewerage treatment system is analyzed hydraulically and planned as shown in Figure 3.8.3.

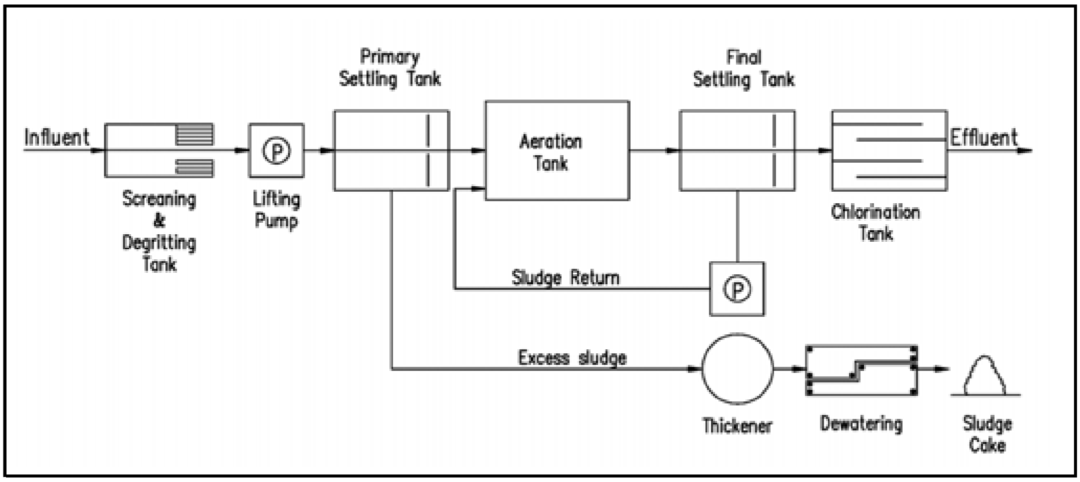


Source: JICA Survey Team

Figure 3.8.3: Wastewater Flow Model of Centralized Treatment System

2) Centralized Wastewater Treatment Method

Considering wastewater volume and quality, the conventional activated sludge process is recommended for wastewater treatment within VIP. For the sludge treatment process, a gravity thickener and mechanical dewatering process are recommended. An outline of the treatment process is shown in Figure 3.8.4.

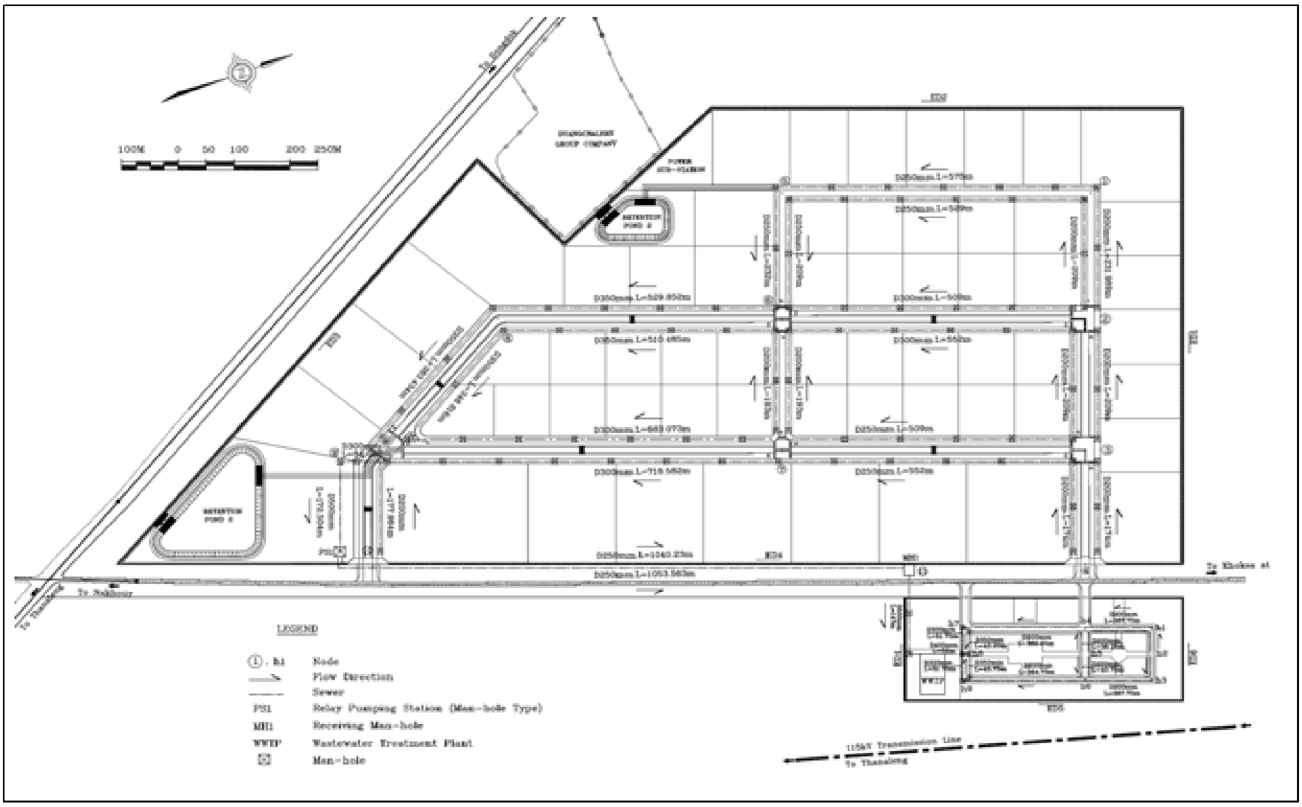


Source: JICA Survey Team

Figure 3.8.4: Diagram of Conventional Activated Sludge Process

3) Overall Plan of Centralized Sewerage Treatment System

Based on the results of hydraulic analysis, an overall plan of the centralized sewerage treatment system is presented in Figure 3.8.5. One relay pumping station will be located at the industrial park center as shown in Figure 3.8.5.



Source: JICA Survey Team

Figure 3.8.5: Overall Plan of Centralized Sewerage Treatment System

The centralized sewerage treatment plan will consist of the following: i) wastewater collection sewer for industrial area, ii) wastewater collection sewer for residential area, and iii) WWTP. Table 3.8.6 presents the components of planned facilities for the centralized sewerage treatment system.

Table 3.8.6: Components of Planned Facilities for Centralized Sewerage Treatment Plan

	Work Item	Quantity	
1	**Wastewater Collection Sewer for Industrial Area**		
a)	Sewer	9,061	m
	D200 mm RC Pipe, Shallower than 4.0 m	1,852	m
	D250 mm RC Pipe, Deeper than 4.0 m	2,633	m
	D300 mm RC Pipe, Deeper than 4.0 m	2,484	m
	D350 mm RC Pipe, Deeper than 4.0 m	1,772	m
	D500 mm RC Pipe, Shallower than 4.0 m	147	m
	D500 mm RC Pipe, Deeper than 4.0 m	173	m

	Work Item	Quantity	
b)	Manhole	366	units
	Manhole for D200-600, 1.2 m x 1.2 m, H=4 m	224	units
	Manhole for D200-600, 1.2 m x 1.2 m, H=7 m	141	units
c)	Relay Pumping Station		
	Pumping Station (H=23 m x D250 mm x 22 kW Submersible Pump: 3 units)	1	units
	D250 mm Ductile Cast Iron Pipe	3,126	m
2	**Wastewater Collection Sewer for Residential Area**		
a)	Sewer	1,990	m
	D200 mm RC Pipe, Shallower than 4.0 m	1,796	m
	D300 mm RC Pipe, Shallower than 4.0 m	52	m
	D350 mm RC Pipe, Shallower than 4.0 m	90	m
	D400 mm RC Pipe, Deeper than 4.0 m	52	m
b)	Manhole	40	
	Manhole for D200-600, 1.2 m x 1.2 m, H=4 m	39	units
	Manhole for D200-600, 1.2 m x 1.2 m, H=7 m	1	units
3	**Wastewater Treatment Plant**		
a)	Wastewater Treatment Plant (Q_{max}=10,000 m^3/d) Conventional Activated Process, Mechanical Sludge Process	1	units
b)	Laboratory Equipments & Sampler	1	set

Source: JICA Survey Team

(4) Plan of Individual Sewerage Treatment System

1) Industrial Wastewater Treatment Method

Table 3.8.7 presents the industrial wastewater characteristics and typical treatment methods categorized by type of industry. There are multifarious industrial wastewater treatment methods to be adopted not only for the individual sewerage treatment system but also for pretreatment of the centralized sewerage treatment system as shown in Table 3.8.7.

Table 3.8.7: Wastewater Characteristics and Treatment Methods Categorized by Industry

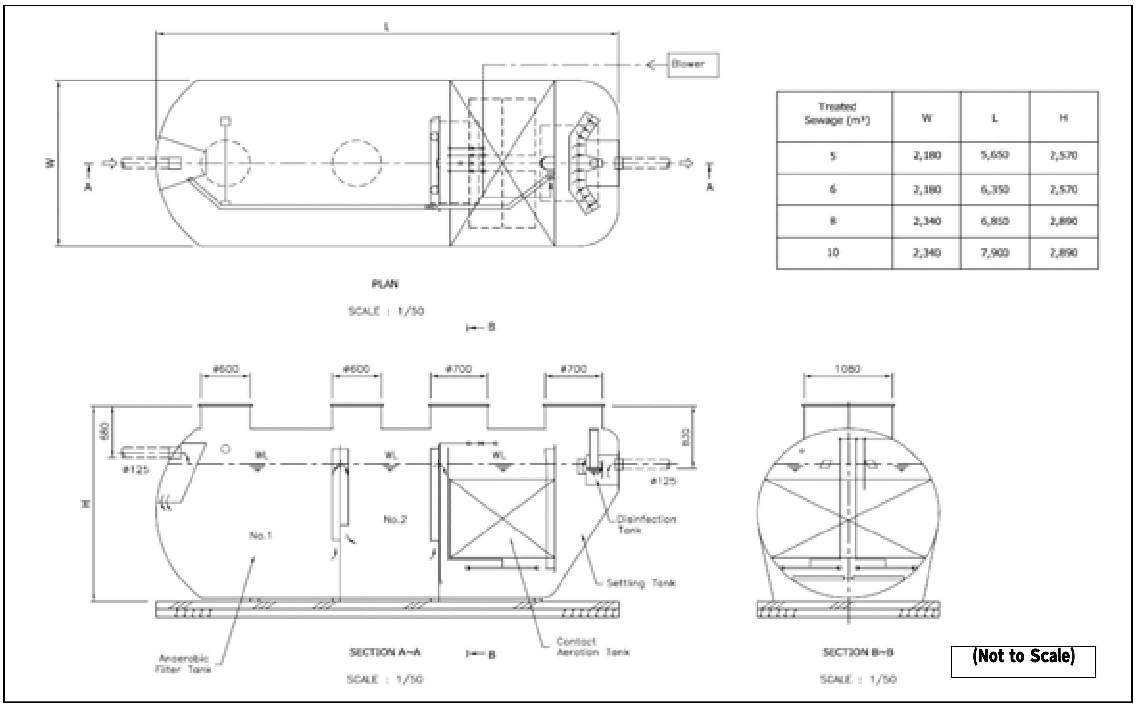
	Industry	BOD PPM	COD PPM	SS PPM	PH	Typical Treatment
1.	Food					
	Processing	1,000 - 2,700	430 - 2,700	450 - 800	1 - 14	A.S
	Dairy Products	250	170	200	65 - 11	A.S
	Seasoning	340 - 2,300	109 - 11,900	76 - 4,250	6 - 8	A.S
	Milling	1,900	1,600	2,400	6 - 8	OF + A.S
	Soft Drink	340	330	370	9 - 12	A.S
	Alcoholic Drink	490 -1,700	127 - 1,400	88 - 776	8 - 11	A.S
	Frozen	410	170	200	-	A.S
	Confectionery	860	780	610	6 - 8	OF + A.S
	Feed/Fertilizer	1,200	480	25	-	A.S
	Cooking Oil	4,400	3,100	2,600	1 - 7	OF + A.S
	Others	450 - 2,400	450 - 1,200	450 - 1,200	6 - 8	A.S
2.	Spinning	20 - 300	30 - 610	15 - 630	3, 5 - 9	A.S
	Tex tile	60	30	100	6 - 8	A.S
	Garment	10	10	30	6 - 8	A.S
	Dyeing	200 - 300	160 - 450	80 - 200	3 - 11	C.D
3.	Chemical					
	Organic Chemical	300 - 600	460 - 870	100 - 150	1 - 13	N.T + A.S/C.S
	Plastic/Rubber	10	20	50	-	N.T + A.S
	Petro - Chemical	20 - 200	20 - 200	20 - 100	1 - 13	OF + A.S / G.S
	Others	500	500	30	-	A.S / C.D
4.	Wood/Furniture	10	10	30 - 40	-	A.S
5.	Glass/Ceramic	3 - 10	1 - 13	30 - 20,000	7 - 9	C.S / F.M
6.	Cement/Concrete	8 - 30	7 - 17	200 - 1,400	9 - 14	N.T
7.	Metal product	20 - 360	20 - 360	20 - 560	2 - 8	N.T / C.S
8.	Plate	-		30 - 150	1 - 6	N.T / C.D
9.	Pulp/Paper	300	250	180	7 - 9	A.S / C.S
10.	Machinery	10	30	100	-	OF + A.S / C.D
11.	Automobile	50	90	100	-	OF + A.S / C.D
12.	Electronics	10	30	100	-	OF + A.S / C.D
13.	Miscellaneous	5	10	40	6 - 8	A.S

Source: Gridline of Industrial Wastewater Treatment Method in Japan

A.S : Activated Sludge Method
C.S : Coagulated Sedimentation
O.F : Oil Floating
F.M : Filter Method
N.T : Neutralization Treat
C.D : Chemical Treat

2) Combined Type Septic tank

In case of the individual sewerage system, the combined type septic tank is recommended for domestic wastewater treatment at industrial and residential area as shown in Figure 3.8.6. The combined type septic tank is being produced and used in Thailand. The ready-made septic tank accommodates treatment capacity of 0.5 to 100 m^3/day by combining many tanks.



Source: JICA Survey Team

Figure 3.8.6: Typical Combined Type Septic Tank (Johkaso)

The combined type septic tank with a capacity of over 100 m^3/day will be designed with a cast-in-place RC tank instead of the ready-made tank since installation cost of the latter is higher than the construction cost of the former. For domestic wastewater treatment of residential area, the communal combined type septic tank with cast-in-place RC is planned as shown in Table 3.8.8.

Table 3.8.8: Communal Combined Type Septic Tank for Residential Area

Item		Description
1	Capacity of Septic Tank	950 m^3/d (estimated)
2	Raw Wastewater Quality	BOD: 300 mg/L
3	Treatment Method	Extended Aeration Process
4	Treated Wastewater Quality	BOD: less than 30 mg/L
5	Structure	Cast-in-place Concrete
6	Area of Septic Tank	Requires about 0.2 ha

Source: JICA Survey Team

3) Required Facilities for Individual Sewerage System

The individual sewerage treatment plan consists of the following: i) wastewater collection sewer for industrial area, ii) wastewater collection sewer for residential area, and iii) water quality test equipment as shown in Table 3.8.9. Industries shall provide industrial wastewater treatment plants while residents shall install their own combined type septic tank for domestic wastewater treatment.

Table 3.8.9: Components of Individual Sewerage Treatment Plan

Work Item		Quantity	
1	**Wastewater Collection Sewer for Industrial Area**		
a)	Outlet RC Pipe D300	278	m
b)	Inspection & Water Sampling Pit, 1.2 x 1.2 m, H=4 m	185	units
2	**Wastewater Collection Sewer for Residential Area**		
a)	Outlet RC Pipe D300	32	m
b)	Inspection & Water Sampling Pit, 1.2 x 1.2 m, H=4 m	21	units
3	**Water Quality Test Equipment & Sampler**	1	set

Source: JICA Survey Team

(5) Recommended Effluent Standard of Wastewater

In order to apply both centralized and individual sewerage and treatment systems, effluent standard of treated wastewater for VIP is proposed as shown in Table 3.8.10.

Table 3.8.10: Effluent Standard of Wastewater for VIP

Parameter	Unit	Value (not higher than)
BOD_5	mg/l	30
Ammonia Nitrogen	mg/l	4
Total Suspended Solid (TSS)	mg/l	40
pH	mg/l	6-9.5
Temperature*	Degree Celsius	40
Total dissolved solid (TDS)*	mg/l	1,500
COD*	mg/l	120
Total Kjeldahl Nitrogen (TKN)*	mg/l	100
Phenols	mg/l	0.3
Phosphorus	mg/l	1
Silver	mg/l	0.1
Zinc	mg/l	1
Sulphide	mg/l	1
Free chlorine	mg/l	1
Chloride	mg/l	500
Iron	mg/l	2
Fluoride	mg/l	15
Cyanide	mg/l	0.1
Copper	mg/l	0.5
Lead	mg/l	0.2
Oil and grease	mg/l	5
Nickel	mg/l	0.2
Mercury	mg/l	0.005
Manganese	mg/l	1
Arsenic	mg/l	0.25
Barium	mg/l	1
Cadmium	mg/l	0.03
Chromium (+6)	mg/l	0.1
Total Chromium	mg/l	0.5

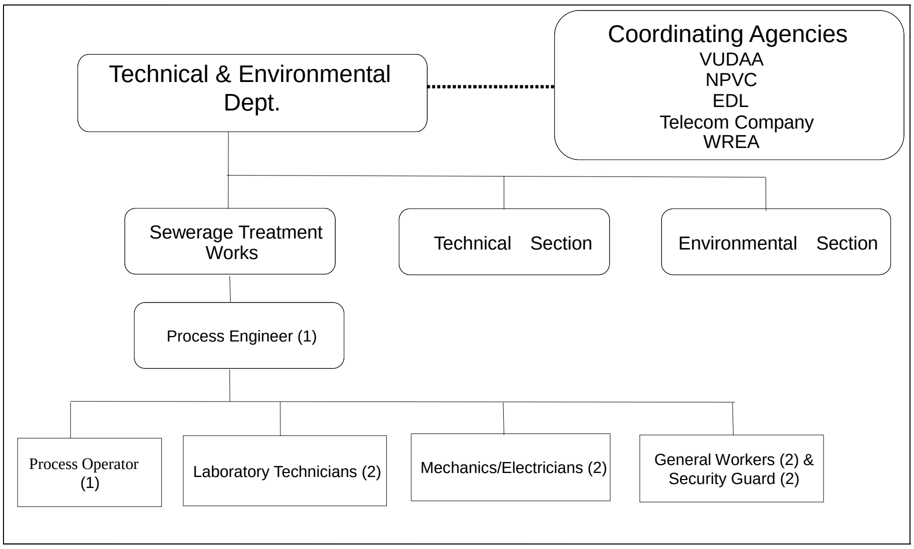
Source: Effluent Standard of MOIC, * Standard For Wastewater Treatment of WREA

(6) O&M Plan

1) Centralized Sewerage Treatment System

The following institutional aspects are taken into account to reinforce the project implementation organization and establish the O&M mechanism in Vientiane Industrial Park Authority-Management Office (VIPA-MO) for the centralized sewerage treatment system in VIP. Sewerage Treatment Works is formed in addition to the Technical Section as shown in Figure 3.8.7 for concentrating on the O&M of the sewerage treatment plant. Regular patrolling and sweeping of wastewater collection sewers are conducted by the technical section on a routine basis. Main activities of the Sewerage Treatment Works are:

- Operation of the sewerage treatment plant, laboratory, relay pumping station and their maintenance;
- Regular water quality analysis for proper plant operation and inspection of wastewater quality discharged from tenants;
- Seasonal maintenance and rehabilitation of sewer lines, etc.; and
- Regular measurement and monitoring of water quality and flow discharge.



Source: JICA Survey Team

Figure 3.8.7: Structure of O&M Section

For O&M of all facilities related to the centralized sewerage treatment system, 10 staffs that include a process engineer, four technicians, and four workers will be required as shown in Table 3.8.11.

Table 3.8.11: Required Staff Members for O&M

Position	Number of Stuff
Process Engineer	1
Process Operator	1
Mechanic	1
Electrician	1
Laboratory Technicians	2
General Workers	2
Security Guards	2
Total	10

Source: JICA Study Team

O&M of the centralized sewerage treatment system is recommended to be executed independently from other infrastructure. For the centralized sewerage project, the ratio of annual O&M cost to the direct construction cost of sewer system and sewerage treatment plant is proposed to be 0.7% and 2%, respectively. Annual O&M cost of about LAK3.91 billion per year (equivalent to JPY41 million) has been estimated for the centralized sewerage treatment system. In general, in most developed countries, O&M cost for a centralized sewerage system is recovered through beneficiaries. Thus, to secure O&M cost, the sewerage levy-based system shall be established prior to implementation of the centralized sewerage system. It is recommended that sewer charges by means of prorating the O&M cost to the development area should be collected from tenants.

Since operational control of the centralized sewerage treatment system requires frequent sampling and laboratory analysis, O&M equipment are procured and secured for the proper functioning of the centralized sewerage treatment system as listed in Table 3.8.12.

Table 3.8.12: O&M Equipment

No	Items	Unit	Quantity
1	Multi water qualities monitor (pH, ORP, Water Depth, Conductivity, Temperature, Turbidity)	Set	1
2	Potable DO meter	Unit	1
3	pH meter	Unit	1
4	Electric conductivity meter	Unit	1
5	COD concentration analyzer	Unit	1
6	BOD analyzer	Unit	1
7	MLSS/Sludge-liquid interface meter	Unit	1
8	NPK analyzer	Unit	1
9	Scum thickness measure	Unit	1
10	Sludge thickness measure	Unit	1
11	Sludge sedimentation test graduate cylinder	Unit	1
12	Multi temperature control cabinet	Set	1
13	Sampler	L.S.	1
14	Laboratory equipment	L.S.	1
15	Reagents for 6 month use	L.S.	1
16	Computer & Printer	Set	1
17	Miscellaneous (Vacuum filter, etc.)	L.S.	1

Source: JICA Survey Team

2) Individual Sewerage Treatment System

In the individual sewerage treatment system, wastewater is treated by tenants and treated wastewater is discharged through the storm water drainage system through inspection and water sampling pit. O&M of the individual sewerage system is recommended to be executed together with the drainage system and road network. For O&M of all facilities related to road network, drainage, and sewerage, 14 staffs that include a chief engineer, a technician and 10 workers will be required as described in Section 3.6.2. Although the annual O&M cost for the drainage and sewerage systems has been estimated at about LAK294 million per year (equivalent to JPY3.1 million), a sewerage portion of annual O&M cost has been found to be LAK100,000. The O&M cost for drainage and sewerage system shall be levied from each tenant as part of management charge for the whole area of VIP.

Sampling and laboratory analysis that are conducted by tenants and VIPA-MO shall be required to monitor adequate function of individual treatment plant of each tenant. It is recommended that the seasonal sampling and analysis will be conducted by outsourcing the parameters of effluent standard for VIP as indicated in Table 3.8.10. Meanwhile, regular sampling and water quality test will be executed by VIPA-MO using potable measures for simple parameters as shown in Table 3.8.13.

Table 3.8.13: Water Quality Test Equipment

	Item	Number
a)	Multi water qualities monitor (pH, ORP, Water Depth, Conductivity, Temperature, Turbidity)	1 set
b)	Potable DO meter	1 set
c)	Sampler	1 set

Source: JICA Survey Team

(7) Conclusion and Recommendations

1) Conclusion

Table 3.8.4 presents the results of the comparison between the centralized sewerage treatment system and the individual sewerage treatment system from the aspects of required facilities, construction cost, and O&M expenses. Compared with the costs of the individual system, a huge amount of initial cost and O&M expenses are required for adopting the centralized system.

Table 3.8.14: Construction Cost and O&M Expenses of Centralized and Individual Systems

Parameter	Centralized Treatment System	Individual Treatment System
1) Summary of Planned Facilities		
Sewer	11.1 km	0.3 km
Wastewater Treatment Plant	1 unit	None
2) Construction Rough Cost		
Sewer	JPY172 million	JPY22 million
Wastewater Treatment Plant	JPY2.01 billion	-
Total	JPY2.18 billion	JPY22 million
3) Annual O&M Expenses		
Sewer	LAK120 million	LAK10 million
Wastewater Treatment Plant	LAK3.8 billion	-
Total	LAK3.92 billion	LAK10 million

Source: JICA Survey Team

For wastewater management in VIP, it is concluded that the individual sewerage treatment system should be adopted due to the following reasons:

i) It is risky to adopt the centralized sewerage treatment system with WWTP in VIP since the Lao PDR lacks sufficient experience and expertise for O&M of the public sewerage system with final WWTP.

ii) Larger construction cost and O&M expenses are necessary for the centralized sewerage treatment system. Moreover, long-term training is required for technology transfer regarding the proper execution of O&M of WWTP.

iii) It is considered that the centralized sewerage treatment system should be introduced gradually on the initiative of the Government of the Lao PDR as the public sewerage system relies heavily on the technology capacity available in an agency responsible for O&M of WWTP.

iv) In case the individual sewerage treatment system is applied in VIP, sewerage management is conducted easily and definitely by tenants. Tenants have sufficient know-how to treat their own industrial wastewater and manage treatment facilities.

v) Therefore, the individual sewerage treatment system is acceptable and proposed for sewerage management in VIP.

2) Recommendations

For the implementation of the proposed individual sewerage treatment plan, the following measures are recommended:

a) Structural Measures

- The combined type septic tank is recommended for domestic wastewater treatment at industrial area and residential area in VIP.
- Inspection and water sampling pits should be installed at each tenant to monitor treated wastewater quality.

b) Non-Structural Measures

- O&M of sewer facilities for the individual sewerage treatment system in VIP will be conducted by VIPA-MO.
- The monitoring system of treated wastewater quality shall be established adequately and promptly by VIPA-MO to ensure the reliability of the individual sewerage treatment system.