H.3 Water Balance Study

H.3.1 Water Resources Potential

H.3.1.1 Surface Water Resources Potential

(1) General

Water resources potential in a quasi-natural condition is firstly evaluated using the simulated runoff. The usable water in a stable manner through a year is often limited and is basically determined by the low flow regime in dry season. The regulation of flow by storage dams would increase the usable flow in a stable manner drastically. The usable water volume by the existing and proposed storage dams is then evaluated, considering rather simple water balance for the storage sites. The increment of the usable water volume in a stable manner is regarded as the increase of surface water potential by the storage dams.

(2) Surface Water Resources Potential in Quasi-Natural Flow Condition

As one of criteria to represent surface water potential, a dependable flow has long been employed in NWRB. The dependable flow is defined as the flow, which possesses the probability of exceedence of 80% in a flow duration curve under a quasi-natural flow condition.

In addition to this criterion, the following criteria are also considered in the present study.

- Probable annual average discharge
- Probable minimum monthly discharge

The annual average discharge represents the possible maximum water volume to be utilized in a stable manner when there is enough storage capacity to fully regulate the flow condition. On the other hand, the minimum monthly discharge represents the possible water volume to be utilized in a stable manner through a year in a quasi-natural flow condition without regulation of the flow.

In the present study, based on the simulated runoff for the last 50 years (1958 -2007) described in *Sector Report A: Topography and Meteo-hydrology*, the surface water potential in a quasi-natural flow condition is evaluated. The simulated runoff is monthly basis. The dependable flow is approximated by the computed one by the simulated monthly discharge as a first order approximation. The probable annual average discharge and the probable minimum monthly discharge are also computed by the simulated monthly discharge.

Table H.3.1.1 summarizes the estimated surface water resources potential at representative control points as well as the total in the study area. The control points have been set at the boundary of the delineated water balance catchment, referring confluence of major tributaries, major intake points and major storage dams (see Annex-F H.3.1.1). The control points are shown in Annex-T H.3.1.1 and Annex-F H.3.1.2. The surface water resources potential at other control points is listed in Annex-T H.3.1.2.

Table H. 3.1.1 Summary of Surface Water Resources Potential in Quasi-Natural Condition

Control Point*	Probable Annual Average Discharge			Probable Minimum Monthly Discharge			Dependable flow
	1/2years	1/5years	1/10years	1/2years	1/5years	1/10years	
P1 (Pampanga River) (m^3/s)	279.05	201.02	179.32	24.76	17.05	15.60	39.55
A1 (Angat River) (m^3/s)	71.01	59.30	55.92	7.56	4.80	3.76	19.31
S1 (Pasac River) (m^3/s)	37.57	28.01	26.51	18.45	14.79	12.53	19.91
Total in the study area (m^3/s)	399.17	296.49	268.61	52.19	37.62	32.63	80.45
Total in the study area (MCM/year)	12,588	9,350	8,471	1,646	1,186	1,029	2,537

Note: The control points are as shown in Annex-T H.3.1.1 and Annex-F H.3.1.2.
Source: JICA Study Team

(3) Existing Large Storage Dams

There exist the following two large storage dams in the study area.

- Angat storage dam (V_{eff} =894MCM)
- Pantabangan storage dam (V_{eff} =2,775MCM)

The details for these existing storage dams are described in Chapter H.2.3.

(4) Proposed Large Storage Dams

The following proposed storage dams are considered as candidate sites for future water resources development with at least a pre-feasibility study.

- Bayabas storage dam (V_{eff} =144MCM)
- Maasim storage dam (V_{eff} =95MCM)
- Balintingon storage dam (V_{eff} =488MCM)
- Gumain storage dam (V_{eff} =99MCM)
- Balog-Balog storage dam (V_{eff} =575MCM)

The details for these proposed storage dams are described in Chapter H.2.3.

(5) Surface Water Resources Potential with Existing and Proposed Large Storage Dams

The incremental surface water resources potential by the existing and proposed large storage dams is evaluated by analyzing water balance at the storage dam sites as below.

(a) The inflow and storage capacity is firstly given. By changing the constant demand through a year, temporal change in storage volume is then computed. Number of occurrence of zero storage during the simulated period is counted to check the safety level for satisfying the given demand.

(b) Duration of the simulation is 50 years (1958 - 2007).

(c) The inflow is given by combination of the observed and generated ones. When the observed inflow is available, it is used. The generated runoff for the storage dam sites by the calibrated rainfall-runoff model described in *Sector Report A: Topography and Meteo-hydrology* is supplemented to the observed data.

(d) The inflow by trans-basin water transfer is given as follows.

- The monthly inflow pattern is assumed using the available observed data. The same pattern is applied for each year.
- The expected additional inflow by completing the remained intakes in Umiray-Angat trans-basin scheme is estimated by area ratio between the catchment for the existing intake and that for the remained intakes.

(e) The loss is taken into account for the water balance of the storage dams. The loss for the existing storage dams is estimated by the observed water balance data. For the proposed storage dams, the unit loss (loss per water surface area) is assumed to be same as the one in Angat storage dam.

The results of the evaluation are summarized in the following tables.

Table H. 3.1.2 Surface Water Resources Potential for Existing Storage Dams

Existing storage dam	Average Inflow		Potential with safety level of 1/5years (80% reliability)		Potential with safety level of 1/10years (90% reliability)	
	(m^3/s)	(MCM/year)	(m^3/s)	(MCM/year)	(m^3/s)	(MCM/year)
Angat	58.8	1,854	50.9	1,605	49.4	1,558
Angat + Umiray (existing)	70.5	2,223	62.1	1,958	60.4	1,905
Angat + Umiray (existing +Sumag)	72.8	2,296	64.3	2,028	62.5	1,971
Pantabangan (incl.Aurola trans-basin)	37.3	1,176	37.0	1,167	35.4	1,116
Pantabangan (incl.Aurola trans-basin) + Casecnan	61.1	1,927	61.1	1,927	59.0	1,861

Source: JICA Study Team

Table H. 3.1.3 Surface Water Resources Potential for Proposed Storage Dams

Proposed storage dam	Average Inflow		Potential with safety level of 1/5years (80% reliability)		Potential with safety level of 1/10years (90% reliability)	
	(m^3/s)	(MCM/year)	(m^3/s)	(MCM/year)	(m^3/s)	(MCM/year)
Bayabas	3.1	98	3.1	98	3.1	98
Maasim	2.5	79	2.5	79	2.4	76
Balintingon	18.0	568	18.0	568	17.8	561
Gumain	8.1	254	6.5	205	5.1	161
Balog-Balog	19.9	628	19.0	599	18.5	583

Source: JICA Study Team

The surface water resources potential with increment by the storage dams at the representative control points as well as the total in the study area is summarized in Table H.3.1.4. In the table, the water resources potential that is equivalent to 80% reliability is shown as one of representative parameters. The surface water resources potential at other control points is listed in Annex-T H.3.1.3 and shown in Annex-F H.3.1.3.

Table H. 3.1.4 Summary of Surface Water Resources Potential (Equivalent to 80% Reliability) with Existing and Proposed Storage Dams

Control Points*	Qausi-natural**	with Existing storage dams w/o trans-basin	with Existing storage dams with trans-basin	with Existing storage dams + Proposed storage dams
P1 (Pampanga River) (m^3/s)	39.6	71.5	95.6	111.6
A1 (Angat River) (m^3/s)	19.3	53.2	64.4	69.6
S1 (Pasac River) (m^3/s)	19.9	19.9	19.9	23.5
T2 (Tarlac River) (m^3/s)***	2.4	2.4	2.4	20.0
Total in the study area (m^3/s)	**84.1**	**149.9**	**185.2**	**227.6**
Total in the study area (MCM/year)	2,652	4,728	5,842	7,178

Note: * The control points are as shown in Annex-T H.3.1.1 and Annex-F H.3.1.2.
** Water resources potential in quasi-natural condition is assumed to be represented by the estimated dependable flow.
*** Water resources potential in Tarlac River is included in computing the total in the study area.
Source: JICA Study Team

It should be noted that the potential is evaluated by assuming constant demand through a year and no return flow from used water. It can be used for over viewing how much water volume could be approximately usable in a stable manner. Detail water balance with considering the demand pattern in a year and the return flow is further discussed in Chapter H.3.3.

H.3.1.2 Groundwater Resources Potential

(1) General

NWRC has examined the groundwater resources potential in a nationwide scale in 1982[32)]. The aquifer condition was investigated for each province, and both safe yield and mining yield have been determined. According to the unpublished report by NWRC in 1982, the safe and mining yields were defined and determined as follows.

- **Safe yield** is possible abstraction volume in unit time with sustainable manner in terms of groundwater aquifer. In the report, it is determined under the assumption that the safe yield is equal to total inflow to groundwater aquifer. In the provinces of Bulacan, Pampanga, Nueva Ecija and Tarlac, the total inflow was calculated as 23% of long-term average annual total precipitation. It should be noted that even when the abstraction of groundwater is less than the safe yields, surface flow in a river channel could be affected somehow.
- **Mining yield** is safe yield plus abstraction volume in unit time with consuming the existing water in aquifers. The existing volume of water in aquifers was determined by geological survey. According to the Implementing Rules and Regulations of the Philippines Water Code, fifty-year (50- year) groundwater mining is allowed (Section 46). This means that the periods of exhaustion of the aquifers could be 50 years and the corresponding amount of water to be withdrawn is the groundwater mining yield.

The water use permits have been issued basically based on the above-mentioned safe and mining yields in NWRB. The area in the province is divided into several sub-areas by type of aquifers as shown in Annex-F H.3.1.4. For each sub-area, the safe and mining yield has been determined. Table H.3.1.5 summarizes the safe and mining yields by NWRC in 1982 for provinces of Bulacan, Pampanga, Nueva Ecija and Tarlac.

It should be noted that the annual total precipitation used for the calculation seems to be 3,000mm/year and this is obviously too large as the average precipitation in Pampanga river basin. The safe yield could be about 2/3 of the estimated values by NWRC if the average precipitation of 2,100mm/year is used with same recharge rate of 23%.

Table H. 3.1.5 Safe and Mining Yields by NWRC

Province	Category	Sub-area	Safe Yield[*1] (mm/year)	Mining Yield[*1] (mm/year)	(Mining Yield - Safe Yield)[*1] (mm/year)	Estimated ratio of restricted area for groundwater usage in terms of aquifer condition[*2]
Bulacan	A	1	690	1,138	448	0.000
	B	2	300	570	270	0.565
	C	3	No sufficient data			1.000
	S	SWEA	No evaluation			0.000[*3]
Pampanga	A	1	690	1,195	505	0.000
	B		(No category)			
	C	2	No sufficient data			1.000
	S	SWEA	No evaluation			0.000[*4]
Nueva Ecija	A	3	690	1,072	382	0.000
	B	2	450	655	295	0.348
	C	1	150	344	194	0.783
Tarlac	A	1	690	1,414	724	0.000
	B	2	315	676	362	0.544
	C	3	No sufficient data			1.000

Note: SWEA = Salt-Water Encroached Area

Source: *1 - NWRC, Unpublished documents, 1982 (Unit is converted to mm/year by JICA Study Team),
*2 - Estimated by JICA Study Team based on the safe yield determined by NWRC
*3 - It is assumed that the aquifer condition is similar to that in Sub-area 1 of the province of Bulacan
*4 - It is assumed that the aquifer condition is similar to that in Sub-area 1 of the province of Pampanga

Considering the sustainable usage of groundwater, the groundwater resources potential should be less than the safe yield defined in the above. The mining yield should be restricted to be minimal to avoid consuming water in aquifers.

In the present study, the safe yield is firstly evaluated by expected recharge volume of groundwater. Then, the following constraints for groundwater abstraction are also considered when the groundwater resources potential is evaluated.

- Restriction by general aquifer condition (productivity of aquifer)
- Restriction by water quality (saltwater intrusion etc.) and others

(2) Recharge of Groundwater

There are basically two methods to estimate recharge of groundwater as follows.

- Water Balance Method
- Empirical Method

The water balance method usually requires detailed meteorological, hydrological and hydrogeological data. On the other hand, the empirical method requires much less data, assuming empirical recharge rate. In the empirical method, previous experiences on water balance studies and/or investigations are utilized. Examples of recharge rate against annual total precipitation in previous studies are shown in Table H.3.1.6.

Table H. 3.1.6 Empirical Groundwater Recharge Rate

Recharge rate	Natural Condition	Source
10%	Alluvium, Tertiary, Older rocks	- Groundwater in the Philippines (1980) - Framework Plans of 41 Major River Basins (1979-1983)
5.1-6.1%	Alluvium. Fine material	The Groundwater Development in Metro Manila, 1992 (computer simulation)
3.9%	Alluvium Fine material	The Groundwater Development in Cavite Province, 1996.
5%	Alluvium, Tertiary, Older rocks	M/P Study on Water Resources Management in ROP, Final Report, Vol. III-1, Supporting Report (Groundwater), JICA Study 1998.
16.3%	Alluvium. Lahar	Groundwater Flow and Recharge in Lahar Disaster Area, Pasig-Potrero and Porac River Basins, by S. Hiraide, J.D. Rondal etal, 2004.
10-15%	Alluvium	Groundwater Evaluation & Well Inventory of Concepcion Tarlac, by Rick Rodollc. Luis & Clarissa G. Villanueva MGB-III Apr. 14, 2008.
23%	Alluvium	Unpublished Report for Groundwater Potential in the provinces of Bulacan, Pampanga, Nueva Ecija, Tarlac by NWRB, 1982
8-15%	Temperate climate	JICA study. Bulgaria, Mongolia
10-20%	Mediterranean climate	
8%: Tailand 23%: Japan	Paddy field	Recharging to groundwater from paddy field by K. Yamamoto, Tokyo University.

In the present study, the long-term rainfall-runoff simulation discussed in *Sector Report A: Topography and Meteo-hydrology* would be utilized for estimating recharge of groundwater, which is somehow between the empirical method and water balance method. The estimated annual total recharge for each sub-basin is presented in Table H.3.1.7. The recharge rate against annual total precipitation is also shown in the table.

The estimated recharge rate for each sub-basin ranges from 5 to 27%. The average recharge rate for the entire study area is estimated at 12%. It is in general reasonable compared to the past applied empirical recharge rate in several different studies and documents. The sub-basins located mostly in flat area, in which good aquifers exist, tends to have smaller recharge rate. Considering that there are many uncertain factors in estimating the recharge of groundwater, it is proposed to apply two criteria for estimating the recharge of groundwater in the present study as follows; 1) the average recharge rate of 12%, and 2) the most conservative recharge rate of 5%. The estimated recharge of groundwater for each city/municipality is presented in Annex-T H.3.1.4.

Table H. 3.1.7 Estimated Annual Total Recharge for Each Sub-Basin

Sub-basin	Area (km^2)	Annual Total Precipitation (mm/year)	Annual Total PET (mm/y)	Annual Total Runoff (mm/year)	Annual Total Recharge (mm/year)	Recharge Rate (%)
PAM01	159	1,750	1,415	955	80	5
PAM02	1,517	1,838	1,367	992	101	6
PAM03	40	1,530	1,393	723	88	6
PAM04	799	1,752	1,365	950	90	5
PAM05	437	2,049	1,262	1,045	449	22
PAN01	849	2,222	1,186	1,247	532	24
RCH01	2,895	1,960	1,354	1,155	123	6
PEN01	570	2,678	1,256	1,743	296	11
COR01	712	2,494	1,197	1,482	621	25
ANG01	194	1,818	1,411	905	94	5
ANG02	346	2,453	1,308	1,508	120	5
ANG03	546	4,430	1,173	3,380	225	5
PAS01	1,234	2,126	1,358	999	565	27
Total	10,435	2,187	1,315	1,271	270	12

Note: Data show average values in 1958 -2007.
Source: JICA Study Team

(3) Restrictions of Groundwater Abstraction

(a) Restriction by general aquifer condition (productivity of aquifer)

In the unpublished documents on the estimation of safe and mining yields by NWRC, a territory of province is divided into several sub-areas based upon the condition of aquifers, which reflects the hydrogeological conditions. The estimated safe yield is different for each sub-area, presumably reflecting the hydrogeological condition in each sub-area. From the difference of the safe yield for each sub-basin, the ratio of the restricted area for groundwater usage in terms of general aquifer condition is estimated and shown in Table H.3.1.5. The ratio for each municipality and city is also calculated and presented in Annex-T H.3.1.4. This ratio is employed for estimation of the groundwater resources potential.

(b) Restriction by water quality (saltwater intrusion etc.) and others

As have discussed in *Sector Report F: Water-related Environmental Management*, the area with salinity intrusion extends widely in the coastal zone in the provinces of Bulacan and Pampanga. In the unpublished documents on the estimation of safe and mining yields by NWRC, the salt-water encroached area was identified and the safe and mining yields were not evaluated in such area. This means that the groundwater resources potential is restricted there.

The possible land-subsidence area also extends in the province of Pampanga based on available information as discussed in *Sector Report A: Topography and Meteo-hydrology*. It almost coincides with the possible salinity water affected area. It is recommended that the usage of the groundwater in such area be restricted also to avoid further land-subsidence.

In the present study, the salt-water encroached area identified by NWRC is tentatively regarded as the restricted area for groundwater usage in terms of the possible salinity water intrusion for the discussion of groundwater resources potential. The ratio of the restricted area in terms of salinity water intrusion for each municipality and city, based on the salt-water encroached area identified by NWRC, is presented in Annex-T H.3.1.4. This ratio is employed when the restricted area for groundwater usage in terms of the possible salinity water intrusion is taken into account for the evaluation of groundwater resources potential.

(4) Groundwater Resources Potential

The groundwater resources potential is basically evaluated by the recharge of groundwater from view point of sustainable usage. In addition, the restrictions of the groundwater abstraction are considered. The followings are defined in the present study.

- **GWP**

  Groundwater resources potential without considering restricted area by possible salt-water intrusion, which can be estimated as follows.

  $$GWP = GWR \cdot (1 - R_a)$$

  where GWR = recharge of groundwater, R_a = ratio of restricted area for groundwater usage in terms of general aquifer condition.

- **SWE**

  Part of groundwater resources potential which may be affected by possible salt-water intrusion, which can be estimated as follows.

  $$SWE = GWR \cdot R_S$$

  where GWR = recharge of groundwater, R_s = ratio of restricted area for groundwater usage in terms of possible salt-water intrusion.

Because it is difficult to know the groundwater recharge rate, it is decided to set two different criteria for the GWP and SWE.

- **GWP-H & SWE-H**

  GWP & SWE for which groundwater recharge rate is assumed to be 12% of average annual precipitation. The 12% is the average value in the entire study area based on the result of rainfall-runoff model in the present study.

- **GWP-L & SWE-L**

  GWP & SWE for which groundwater recharge rate is assumed to be 5% of average annual precipitation. The 5% is the minimum value in the entire study area based on the result of rainfall-runoff model in the present study.

The estimated groundwater resources potential is summarized in Table H.3.1.8. The estimated groundwater resources potential for each municipality and city is shown in Annex-T H.3.1.4.

Table H. 3.1.8 Summary of Estimated Groundwater Resources Potential

	GWP-H (MCM/year)	GWP-L (MCM/year)	SWE-H (MCM/year)	SWE-L (MCM/year)
Bulacan	247	103	56	23
Nueva Ecija	733	305	0	0
Pampanga	364	152	70	29
Tarlac	132	55	0	0
Total	1,476	615	126	52

Note: Inside the study area only
Source: JICA Study Team

H.3.2 Water Demand Projection

H.3.2.1 General

In the present section, the present water demand and future water demand at 2025 are estimated based on the available information collected during the course of the study. The projected water demand at 2025 would be utilized for discussing possible future water balance in the study area as a basis for formulating the IWRM plan in the study area.

In order to simplify the water demand projection, the water demand projection has been conducted for the following categories.

- Municipal water demand
- Industrial water demand
- Irrigation water demand
- Other water demands

The category of the municipal water demand in the present study basically includes the following type of water use defined by Water Code; domestic, municipal. The commercial and light industrial water demand, which may be provided by water providers and may not be granted as industrial purpose in the water permit issued by NWRB, is included in the category of the municipal water demand.

The category of the industrial water demand is assumed to consist of the water demands by the industries which have own production wells or intake facilities and are thereby separated from the category of the municipal water demand. After evaluating the future water balance, it could be necessary to be provided by bulk water supply system, however.

The water demand for the power generation in the study area is rather passive demand, because the water use for the hydropower generation in the study area is allowed only when other beneficial water uses require the release of water or NWRB agrees the release of water case by case. The water demand projection for the power generation is not conducted.

The category of the other water demands in the present study consists of the following type of water use defined by Water Code; fisheries, livestock, recreational and other purposes. The fisheries and livestock water demands are separately estimated. The water demands for recreational and other purposes are included in the municipal water demand as a fixed percentage of it for simplicity.

The water demand projection has been conducted for spatially separated units with certain scale in order to examine the water balance in the study area. For the water demand with groundwater sources, the municipality and/or city is selected as the minimum unit for the water demand projection, because the current main user of groundwater resources is public water providers whose unit is basically municipality and/or city. For the water demand with surface water, the water balance catchment shown in Annex-F H.3.1.1 is selected as the unit, considering the surface water movement with current and future possible major abstraction points as well as natural drainage system.

H.3.2.2 Municipal Water Demand

MWSS has projected that any additional water volume other than the present granted water supply volume ($46m^3/s$) would be no longer required to the water source in the study area. However, the proposed Bulacan Treated Bulk Water Supply Project assumes abstraction of $2.7m^3/s$ and the most possible water source of it is from Angat-Umiray system. The future municipal water demand from Angat-Umiray system is expected to be $48.7m^3/s$ in total.

On the other hand, the municipal water demand to the groundwater in the study area would increase due to population growth, rise in living standard, increment of economic products and other various socio-economic factors. Accordingly the municipal use within the study area is the major concern on the water demand projection and, its demand projection was made based on the present and future population, service ratio, unit water demand and unaccounted water demand. The details for municipal water demand projection is described in *Sector Report D: Municipal Water Supply, Sanitation and Sewerage System Management.* The main assumptions and parameters used are as follows.

- Population

  Population growth projection by NSCB is applied.

- Service Ratio and Served Population

Based on the target set until 2025, service ratio and served population for Level 1, 2, 3 water supply system is estimated.

- Unit Water Demand

The unit water demand is set as shown in the following table.

Table H. 3.2.1 Present and Projected Unit Water Demand

(unit: liter/day/person)

	Present as of 2008			Projected in 2015			Projected in 2025		
	Level 3	Level 2	Level 1	Level 3	Level 2	Level 1	Level 3	Level 2	Level 1
Urban	120	60	60	129	64	64	142	71	71
Rural	100	50	50	107	54	54	118	60	60

Source: JICA Study Team

- Unaccounted Water and Others

The unaccounted water is assumed as shown in the following table.

Table H. 3.2.2 Unaccounted Water

(unit: %)

	Present as of 2008			Projected in 2015			Projected in 2025		
	Level 3	Level 2	Level 1	Level 3	Level 2	Level 1	Level 3	Level 2	Level 1
Urban & Rural	30	30	0	25	25	0	20	20	0

Source: JICA Study Team

The non-domestic water use such as commercial, light industrial, recreational and other purposes water demand was, further, assumed at 10% of the municipal demand for Level 3 water supply systems. Then, the total is expressed as the municipal water demand in the present study.

The estimated municipal water demand is shown in Annex-T H.3.2.1 and summarized as below:

Table H. 3.2.3 Summary of Present and Projected Municipal Water Demand in the Study Area

Province		Present as of 2008	Projected in 2015	Projected in 2025
Bulacan (m^3/day)	Urban	124,909	157,582	219,368
	Rural	42,594	51,905	67,501
Neva Ecija (m^3/day)	Urban	119,317	142,124	190,175
	Rural	59,097	68,605	83,373
Pampanga (m^3/day)	Urban	206,806	248,968	332,190
	Rural	45,004	53,209	65,928
Tarlac (m^3/day)	Urban	29,123	34,588	43,806
	Rural	15,041	18,001	22,500
Total (m^3/day)	Urban	480,155	583,262	719,998
	Rural	161,736	191,720	239,301
Total (m^3/day)		641,891	774,982	1,024,841
Total (m^3/s)		7.429	8.970	11.862
Total (MCM/year)		234	283	374

Note: Inside the study area only
Source: JICA Study Team

H.3.2.3 Industrial Water Demand

The industrial water demand is preliminary estimated based on the granted water permit as follows.

- The present water demand is assumed to be equal to the currently granted water quantity.
- The future water demand is projected by assuming that the increasing rate of the demand is proportional to the increasing rate of GRDP of industrial sector in Region III. The proportional coefficient is assumed to be 0.132, based on the relationship between the average increasing rate for the total water right for industrial water use in Philippines and that for GDP of industrial sector in Philippines in the last five years, according to the statistical data by

NSCB[33]. It is also observed that the annual increasing rate of the GRDP of industrial sector in Region III in the last five years is 9.0%/year in average, according to the statistical data by NSCB. The increasing rate of industrial water demand is therefore set at 1.2%/year.

The estimated industrial water demand in the study area is summarized in the following table. The water demand by spatially separated units for surface water and groundwater are presented in Annex-T H.3.2.2 and H.3.2.3, respectively.

Table H. 3.2.4 Summary of Estimated Industrial Water Demand

Water Sources	Present Water Demand (2008)		Future Water Demand (2025)	
	(m^3/s)	(MCM/year)	(m^3/s)	(MCM/year)
Surface water	0.116	3.7	0.142	4.5
Groundwater	1.149	36.2	1.407	44.4
Total	1.265	39.9	1.549	48.9

Source: JICA Study Team

H.3.2.4 Irrigation Water Demand

The irrigation water demand has been preliminarily estimated for the water balance analysis of Pampanga river basin both for existing and future firm-up service area. For NISs whose water source is surface water, the data on the firm-up service area are taken from information given by NIA, and the water demands have been estimated at their intake points, while the estimated water demands for CISs whose water source is surface water are summed up in the water balance catchment shown in Annex-F H.3.1.1. The irrigation water demands are determined on the average at monthly basis. The details for irrigation water demand estimation is described in *Sector Report C: Agricultural and Fishery Water Management.*

(1) Present Irrigation Water Demand

The existing NISs whose water source is surface water are schematically shown in Annex-F H.3.2.1. The estimated net diversion water demands at each intake point are summarized in Table H.3.2.5.

Table H. 3.2.5 Estimated Net Diversion Water Demands for Existing NISs

Irrigation System	Intake Point	River	Net Diversion Water Requirement (m^3/s)											
			Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec
UPRIIS, Div-I	Talavera Dam	Talavera	2.1	2.3	0.7	0.0	0.1	2.0	2.0	0.6	0.7	1.9	1.6	1.6
UPRIIS, Div-I,II, V	Rizal Dam	Pampanga	68.4	78.9	66.4	21.0	2.0	38.0	29.5	8.0	9.5	21.0	38.0	60.9
UPRIIS, Div-III, IV	Bongabon Dam	Pampanga	30.3	34.4	25.0	4.5	5.9	22.5	8.5	4.0	4.7	8.9	18.0	26.1
Aulo	Aulo SRIP	Aulo	1.1	1.2	0.6	0.0	0.2	0.7	0.3	0.1	0.2	0.4	0.7	0.9
UPRIIS, Div-IV	Penaranda Dam	Penaranda	25.0	27.1	15.3	0.0	4.2	16.4	6.1	3.4	3.8	9.9	17.0	20.3
PDRIS	Cong Dadong Dam	Pampanga	8.7	9.4	5.3	0.0	1.5	5.7	2.1	1.2	1.3	3.4	5.9	7.0
AMRIS	Bustos Dam	Angat	41.3	41.7	32.2	9.7	0.0	25.5	9.9	1.2	5.4	10.1	18.8	34.2
TASMORIS	Tarlac Dam	Tarlac	5.3	6.1	5.1	1.6	0.2	3.5	2.1	0.6	0.8	1.6	2.7	4.8
TASMORIS	Smoris Dam	O'Donnel	0.3	0.3	0.3	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.1	0.2
Porac-Gumain	Porac Dam	Porac	1.0	1.2	1.0	0.3	0.0	0.7	0.4	0.1	0.1	0.3	0.5	0.9
Porac-Gumain	Solib Dam	Porac	0.9	1.1	0.9	0.3	0.0	0.6	0.4	0.1	0.1	0.3	0.5	0.8
Porac-Gumain	Gumain Dam	Gumain	2.2	2.5	2.1	0.7	0.1	1.4	0.8	0.3	0.3	0.7	1.1	2.0

Source : JICA Study Team

The estimated water demand for the existing CISs and small scale irrigations under BSWM in each water balance catchment is shown in Annex-T H.3.2.4, and is summarized in Table H.3.2.6.

Table H. 3.2.6 Estimated Total Water Demands for Existing CISs and Small Scale Irrigations

	Diversion Water Requirement (m^3/s)											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec
Total Water Demand	31.60	34.25	19.30	0.00	7.73	30.27	11.25	6.34	7.02	18.28	21.48	25.58

Source : JICA Study Team

(2) Projected Irrigation Water Demand

The projected future NISs, whose water source is surface water in addition to the existing NISs, is schematically shown in Annex-F H.3.2.2. The estimated net diversion water demand at each intake point for the future NISs are summarized in Table H.3.2.7.

Table H. 3.2.7 Estimated Net Diversion Water Demands for Projected Future NISs

Irrigation System	Intake Point	River	Net Diversion Water Requirement (m^3/s)											
			Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec
UPRIIS, Div-I	Talavera Dam	Talavera	2.1	2.3	0.7	0.0	0.1	2.0	2.0	0.6	0.7	1.9	1.6	1.6
UPRIIS, Div-I,II, V	Rizal Dam	Pampanga	93.3	107.6	90.6	28.6	2.7	51.8	40.2	10.9	12.9	28.6	51.8	83.1
UPRIIS, Div-III	Bongabon Dam	Pampanga	30.3	34.4	25.0	4.5	5.9	22.5	8.5	4.0	4.7	8.9	18.0	26.1
Aulo	Aulo SRIP	Aulo	1.1	1.2	0.6	0.0	0.2	0.7	0.3	0.1	0.2	0.4	0.7	0.9
Balintingon	Balintingon Dam	Penaranda	19.5	21.2	11.9	0.0	3.3	12.8	4.8	2.7	3.0	7.7	13.3	15.8
UPRIIS, Div-IV	Penaranda Dam	Penaranda	25.0	27.1	15.3	0.0	4.2	16.4	6.1	3.4	3.8	9.9	17.0	20.3
PDRIS	Cong Dadong Dam	Pampanga	8.7	9.4	5.3	0.0	1.5	5.7	2.1	1.2	1.3	3.4	5.9	7.0
AMRIS	Bustos Dam	Angat	41.3	41.7	32.2	9.7	0.0	25.5	9.9	1.2	5.4	10.1	18.8	34.2
BBMP	Balog-Balog Dam	Tarlac	52.5	50.9	21.2	6.5	14.2	24.8	16.5	12.6	7.6	14.2	45.6	45.9
Porac-Gumain	Gumain Dam	Gumain	12.9	12.9	7.6	6.3	6.7	6.2	4.3	6.0	5.3	2.8	8.8	12.5

Source: JICA Study Team

The estimated water demand for the projected future CISs and small scale irrigations under BSWM in each water balance catchment is shown in Annex-T H.3.2.5, and is summarized in Table H.3.2.8.

Table H. 3.2.8 Estimated Total Water Demands for Projected Future CISs and Small Scale Irrigations

	Diversion Water Requirement (m^3/s)											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec
Total Water Demand	41.75	45.24	25.48	0.00	10.45	40.87	15.22	8.56	9.50	24.73	28.32	33.76

Source : JICA Study Team

(3) Irrigation Water Demand for Groundwater Source

The following table summarizes the present and future irrigation water demand for groundwater source in total in the study area. The water demand by each municipality or city is listed in Annex-T H.3.2.6.

Table H. 3.2.9 Estimated Present and Future Irrigation Water Demand for Groundwater Source in the Study Area

	Average Water Requirement (m^3/s)
Present Total (2008)	0.578
Future Total (2025)	2.242

Source : JICA Study Team

H.3.2.5 Other Water Demands

(1) Fisheries Water Demand

The water demand for fisheries is estimated as follows.

- The unit water demand for fisheries which is used as standard criterion or procedure for water permit grant in NWRB is employed. Assuming that there is minimal prawn cultivation, the unit water demand of 0.9259 liter/s/ha is applied.
- The area of fish pond as well as the ratio of freshwater fish pond at present for each city/municipality is given by BFAR Region III.
- It is assumed that the area of fish pond will be kept in future.

The estimated water demand for fisheries in total in the study area is shown in the following table. The water demand by each water balance catchment is presented in Annex-T H.3.2.7. In the water balance study, water demand only for fresh water would be considered.

Table H. 3.2.10 Estimated Fisheries Water Demand in the Study Area

		Present condition (2008)	Future condition (2025)
Fish pond Area (km^2)	Brackish water	193.3	193.3
	Fresh water	68.7	68.7
Water demand (m^3/s)	Brackish water	17.9	17.9
	Fresh water	6.4	6.4
Total water demand (m^3/s)		24.3	24.3
Total water demand (MCM/year)		765	765

Source: JICA Study Team

(2) Livestock Water Demand

The water demand for livestock is estimated as follows.

- The unit water demand for livestock which is used as standard criterion or procedure for water permit grant in NWRB (0.00024 liter/s/head for cattle and swine, 0.00000146 liter/s/head for poultry) is employed.
- City/Municipality data for number of livestock are used for the present water demand.
- The increasing rate in number of livestock is assumed to be proportional to the increasing rate of the GRDP for agricultural sector in Region III. The proportional coefficient is assumed to be 0.282 for livestock and 0.151 for poultry, respectively, based on the relationship between the average increasing rate for the total number of livestock and poultry in Philippines and that for GDP of agricultural sector in Philippines in the last five years, according to the statistical data by NSCB. It is also observed that the annual increasing rate of the GRDP of agricultural sector in Region III in the last five years is 8.2%/year in average, according to the statistical data by NSCB. The increasing rate in the number is therefore set at 2.3%/year for livestock and 1.2% for poultry, respectively.

The estimated water demand for livestock in total in the study area is shown in the following table. The water demand for each municipality and city is presented in Annex-T H.3.2.8.

Table H. 3.2.11 Estimated Livestock Water Demand in the Study Area

	Present condition (2008)	Future condition (2025)
Total number of livestock (head)	1,075,245	1,582,681
Total number of poultry (head)	22,166,976	27,150,334
Water demand (m^3/s)	0.290	0.419
Water demand (MCM/year)	9.2	13.2

Source: JICA Study Team

(3) Recreational and Other Purposes Water Demands

According to the granted water use permit in the study area, these water demands are expected to be less than 5% of the actual municipal water demands. The recreational and other purposes water demands are counted as a part of the additional 10% of the municipal demand for Level 3 water supply.

H.3.2.6 Minimum Stream Flow Requirement

(1) General

Aside from the water demand shown in the previous sections, the minimum stream flow should be kept with higher priority in order to protect the environment of the water body

and/or by the other specific reasons. In this section, the required minimum stream flow is discussed as one of water demands.

According to the Water Code of the Philippines, 1978 and its Amended Implementing Rules and Regulations, 2005, it is understood that NWRB is a responsible agency to determine the minimum stream flow when it is judged to be established.

(2) Category on Methods for Determining Minimum Stream Flow

In general, the method to determine the minimum stream flow could be largely categorized as follows.

- Hydrological Method

  It is relatively simple method to determine minimum flow requirement from statistical characteristics of hydrological data. It is usually employed in a master plan level planning and/or in a preliminary study for the consequent detail study.

- Habitat Method

  Habitat condition for organisms in a river system is analyzed and necessary minimum flow as one of indispensable habitat conditions is clarified. This is relatively complicated method and requires more data and detail investigation on the organisms. It may be employed when the minimum stream flow should be determined with great care by some reasons. For example, when a conflict between environmental conservation for some species and an impact by water usage in a particular proposed project is severe, a detail study with the habitat method may be required for discussion among stakeholders.

In the present study, the overall situation in a basin-wide level would be discussed as a part of water resources management study. In this sense, rather simple method to employ hydrological data could be appropriate. It has been thus decided to employ the hydrological method to discuss the minimum stream flow in the present study. It should be noted that the minimum stream flow discussed in the present study could be used as a guide for the overall water resources planning and management. It may require more detail study before a particular project is actually implemented, however.

(3) Estimation of Minimum Stream Flow

There are many criteria for determining the minimum stream flow using hydrological method. The most famous one is the Tenant method[33)] which empirically categorizes habitat condition by percentage of long-term averaged annual mean flow. According to the Tenant Method, when river discharge becomes lower than 10% of mean annual average flow, the habitat condition in a river is deteriorated very much, which should be avoided. In the Tenant method, the minimum stream flow is thereby set at 10% of mean annual average flow. However, if one applies the original Tenant method in the study area, the minimum stream flow requirement becomes almost same order of the dependable flow, which means that only limited volume of water could be utilized in a drought condition. The original Tenant method could be applied for the environment with less precipitation and less discharge fluctuation, and may not be appropriate for Pampanga river basin, considering the balance between river environment and usage of water.

As shown in Table H.3.2.12, NWRB showed its criteria on the minimum stream flow as 10% of the dependable flow. The dependable flow is the discharge in which probability of exceedance is 80% in a flow duration curve with a quasi-natural flow condition. In the present study, this criterion is applied for estimating the minimum stream flow requirement.

Table H. 3.2.12 Minimum Stream Flow Requirement Described in Resolution No.01-0901

Resolution	Description
Resolution No.01-0901 September 24,2001 310th Board Meeting Policy of Granting the Volume of Water for Applications for Domestic Use based on the Capacity of the Well and Requiring a Minimum of Dependable Flow to be Released at All Times for the Environmental Requirement	RESOLVED, AS IT IS HEREBY RESOLVED, to grant the volume of water applied for domestic use only based on the capacity of the well. RESOLVED FURTHER, to require a minimum 10% of the dependable flow to be released at all times for the environmental requirement and protection of fisheries downstream at the point of diversion in any river system.

Note: According to NWRB, the dependable flow is usually determined as the discharge in which the probability of exceedance is 80% in a flow duration curve with quasi-natural condition.
Source: NWRB, Resolution No.01-0901, September 24, 2001

Table H.3.2.13 shows the estimated minimum stream flow at representative control points of the river system in Pampanga river basin. The quasi-natural flow condition simulated by the rainfall-runoff model is used for estimation of the minimum stream flow. The simulated runoff is monthly basis. The dependable flow is approximated by the computed one by the simulated monthly discharge as a first order approximation. The estimated minimum stream flow at other control points are presented in Annex-T H.3.2.9.

Table H. 3.2.13 Estimated Minimum Stream Flow Requirement at Representative Control Points

Control Point	Estimated Minimum Flow Requirement (10% of dependable flow)	
	(m^3/s)	(MCM/year)
P1 (Pampanga River)	4.0	126
A1 (Angat River)	1.9	60
S1 (Pasac River)	2.0	63

Source: JICA Study Team

H.3.2.7 Summary of Whole Water Demand

The whole water demands in the entire study area for the present condition and the future projected condition are summarized as shown in the following table.

Table H. 3.2.14 Estimated Whole Water Demand in the Entire Study Area

	Unit	Present Water Demand (2008)			Future Water Demand (2025)		
		SW	GW	Total	SW	GW	Total
Municipal	(m^3/s)	0.000	7.429	7.429	0.000	11.862	11.862
Industrial		0.116	1.149	1.265	0.142	1.407	1.549
MWSS + Bulacan		46.000	0.000	46.000	48.700	0.000	48.700
Irrigation		112.778	0.578	113.356	169.885	2.242	172.127
Fisheries (Brackish water)		17.900	0.000	17.900	17.900	0.000	17.900
Fisheries (Fresh water)		6.400	0.000	6.400	6.400	0.000	6.400
Livestock		0.000	0.290	0.290	0.000	0.419	0.419
Total excl. Fisheries(Brackish)	(m^3/s)	165.294	9.446	174.740	225.127	15.930	241.057
Total		183.194	9.446	192.640	243.027	15.930	258.957
Total excl. Fisheries(Brackish)	(MCM/ year)	5,213	298	5,511	7,100	502	7,602
Total		5,777	298	6,075	7,664	502	8,166

Note: SW=Surface water, GW=Groundwater
Source: JICA Study Team

H.3.3 Water Demand – Supply Balance

H.3.3.1 Balance of Demand and Potential for Groundwater

The water demand for groundwater is firstly categorized by possible water sources as shown in the following table, in order to examine the balance of demand and potential for groundwater.

Table H. 3.3.1 Categorization of Water Demand for Groundwater

Water Demand		Water Source	Note
DG1	Municipal Level 2&3	GW (mainly deep) or SW	GW resources which may be affected by salt-water intrusion is assumed to be not usable.
	Industrial		
DG2	Municipal Level 1	GW (mainly shallow)	Total groundwater resources potential is assumed to be usable.
	Irrigation		
	Livestock		

Source: JICA Study Team

The main concern on groundwater balance is if the present and future level 2 and 3 municipal and industrial water supply, which could abstract a large volume of groundwater, may affect sustainability of groundwater sources. The sustainably usable groundwater against the demand of ***DG1***, ***GWP_DG1***, is determined by the following equation, considering both the usage of groundwater except for level 2 and 3 municipal and industrial water supply and the possible salt-water intrusion.

$$GWP_{\_DG1} = GWP - \max(DG2, SWE)$$

where ***SWE*** = Part of groundwater resources potential which may be affected by possible salt-water intrusion.

The demand of ***DG1*** is then compared with ***GWP_DG1*** . When ***DG1*** is larger than ***GWP_DG1*** , the groundwater condition would be at risk. The present and future risk on groundwater usage is evaluated as shown in the following table, considering the possible range of groundwater recharge.

Table H. 3.3.2 Evaluation of Present and Future Risk for Groundwater Usage

Condition	Evaluation
DG1 < GWP-L $_{DG1}$	No risk
GWP-L $_{DG1}$ < DG1 < GWP-H $_{DG1}$	At risk
GWP-H $_{DG1}$ < DG1	At high risk

Note: **GWP-L: GWP** for which groundwater recharge rate is assumed to be 5% of average annual precipitation.
GWP-H: GWP for which groundwater recharge rate is assumed to be 12% of average annual precipitation.
Source: JICA Study Team

The results of the evaluation are demonstrated in Annex-T H.3.3.1 and Annex-F H.3.3.1 and H.3.3.2. In summary, the followings are noted.

- It is evaluated that, at present, among seventy six (76) municipalities/cities inside the study area in provinces of Bulacan, Nueva Ecija, Pampanga and Tarlac, nine (9) municipalities/cities are at high risk and eleven (11) are at risk. Many municipalities/cities located at low-land area in Bulacan as well as Angels, San-Fernando in Pampanga are at high risk.
- In future (2025), it is expected that eighteen (18) municipalities/cities in provinces of Bulacan and Pampanga be at high risk and twelve (12) including Tarlac and Cabanatuan be at risk.

For the time being, groundwater could be abstracted by utilizing mining yield even if the demand exceeds the potential. However, it should be minimized considering the sustainability of aquifer and groundwater resources. At least, it is necessary to consider the conversion of groundwater source to another source, such as surface water, in the place where the groundwater usage is currently at high risk or is expected to be at high risk in future. The recommended measures are as follows.

1) Case 1: ***DG1*** is larger than ***GWP-H*** $_{DG1}$

- Expected excess water volume in 2025 to be converted to either residual groundwater source at adjacent municipality/city or surface water source.
- Regulation on the usage of groundwater should be considered.
- Periodical intensive groundwater monitoring is required.

2) Case 2: ***DG1*** is larger than ***GWP-L*** $_{DG1}$

- Periodical intensive groundwater monitoring is required.
- If it will be judged that groundwater level will continue to lower, the conversion of groundwater source to either residual groundwater source at adjacent municipality/city or surface water should be considered.

The following table summarizes the total deficit of sustainable local groundwater source by provinces, considering the above-mentioned recommended measures. Annex-T H.3.3.2 shows the deficit by municipality/city. The development of either residual groundwater source at adjacent municipality/city or surface water source should be considered for this volume of water.

Table H. 3.3.3 Deficit of Sustainable Local Groundwater Source

	Present (2008) (MCM/year)		Future (2025) (MCM/year)	
	Demand for Level 2&3 and Industrial use	Deficit	Demand for Level 2&3 and Industrial use	Deficit
Bulacan	50.2	23.9	90.8	49.8
Nueva Ecija	45.3	0.0	76.0	0.0
Pampanga	101.7	31.3	159.0	67.1
Tarlac	12.0	0.0	18.3	1.5
Total	209.2	55.2	344.1	118.3

Note: Inside the study area only
Source: JICA Study Team

H.3.3.2 Water Balance for Surface Water

(1) General

In order to examine the water balance for surface water in the study area in detail, MODSIM model, which has been developed in Colorado State University, is introduced in the present study. The MODSIM is freely available from the web-site of Colorado State University[27]. This model supports the water allocation considering priorities among several multi-sector water users with Graphical User Interface.

Firstly, the model is setup by considering the existing and future possible water usage and water resources development facilities. Secondly, the water balance in the present condition is examined. The water balance in the future condition with projected future water demand and proposed storage dams is then preliminary investigated. Based on the results of the water balance study, future direction of the water resources development and management is explored.

(2) Model Setting

The model has been set for the entire study area and related trans-basin catchment. The model network consists of nodes and links. There are several kinds of nodes as follows.

- The **non-storage nodes** which represent the actual river network and trans-basin water transfer, and they are connected by the links. The nodes are positioned basically on the most downstream point of a water balance catchment except for the case that the node represents inflow from a catchment.

- The **reservoir nodes** are placed at the existing and proposed storage dam sites. Some hydropower plants are also represented by the reservoir node with zero storage volume.
- The **consumptive demand nodes** represent water users who require water for their consumptive use. The nodes are connected to the representative intake points.
- The **flow through demand nodes** represents minimum flow requirement at specific points.
- The **network sink nodes** are placed at the most downstream of the river systems.

The model river networks for the present condition and future possible condition are presented in Annex-F H.3.3.3 and 3.3.4. Fifty nine (59) non-storage nodes, nine (9) reservoir nodes, fifty (50) consumptive demand nodes, fourteen (14) flow through demand nodes and four (4) network sink nodes in total are used in the model for the present condition. Major points of the model setting are described as below.

- At the non-storage nodes, time series of inflow in quasi-natural condition is given. The simulated runoff using the rainfall-runoff model is used for the inflow except for the inflow to storage dams and the volume of trans-basin water transfer. The inflow to the storage dams and the volume of trans-basin water transfer is given by the same method described in Chapter H.3.1.1, which is a combination of the observed inflow and the simulated runoff.
- At the reservoir nodes, live storage volume and storage target volume are specified. The storage target volumes for the existing storage dams are given based on the seasonal change of the upper storage limit of conservation volume considering the storage for flood control. For the proposed storage dams, the storage target volumes are tentatively set to the live storage volumes through a year.
- The water demand for several water users are given at the consummative demand nodes. The water user who abstract significant volume of water at an intake point, such as major NIS systems, is represented by single demand node. Other water users are summed up in a water balance catchment, and the total is represented by single consummative demand node. The list of the consummative demand nodes are presented in Annex-T H.3.3.3.
- The return flow from the consummative demand nodes are considered in the present study. The excess water distributed to irrigation field is usually infiltrated and is drained through drainage channels. Some volume of the drained water could be re-used in the irrigation system, and the remained would return to the river downstream. The observed flow at HMS343 (Arayat) indicates that there are considerable volume of return flow after Pantabangan storage dam started its operation in 1974 as have discussed in *Sector Report A: Topography and Meteo-hydrology*. The fraction of the return flow from the irrigation area is set at 20% in the present study, by comparing the simulated and the observed discharges at around HMS343 for the existing condition, and by referring the Casecnan project[24)]. The delay of return flow is assumed to be approximated by the following exponential type response function.

$$R(\Delta t) = 1 - \exp\left(-\frac{\Delta t}{T_r}\right)$$

where $R(\Delta t)$ = return flow rate, Δt = lag time, T_r = time constant for delay. In the present study, T_r is set at 30days, considering the parameters used in the rainfall-runoff model as well as the comparison between the simulated and the observed discharges at around HMS343. The return flow from other water users are assumed to be 50% with T_r = 30days. The location of return flow for each consummative demand node is shown in Annex-T H.3.3.3.

- At the flow through demand nodes, the minimum stream flow requirement estimated in Chapter H.3.2.6 is given. The flow through demand nodes are set at the major intake points. The list of the flow through nodes is shown in Annex-T H.3.3.3.
- In the MODSIM model, the priority among water users and target storages of storage dams can be specified. The priority set in the simulation is shown in Annex-T H.3.3.3.
- The MODSIM model can also specify the conditional priority with responding hydrological condition as well as storage condition of storage dams. This option makes it possible to simulate the water balance with cooperative operation between two reservoirs as well as restriction in water release due to reservoir condition, which has been utilized for the water balance related to Angat storage dam. In Angat storage dam, the model has been set that no water would be supplied to AMRIS when the water level of the reservoir becomes lower than 180m above mean sea level for the present water balance.

(3) Water Balance in Present Condition

The water balance simulation for the present (2008) water demand has been conducted against the inflow with 50 years (1958 - 2007). The present water demand described in Chapter H.3.2 is given in the simulation. Based on the simulated results, the followings are noted.

(a) Water supply for UPRIIS by Pantabangan storage dam

No shortage occurs in 50 years. It is judged that the existing water supply capacity is large enough against the existing irrigation water demand in UPRISS.

(b) Water supply for PDRIS

Water supply shortage occurs twice in 50years. It is judged that the existing water supply capacity by the Pampanga River is large enough against the existing irrigation water demand in PDRIS. The water is supplied by tributary catchment and return flow from irrigation area.

(c) Water supply for MWSS and AMRIS by Angat storage dam

(i) Case 1

- Conditions
  - ✧ No lower rule curve is considered.
  - ✧ The restriction of release for storage volume lower than 180m AMSL is removed.
- Results
  - ✧ Safety level of AMRIS = 1/4years (14 shortages in 50 years)
  - ✧ Safety level of MWSS = 1/4years (12 shortages in 50 years)

(ii) Case 2

- Conditions
  - ✧ No lower rule curve is considered.
  - ✧ The restriction of release for storage volume lower than 180m AMSL is **not** removed.
- Results
  - ✧ Safety level of AMRIS = less than 1/2years (31 shortages in 50 years)
  - ✧ Safety level of MWSS = 1/10years (5 shortages in 50 years)

It is confirmed that the reliability of water supply for both AMRIS and MWSS is less than 1/5years safety level (equivalent to 80% reliability) even if the restriction of release for storage volume lower than 180m AMSL is removed.

(d) Water supply for CISs and Other Agricultural Use such as Fresh Water Aquaculture

In general, the water to be abstracted in dry season is quite limited. In the dry season, the water shortage occurs every year in many CISs which utilizes local flow. Annex-F H.3.3.5 shows the average demand and deficit of CISs and other agricultural use such as fresh water aquaculture in 50 years.

(e) Average flow pattern in Pampanga River

The change of flow pattern from the quasi-natural condition at the upstream of Cong Dadong dam (around HMS343) is presented in Annex-F H.3.3.6. Although the average discharge decreases due to consummative use of water in the basin, the discharge in the dry season increases because of return flow from irrigation area. This has been indicated in the observed data. The simulation model has been calibrated to reproduce the observed tendency.

The increase of the discharge in dry season would be beneficial for the water users in the downstream area.

(4) Water Balance in Projected Future Condition

The water balance simulation for the projected future water demand in 2025 has been conducted against the inflow with 50 years (1958 - 2007). The projected future water demand described in Chapter H.3.2 is given in the simulation. There are several possible water resources development projects with storage dams. The water balance with such possible storage dams is examined except for the Anga-Umiray system. The water balance for the different alternatives for the recovery of reliability of water supply in the Angat-Umiray system would be discussed separately in the next sub-section. Based on the simulated results, the followings are noted.

(a) Water supply for UPRIIS by Pantabangan storage dam system

The UPRIIS irrigation area will be expanded by 20,321ha in Division V. It is confirmed by the simulation that the safety level of the water supply would be kept at 1/5years (80% reliability) without additional water resources development.

(b) Proposed Balintingon storage dam

It has been proposed that Balintingon storage dam would supply irrigation water to newly developing area of 14,900ha and supplementary to UPRISS Division IV. In the simulation, it is assumed that the entire live storage volume would be used for irrigation water supply. The simulated results show that the safety level not only for the newly developing area but also for the entire UPRISS area would be more than 1/5years.

(c) Water supply for PDRIS

There would be no change in water demand condition in PDRIS. The safety level would be kept at more than 1/5years.

(d) Water supply for MWSS and AMRIS by Angat storage dam in near future

The reliability of water supply in Angat-Umiray system in near future is evaluated under the following conditions.

- Municipal water demand at Ipo dam = 48.7m^3/s (46m^3/s for MWSS and 2.7m^3/s for Bulacan)
- Water demand of AMRIS =19.2m^3/s in annual average (no change)
- Sumag intake is completed.

- There is no change in the upper rule curve.

The simulated results are as follows.

(i) Case 1

- Conditions
  - ✧ No lower rule curve is considered.
  - ✧ The restriction of release for storage volume lower than 180m AMSL is removed.
- Results
  - ✧ Safety level of AMRIS = 1/4years (14 shortages in 50 years)
  - ✧ Safety level of MWSS = 1/4years (13 shortages in 50 years)

(ii) Case 2

- Conditions
  - ✧ No lower rule curve is considered.
  - ✧ The restriction of release for storage volume lower than 180m AMSL is **not** removed.
- Results
  - ✧ Safety level of AMRIS = less than 1/2years (31 shortages in 50 years)
  - ✧ Safety level of MWSS = 1/10years (5 shortages in 50 years)

It can be concluded that no significant change from the present condition on the reliability of water supply would be expected even if Bulacan starts its abstraction of 2.7m^3/s from Ipo dam after the completion of the Sumag intake. However, there will still be water shortage in almost every two years.

(e) Proposed Balog-Balog storage dam

There is the proposed Balog-Balog storage dam in Tarlac River, which may benefit irrigation area of 39,150ha located within the study area. The released water is planned to be conveyed to the study area by trans-basin canals. In the simulation, it is assumed that the entire live storage volume would be used for irrigation water supply. The simulated results show that the safety level for supplying water to the entire irrigation area would be more than 1/5years.

(f) Proposed Gumain storage dam

The Gumain storage dam has been proposed to expand the irrigation area in Gumain River. The planed irrigation area is 16,750ha. In the simulation, it is assumed that the entire live storage volume of the proposed dam would be used for irrigation water supply. In the simulation, it is assumed that the entire live storage volume would be used for irrigation water supply. The simulated results show that the safety level for supplying water to the entire irrigation area would be more than 1/5years.

The Feasibility study for Gumain storage dam was conducted before the Pinatubo eruption. The situation of the proposed dam site could have been changed. Another pre-F/S or F/S level study may be necessary to be considered to reflect the possible change in the proposed dam site as well as the change in socio-economical situation. Because there is a risk for utilizing groundwater in the province of Pampanga as discussed in the previous chapter, the possibility of utilizing the water for municipal and industrial purpose should also be investigated.

(g) Water supply for CISs and Other Agricultural Use such as Fresh Water Aquaculture

The condition of water shortage does not change in general in the projected future condition.

(5) Possibility of Abstraction from Pampanga River as Alternate Source of Groundwater

As have discussed in the previous chapter, the groundwater usage at many municipalities/cities, especially in Bulacan and Pampanga is at high risk. The deficit of the sustainable local groundwater source in the future condition in 2025 is estimated at about 1.6m^3/s in Bulacan and 2.1m^3/s in Pampanga (inside the study area only).

As a preliminary assessment, the possibility of abstraction of 2.1m^3/s for the usage in the province of Pampanga at around Cong Dadong dam in Pampanga River, as one of possible source of surface water, is checked using the simulation model. The result shows that the abstraction of 2.1m^3/s is possible with keeping the safety level of PDRIS more than 1/5years.

(6) Water Balance by Alternatives on Recovery of Reliability of Water Supply in Angat-Umiray System

As discussed in Chapter H.4.4, there are several options to recover the reliability of water supply in Angat-Umiray system. In the present study, four options are selected as shown in the following table.

Table H. 3.3.4 Selected Options

Case	Unit Cost (pesos/m^3)	Maximum Quantity (Annual Average)(m^3/s)	Description
Option A-1: Bayabas	7.1	3.0	An option to increase water resources potential in Angat-Umiray system. The stored water in the proposed Bayabas storage dam will be provided to AMRIS when water level of the Angat storage dam is low.
Option B-1: Balintingon	8.6	2.9 (for gravity distribution of irrigation water in AMRIS)	One of options to decrease irrigation water demand at Bustos dam. The part of stored water in the proposed Balintingon storage dam will be conveyed to AMRIS.
Option B-2: Upgrading AMRIS	5.3	1.0	One of options to decrease irrigation water demand at Bustos dam. More efficient water use for irrigation in AMRIS will be expected through concrete lining of main canals together with several non-structural measures.
Option C-1: *Laiban*	*8.5*	(21)	An option to reduce MWSS water demand at Ipo dam. Reduction of MWSS water demand from Ipo dam by other water sources outside Pampanga river basin such as Laiban dam.

Source: JICA Study Team

(a) All selected options in Pampanga river basin

By application of all selected options in Pampanga river basin, municipal water supply would increase to 51.3m^3/s with safety level of 1/10years and AMRIS irrigation area will be maintained at 26,000 hectares during dry season with safety level of 1/5years, as shown in Table H.3.3.5. The additional 2.6m^3/s can be used for future municipal water supply.

Table H. 3.3.5 Summary of Available Municipal Water Supply with All Selected Options in Pampanga River Basin

Case	Combination of Options	Annual Average Water Demand (m^3/s)		Restriction of Water Release in Angat Dam	Safety Level		Safety Level OK or NG
		Municipal from Ipo	AMRIS from Bustos		Municipal	AMRIS	
ALL Selected Options in Pampanga	Upgrading AMRIS + Bayabas[1)] + Balintingon ($2.9m^3/s$)[2)]	**51.3**	15.4	When WL<180m, no release for AMRIS.	1/10years	1/5years	OK

Remarks:
1) Coordinated operation is necessary. When WL<184m, Bayabas releases for AMRIS.
2) 4,000ha of 26,000ha in AMRIS is supplied by Balintingon. New irrigation area from Balintingon storage dam is 10,000ha (14,900ha in original plan).
Source: JICA Study Team

(b) Proposed Balintingon storage dam

When the target is to recover the reliability of water supply as shown below, it is not necessary to implement all options.

- Municipal water demand =$48.7m^3/s$ ($46m^3/s$ for MWSS and $2.7m^3/s$ for Bulacan)
- Irrigation area in AMRIS =26,000ha (dry season), 20,355ha (wet season)

The alternatives for the recovery of the reliability of water supply have been prepared by combining the options including options outside Pampanga river basin. The attained safety levels, necessary condition of water release in Angat storage dam for each alternative are summarized in Table H.3.3.6.

Table H. 3.3.6 Summary of Attained Safety Levels, Necessary Conditions of Water Release in Angat Storage Dam

Case	Combination of Options	Annual Average Water Demand (m^3/s)		Restriction of Water Release in Angat Dam	Safety Level		Safety Level OK or NG
		Municipal from Ipo	AMRIS from Bustos		Municipal	AMRIS	
ALT-1	Upgrading AMRIS + Bayabas[1)]	48.7	18.2	When WL<180m, no release for AMRIS.	1/10years	1/5years	OK
ALT-2	Upgrading AMRIS + Balintingon ($2.9m^3/s$)[2)] + Laiban($0.5m^3/s$)	48.2	15.4	**Restriction of 180m above mean sea level should be removed.**	1/10years	1/5years	OK
ALT-3	Upgrading AMRIS + Laiban ($3.1m^3/s$)	45.6	18.2	**Restriction of 180m above mean sea level should be removed.**	1/10years	1/5years	OK
ALT-4	Laiban ($4.0m^3/s$)	44.7	19.2	**Restriction of 180m above mean sea level should be removed.**	1/10years	1/5years	OK

Remarks:
1) Coordinated operation is necessary. When WL<184m, Bayabas releases for AMRIS.
2) 4,000ha of 26,000ha in AMRIS is supplied by Balintingon. New irrigation area from Balintingon storage dam is 10,000ha (14,900ha in original plan).
Source: JICA Study Team

H.4 Plan for Water Resources Development, Allocation and Distribution

H.4.1 Problems and Issues on Water Resources Development, Allocation and Distribution

Problems and issues on water resources development, allocation and distribution are identified mainly from inter-sector point of view, referring the IWRM Plan Framework[2)]. The following three methodologies have been utilized for the identification.

- Study on water supply - demand balance
- Verification of the results of the water balance study through interviews to related agencies
- Problems and issues discussed during stakeholder meetings

The identified main problems and issues are summarized as follows.

H.4.1.1 Sustainable Water Source for Municipal Water Supply

The water source of municipal water supply in Pampanga river basin currently relies on groundwater source. The results of water balance between groundwater potential and demand shows that the expected water demand is more than groundwater potential in some cities and municipalities, especially in lower Pampanga river basin. This is mainly because of rapid increase of population and may be associated with salt-water intrusion and land-subsidence.

The main concern on groundwater source is if the present and future level 2 and 3 municipal and industrial water supply, which could abstract a large volume of groundwater, may affect sustainability of groundwater sources. The sustainably usable groundwater (referred to as $\boldsymbol{GWP\_{DG1}}$) against the demand of level 2 and 3 municipal and industrial water use (referred to as ***DG1***) is determined considering both the usage of groundwater except for level 2 and 3 municipal and industrial water supply and the possible salt-water intrusion. The present and future risk on groundwater usage is then evaluated as shown in the following table, considering the possible range of groundwater recharge.

Table H. 4.1.1 Evaluation of Present and Future Risk for Groundwater Usage

Condition	Evaluation
$\mathbf{DG1 < GWP\text{-}L_{DG1}}$	No risk
$\mathbf{GWP\text{-}L_{DG1} < DG1 < GWP\text{-}H_{DG1}}$	At risk
$\mathbf{GWP\text{-}H_{DG1} < DG1}$	At high risk

Note: **GWP-L: GWP** for which groundwater recharge rate is assumed to be 5% of average annual precipitation.
GWP-H: GWP for which groundwater recharge rate is assumed to be 12% of average annual precipitation.
Source: JICA Study Team

The followings are noted from the evaluation.

- It is evaluated that, at present, among seventy six (76) municipalities/cities inside the study area in provinces of Bulacan, Nueva Ecija, Pampanga and Tarlac, nine (9) municipalities/cities are at high risk and eleven (11) are at risk. Many municipalities/cities located at low-land area in Bulacan as well as Angels, San-Fernando in Pampanga are at high risk.
- In future (2025), it is expected that eighteen (18) municipalities/cities in provinces of Bulacan and Pampanga be at high risk and twelve (12) including Tarlac and Cabanatuan be at risk.

In some WDs in Bulacan province, the deterioration of water quality has already exceeded the tolerable level for drinking purpose due to salt-water intrusion. In these WDs, it is necessary to convert groundwater source to either residual groundwater source at adjacent municipality/city or surface water source as soon as possible. In fact, the bulk water supply project in Bulacan was proposed more than 10 years ago, but has not yet been implemented.

For other areas, no clear tendency which shows deterioration of water quality has been observed in general. Therefore, for the time being, groundwater could be abstracted by utilizing mining yield even if the demand exceeds the potential. However, it should be minimized considering the sustainability of aquifer and groundwater resources. At least, it is necessary to consider the possibility of conversion of groundwater source to another source, such as residual groundwater source at adjacent municipality/city and surface water, in the place where the groundwater usage is at high risk.

Periodical intensive groundwater monitoring is also required. If it will be judged that there is continuous lowering of the groundwater level in a place where the groundwater usage is at risk, then conversion of source from groundwater to residual groundwater or surface water of the adjacent municipality/city is also possible. According to Cabanatuan WD, the groundwater level tends to be lowering in their production wells. If the tendency continues, other water source should be explored and developed.

The deficit of sustainable groundwater source in 2025 for municipal water supply in the place where the groundwater usage is currently at high risk or is expected to be at high risk in future (only in the study area) is estimated as follows.

- Bulacan: 49.8MCM/year
- Nueva Ecija: No deficit
- Pampanga: 67.1MCM/year
- Tarlac: 1.5MCM/year

The development of either residual groundwater source at adjacent municipality/city or surface water source should be considered for this volume of water.

H.4.1.2 Securing Necessary Water Sources for Expansion of Large Irrigation System

In order to support regional economic growth and job opportunity, expansion of irrigation area in Pampanga river basin is one of fundamental strategies in agricultural sector. The expansion of irrigation system requires additional water source. There are three proposed water resources development projects including the construction of large storage dam as follows.

- Balintingon Reservoir Multipurpose Project (BRMP): Irrigation area = 14,900ha
- Balog-Balog Multipurpose Project Phase 2: Irrigation area = 39,150ha
- Gumain Reservoir Project: Irrigation area =16,750ha

Based on the water balance study in the present study, these storage dams could supply enough water with 1/5years safety level (80% reliability) for the planned cropping pattern in the target irrigation areas. However, the existing F/S for Gumain storage dam should be re-studied, considering the possibility of supplying water for a part of future municipal water use in Pampanga as well as the effect of Pinatubo eruption on the proposed dam site.

H.4.1.3 Inadequate Reliability of Water Supply in Angat-Umiray System

As discussed in Chapter H.2.5 in detail, the present reliability of water supply in Angat-Umiray system is inadequate for both irrigation and municipal water supply. The main causes of the problems and issues are identified as shown below, based on analysis of the related documents and discussions with the concerned agencies as well as the water balance study.

(1) Increase of Water Allocation to Municipal Water Use without Adequate Water Resources Development

Due to rapid increase in municipal water demand in Metro Manila and late implementation of new water resources development, conditional reallocation of water from irrigation use of AMRIS to municipal use of Metro Manila residents was implemented through series of resolutions without any compensation to NIA. Even after the new water source from Umiray

River became available by completion of Umiray-Angat trans-basin project, the transferred water was not returned to AMRIS due to further increase of municipal water demand. It should be realized that the water resources are already insufficient to supply both the irrigation water demand of NIA-AMRIS and municipal water demand of MWSS. New water resources development is really necessary just to recover the reliability of the water supply for the present water demand. Otherwise, proper compensation should be considered for the water users who receive less water and more economical loss.

(2) Existence of Water Use Permits without Proper Amendment and/or Modification by Issuing Resolutions

The original water use permits have been amended and/or modified by issuing resolutions. By this, the increase of allocation to municipal water use could have been realized. However, there exists sometimes no official document to clarify if a particular resolution is an amendment of a particular water use permit or not. There is no official document to specify the amendment and/or modification which is supposed to be filed together with the water use permit. The water charge is still on the basis of the original water use permit. The process of issuing a resolution is also not transparent, compared to the official process of issuing water use permit. With this situation, water use permit seems to be invalid. This is not a proper water governance, even though the needs of municipal water in Metro Manila has been emergent.

(3) Unclear Definition Used in Resolutions such as "Unutilized Irrigation Water"

The resolution to specify the reallocation of water use of 15m^3/s from AMRIS uses the term "unutilized irrigation water". However, the definition of this term is not clear so that water user such as MWSS and NIA have different interpretation.

(4) Water Use Permit which Does Not Represent Actual Water Demand for Irrigation Water Use

The current practice in granting water permit for irrigation use is to base from the maximum allowable flow in a year. However, the actual water demand for irrigation varies monthly or even weekly depending on farming activities. Therefore the actual amount of water used in cropping seasons within a year is not actually the amount granted in the water permit. This is not really a problem if the water source supplies for irrigation only. Water governance is difficult for a multipurpose water source such as Angat storage dam. In Angat-Umiray system, the water permit granted to NIA is 40m^3/s throughout the year at Bustos Dam, but the actual water demand is an annual average of very much less than 40 m^3/s. The discussion on reallocation of irrigation water to other purposes must consider the right amount of water required for farming activities and proper compensation which should be a part of agreement among the stakeholders.

(5) Unregulated Peak Hydropower Generation

There are times that peak releases by Angat hydropower plant were not coordinated with NIA-AMRIS though reservoir operation is always a part of discussion during TWG meetings. If the capacity of the existing Bustos Dam and Ipo Dam is not enough to re-regulate the fluctuating release, the released water cannot be effectively utilized for other purpose such as irrigation and municipal water uses.

According to NWRB, there is no regulation on the peak release from Angat hydropower plant, although it has been sometimes discussed during TWG for operation of Angat storage dam. Countermeasures such as exemption from the provision of EPIRA and proper regulation should be considered to maximize the utilization of the limited water resources potential in Angat-Umiray system.

(6) Implementation of Operation Rule which is not Approved and Unclear Responsibility on It

To discuss the available storage volume for municipal and irrigation water uses in Angat storage dam, it is necessary to fix the necessary storage volume for preventing over-topping of extreme flood as well as flood control volume. These volumes are usually examined during the planning stage of the dam reservoir and should be authorized by relevant agencies as a flood operation rule. In case of Angat storage dam, the Flood Operation Rule prepared in 1984 has not yet been approved but has been used as a practical guide. Because of this, the study for improving water supply such as AWSOP sometimes assumed the different flood control volume so that more water use could be available. This may lead to misunderstanding among the stakeholders.

H.4.1.4 Expected Increase of Conflict among Water Users, Especially between Municipal and Irrigation Water Users

Increase of conflict among water users, especially between municipal and irrigation water users are easily expected. Necessity of more surface water for both municipal and irrigation water supply in future is expected as shown in the problems and issues in Chapter H.4.1.1 and H.4.1.2. In Pampanga river basin, a large amount of water use permits for irrigation water use has already been granted to NIA. If one needs to develop new water resources with storage dams, the existing water use permits should be adjusted considering the actual water use for irrigation. Otherwise, there will be no available water for additional water permits in the future. Uncertainty on water resources due to possible climate change in future may also cause the increase of the conflict.

The bitter experience on conflict between municipal and irrigation water use in Angat-Umiray system should not be repeated in other areas in Pampanga river basin. The improvement of water governance based on the problems and issues in Angat-Umiray system should be seriously considered to cope with the expected conflict.

H.4.2 Projects as Components of Proposed IWRM Plan

H.4.2.1 Purpose of Water Resources Development, Allocation and Distribution

The water resource development, allocation and distribution discussed in this subsection aims at supporting the achievement of goals especially for two sectors, namely (a) agriculture/irrigation and fishery and (b) municipal water supply, sanitation and sewerage. Of programs/projects for water resources development in the two sectors, those for agriculture/irrigation and fishery may make lower economic contributions as compared with those for municipal water supply. In the IWRM Plan for Pampanga river basin, however, preservation of the present agricultural productivities is given priority over the economic contribution considering the importance to secure the job opportunities in the agricultural sector and the agricultural productivity. In line with this basic consideration, the policy of water resources development, allocation and distribution is oriented to the equal importance of both goals in the two sectors.

H.4.2.2 Increase of Capacity of Hydropower Generation as Secondary Purpose of Water Resources Development

It is not necessary to install new hydropower plants in Pampanga river basin in a proactive manner, in order to achieve the target of the energy independence specified in National Energy Plan, 2006[19]. The hydropower sector targets a cumulative installed capacity of 2,509.8MW in the Luzon grid in 2014 from hydropower resources as one of renewable energy sources. Additional 300MW is necessary to be installed by hydropower resources in the Luzon grid. However, the additional installation of 300MW would be achieved by the indicative hydropower plants outside Pampanga river basin according to National Energy Plan, 2006. There are also many other indicative hydropower plants outside Pampanga river basin for further increase of installed capacity for the Luzon grid.

Considering this, the increase of capacity of hydropower generation in Pampanga river basin would be treated as a secondary purpose when water resources development with large storage dam for irrigation water use and/or municipal water use is proposed.

H.4.2.3 Projects as the Countermeasures against the Problems and Issues on Water Resources Development, Allocation and Distribution

Based on the problems and issues on water resources development allocation and distribution shown in Chapter H.4.1, necessary measures and corresponding projects have been identified. The on-going and proposed projects have been identified, referring the related reports and documents which are collected from water related agencies. The conceptual projects have also been identified by the study team, considering the necessary measures.

Table H.4.2.1 shows the identified projects related to the problems and issues on water resources development, allocation and distribution. Almost all of the projects belong to a specific sector. However, inter-sector projects for water resources management, which are expected to be mainly implemented by NWRB, are also proposed and listed herein. The code of the inter-sector project is specified like IS-*-*. The list of the inter-sector project is shown in Table H.4.2.2 (refer to the detailed project profiles shown in Annex-T H.4.2.1 and the location of project in Annex-F H.4.2.1). The identified projects are largely categorized by four groups, corresponding to the problems and issues. The outline of the projects is described below.

Table H. 4.2.1 On-going, Proposed and Conceptual Projects related to Problems and Issues on Water Resources Development, Allocation and Distribution

Goals: *No goals are set. Main purpose of Water Resources Development, Allocation and Distribution is to support and ensure the achievement of goals of each of water related sectors.*

Problems and Issues / Causes	Countermeasures	Projects	Sector*
1. Sustainable Water Source for Municipal Water Supply • Expected water demand is more than groundwater potential in some cities/ municipalities - Rapid increase of water demand - Salt-water intrusion - Possible land- subsidence	1.1 Development of Bulk Water Supply	• MW-P-02: Sumag River Diversion Project • MW-P-03: Bulacan Treated Bulk Water Supply Project • MW-P-04: Metro Clark Bulk Surface Water Project • MW-C-05: Extended Bulacan Bulk Water Supply Project • MW-C-06: Pampanga Bulk Water Supply Project	MWS MWS MWS MWS
	1.2 Establishment of Groundwater Monitoring	• IS-C-01:Establishment of Comprehensive Groundwater Monitoring in Pampanga River Basin	IS
2. Securing Necessary Water Sources for Expansion of Large Irrigation System • Expansion of irrigation system requires additional water source	2.1 Water Resources Development by Large Storage Dam	• AI-P-01: Balintingon Reservoir Multipurpose Project (BRMP) • AI-P-02: Balog-Balog Multipurpose Project Phase 2 • AI-P-09: Gumain Reservoir Project	AIF AIF AIF
3. Inadequate Reliability of Water Supply in Angat-Umiray System • Increase of water allocation to municipal water use without adequate water resources development • Existence of water use permit without proper amendment and/or modification by issuing resolutions • Unclear definition used in resolutions such as “unutilized irrigation water” • Water use permit which does not represent actual water demand for irrigation water use • Unregulated peak hydropower generation • Implementation of Operation Rule which is not Approved and Unclear Responsibility on It	3.1 Rehabilitation to Sustain Current Water Supply Capacity in Angat-Umiray System	• MW-G-01: Angat Water Utilization and Aquaduct Improvement Project (AWUAIP) Phase 2 • MW-P-01: Rehabilitation of Umiray-Macua Facilities • AI-P-11: Rehabilitation of AMRIS	MWS MWS AIF
	3.2 Water Resources Development and Management for Recovery of Reliability	• IS-C-02: Project for Recovery of Reliability of Water Supply in Angat-Umiray System • IS-C-04: Capacity Development of NWRB and Relevant Agencies on Water Allocation and Distribution	IS IS
4. Expected Increase of Conflict among Water Users, especially between Municipal and Irrigation Water Users • Necessity of more surface water for both municipal and irrigation water supply in future • Existing large amount of water use permits for irrigation water use • Uncertainty on water resources due to possible climate change in future	4.1 Enhancement of Surface Water Monitoring	• IS-C-03: Enhancement of Monitoring System for Surface Water in Pampanga River Basin	IS
	4.2 Improvement of Methodology of Water Allocation and Water Permitting System	• IS-C-04: Capacity Development of NWRB and Relevant Agencies on Water Allocation and Distribution	IS
	4.3 Adaptation to Uncertainty on Water Resources due to Possible Climate Change in Future	• AI-C-02: Introduction of Water Saving Irrigation Technology	AIF
	4.4 Improvement of Dam Operation for Dam Safety and Flood Control	• FL-G-04: Flood Forecasting and Warning System Capacity Building Project upon Dam Release in the Philippines	FL

Source: JICA Study Team

Note: * MWS - Municipal Water Supply, Sanitation and Sewerage, AIF - Agriculture/Irrigation and Fishery, FL - Flood and Sediment Disaster Management, IS – Inter-sector for Water Resources Management

Table H. 4.2.2 List of On-going, Proposed and Conceptual Programs and Projects for Inter-Sector for Water Resources Management

No.	Code	Title of Project	Implementing Agency	Status
1	IS-C-01	Establishment of Comprehensive Groundwater Monitoring in Pampanga River Basin	NWRB/ Others	Conceptual
2	IS-C-02	Project for Recovery of Reliability of Water Supply in Angat-Umiray System	NWRB/NIA/ MWSS/NPC Bulacan Gov.	Conceptual
3	IS-C-03	Enhancement of Monitoring System for Surface Water in Pampanga River Basin	NWRB/ Others	Conceptual
4	IS-C-04	Capacity Development of NWRB and Relevant Agencies on Water Allocation and Distribution	NWRB/ Others	Conceptual

Source: JICA Study Team

H.4.2.4 Projects to Support Sustainable Water Source for Municipal Water Supply

There are two types of projects to support sustainable water source for municipal water supply; (1) Development of bulk water supply, and (2) Establishment of groundwater monitoring.

(1) Development of Bulk Water Supply

In order to reduce the load on the groundwater source at high risk for its sustainability, surface water source or residual groundwater source at adjacent municipalities is developed and conveyed to WDs as a bulk water supply. The following projects are identified.

- MW-P-02: Sumag River Diversion Project
- MW-P-03: Bulacan Treated Bulk Water Supply Project
- MW-P-04: Metro Clark Bulk Surface Water Project
- MW-C-05: Extended Bulacan Bulk Water Supply Project
- MW-C-06: Pampanga Bulk Water Supply Project

The contents of these projects are described in *Sector Report D: Municipal Water Supply, Sanitation and Sewerage System Management*.

(2) Establishment of Groundwater Monitoring

In order to grasps the actual condition of groundwater condition in Pampanga river basin, it is necessary to establish groundwater monitoring system.

(a) IS-C-01: Establishment of Comprehensive Groundwater Monitoring in Pampanga River Basin

This conceptual project is proposed to step-wisely develop the comprehensive monitoring system on the water level/quality of the groundwater as well as the land subsidence in the lower reaches of the study area so as to execute the proper groundwater resources management.

The contents of the project are described in Chapter H.4.3.1.

H.4.2.5 Projects to Secure Necessary Water Sources for Expansion of Large Irrigation System

The following three water resources development projects including construction of large storage dam has been proposed in the study area.

- AI-P-01: Balintingon Reservoir Multipurpose Project (BRMP)
- AI-P-02: Balog-Balog Multipurpose Project Phase 2
- AI-P-09: Gumain Reservoir Project

The contents of these projects are described in *Sector Report C: Agricultural and Fishery Water Management.* The total installed capacity of hydropower plant by the projects AI-P-01 and AI-P-02 has been proposed to be 73.5MW.

H.4.2.6 Projects to Improve Inadequate Reliability of Water Supply in Angat- Umiray System

There are two types of projects to improve inadequate reliability of water supply in Angat-Umiray system; (1) Rehabilitation to Sustain Current Water Supply Capacity in Angat-Umiray System, and (2) Water Resources Development and Management for Recovery of Reliability.

(1) Rehabilitation to Sustain Current Water Supply Capacity in Angat-Umiray System

The following three projects are identified for the rehabilitation to sustain current water supply capacity in Angat-Umiray system.

- MW-G-01: Angat Water Utilization and Aquaduct Improvement Project (AWUAIP) Phase 2
- MW-P-01: Rehabilitation of Umiray-Macua Facilities
- AI-P-10: Rehabilitation of AMRIS

The contents of the projects MW-G-01, MW-P-01 are described in *Sector Report D: Municipal Water Supply, Sanitation and Sewerage System Management.* The contents of the project AI-P-10 is described in *Sector Report C: Agricultural and Fishery Water Management.*

(2) Water Resources Development and Management for Recovery of Reliability

(a) IS-C-02: Project for Recovery of Reliability of Water Supply in Angat-Umiray System

It is evaluated that the present reliability of water supply in Angat-Umiray system is not enough for both Municipal water supply for MWSS and irrigation water supply for AMRIS. To address this problem, the conceptual project for Recovery of Reliability of Water Supply in Angat-Umiray System is proposed. The project would include both new water resources development and reduction of water demand. The alternative study on this project is conducted in Chapter H.4.4 in order to discuss the direction of the project.

(b) IS-C-04: Capacity Development of NWRB and Relevant Agencies on Water Allocation and Distribution

In order to cope with the future incremental potential conflicts among water users, it is indispensable to improve the methodology of water allocation as well as water permitting system. From this point of view, this conceptual project is proposed to execute the capacity development of NWRB and relevant agencies on water allocation and distribution.

The contents of the project are described in Chapter H.4.3.4.

H.4.2.7 Projects to Prepare for Expected Increase of Conflict among Water Users, especially between Municipal and Irrigation Water Users

Four necessary non-structural measures are considered for the expected increase of conflict among water users, especially between municipal and irrigation water user; (1) Enhancement of Surface Water Monitoring, (2) Improvement of Methodology of Water Allocation and Water Permitting System, (3) Adaptation to Uncertainty on Water Resources due to Possible Climate Change in Future, and (4) Improvement of Dam Operation for Dam Safety and Flood Control.

(1) Enhancement of Surface Water Monitoring

(a) IS-C-03: Enhancement of Monitoring System for Surface Water in Pampanga River

The usage of surface water will increase and become more complicated, because of very complicated water movement by abstraction for irrigation and municipal use and their return flow. To utilize the limited water resources more efficiently and effectively, it is vital to monitor the actual condition of water movement by natural and artificial drainage system. The conceptual project for Enhancement Monitoring System for Surface Water in Pampanga river basin is proposed to realize the inter-sector surface monitoring system by enhancing the existing monitoring system by each sector and agency.

The contents of the project are described in Chapter H.4.3.3.

(2) Improvement of Methodology of Water Allocation and Water Permitting System

The following project is proposed.

- IS-C-04: Capacity Development of NWRB and Relevant Agencies on Water Allocation and Distribution

This is not only a project to improve inadequate reliability of water supply in Angat-Umiray system, but also a project to prepare for the expected increase of conflict among water users in the entire Pampanga river basin on the basis of the experience in Angat-Umiray system.

The contents of the project are described in Chapter H.4.3.4.

(3) Adaptation to Uncertainty on Water Resources due to Possible Climate Change in Future

The following project is proposed.

- AI-C-02: Introduction of Water Saving Irrigation Technology

This project is included in the projects for Agriculture/Irrigation and Fishery. The contents of the project are described in *Sector Report C: Agricultural and Fishery Water Management.* It is expected that a standard methodology for future planning on reduction of water demand by the WST will be established in order to prepare for occurrence of drought due to climate change.

(4) Improvement of Dam Operation for Dam Safety and Flood Control

The following project is proposed.

- FL-G-04: Flood Forecasting and Warning System Capacity Building Project upon Dam Release in the Philippines

This project is included in the projects for Management for Flood and Sediment Disaster Problems. The contents of the project are described in *Sector Report E: Flood and Sediment Disaster Management.* In the project, institutional matter related to authorization of the flood operation rule is also one of important issues.

H.4.3 Project Component for the Conceptual Projects

H.4.3.1 IS-C-01: Establishment of Comprehensive Groundwater Monitoring in Pampanga River Basin

It is recommended that periodical intensive groundwater monitoring for the municipalities and cities whose groundwater usage is at risk. There is also inferred land subsidence in the lower reach of the study area based on some previous studies, which should be verified in detail. Considering these, the conceptual projects for Establishment of Comprehensive Groundwater Resources Monitoring in Pampanga River Basin is proposed in the present study.

(1) Proposed Activities

The projects should include the following activities.

(a) Establishment of monitoring wells and observation

- Proper locations and density of monitoring wells to capture the lowering of groundwater level and salt-water intrusion in a basin scale, especially for lower reach of Pampanga river basin, should be selected.
- Monitoring wells for sole use should be installed.
- Monitoring network for land subsidence in lower reach of the study area should be installed, utilizing the installed monitoring wells.
- Database and their management system should be established.
- Water level and water quality in the monitoring wells should be periodically monitored by WDs, LGUs etc.
- The monitoring results should be stored in one database and shared by stakeholders.

(b) Groundwater resource management

- Groundwater resource management by NWRB and/or river basin organization based on the periodically monitored data, which may include the policy establishment for groundwater regulation and so on, should be implemented.

(2) Project Cost

The initial investment cost is roughly estimated by assuming the following.

- It is assumed that the average density of monitoring wells is 1monitoring well/30km^2 in average.
- The monitoring wells would be installed in plane area with 5,400km^2, which requires about 180 monitoring wells.
- It is assumed that the cost for developing a monitoring well is 1.5Mil. Pesos/well, which results in 270Mil. Pesos for installing the monitoring wells. It is further assumed that 10% of the cost for installation of monitoring wells is required for establishing the data management system as well as monitoring network for land subsidence.
- The estimated initial investment cost is 297Mil. Pesos.

The O&M cost is roughly estimated by assuming the following.

- Annual maintenance cost for the installed monitoring wells and data management system is assumed to be 0.5% of the initial investment cost.
- The cost for observation by observer is assumed to be 12,000pesos/well/year, which requires 2.2Mil. Pesos/year for operation of the monitoring.
- The estimated annual O&M cost is 3.7Mil. Pesos/year.

(3) Proposed Implementation Schedule

It is proposed that the installation of monitoring wells would be gradually expanded during 15years. The lower Pampanga area should be firstly covered by the monitoring wells.

H.4.3.2 IS-C-02: Project for Recovery of Reliability of Water Supply in Angat-Umiray System

This project is discussed in details in Chapter H.4.4.

H.4.3.3 IS-C-03: Enhancement of Monitoring System for Surface Water in Pampanga River

The usage of surface water will increase and become more complicated, because of very complicated water movement by abstraction for irrigation and municipal use and their return flow. To utilize the limited water resources more efficiently and effectively, it is vital to monitor the actual condition of water movement by natural and artificial drainage system. The conceptual project for Enhancement Monitoring System for Surface Water in Pampanga River Basin is proposed to realize the inter-sector surface monitoring system by enhancing the existing monitoring system by each sector and agency.

(1) Proposed Activities

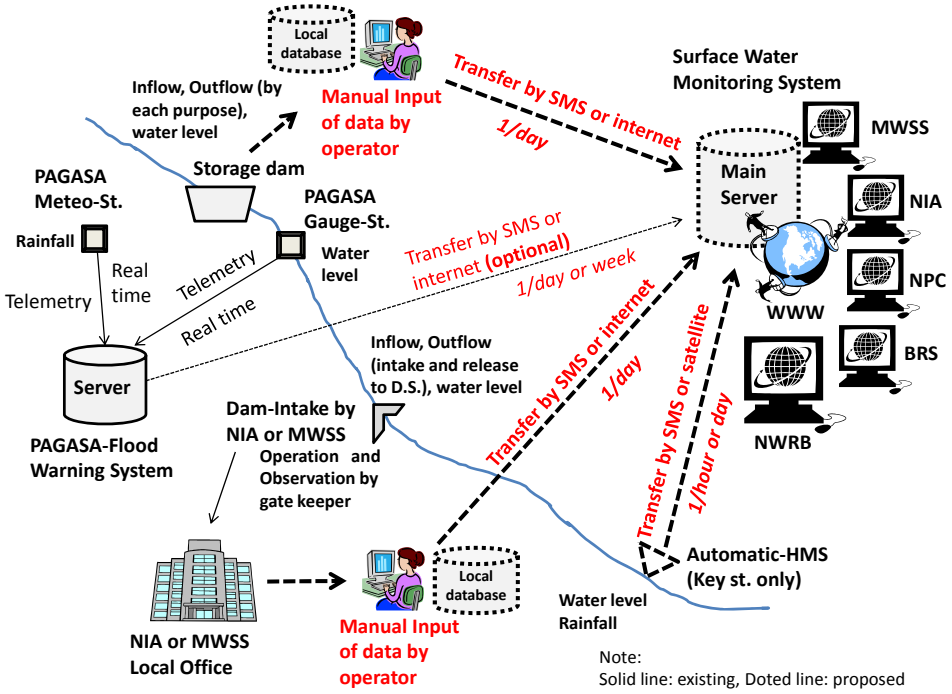
The projects should include the following activities.

(a) Establishment of monitoring networks

- Proper and important monitoring locations for capturing the actual movement of surface water in the basin should be selected. The monitoring points may include the existing hydrometric stations, large storage dams and major intakes. Tentatively recommended monitoring locations are shown in Annex-F H.4.3.1.
- At the selected monitoring stations, the strengthening of monitoring method such as automatic observation and transfer of data should be introduced. Database and their management system should be established. The schematic diagram of data acquisition and sharing for the proposed surface water monitoring system is shown in Figure H.4.3.1 and the recommended measures are summarized in Table H.4.3.1.
- Monitoring results should be stored in one database and shared by stakeholders.

(b) Surface water resource management

- Surface water resource management by NWRB and/or river basin organization based on the monitored data should be conducted. The monitored data may be utilized for controlling water use permit.



Source: JICA Study Team

Figure H. 4.3.1 Schematic Diagram of Data Acquisition and Sharing for Proposed Surface Water Monitoring System

Table H. 4.3.1 Recommended Measures for Enhancement of Surface Water Monitoring System

Item	Recommended measures	Quantity		
		Umiray-Angat	Pampanga Main & Pasac	Total
Main data storage and database management system	- Establishing main database and data transfer system - Software and system development for database management system	0	0	1
Storage dam	- Establishing local database and data transfer system • Inflow, Outflow (by each purpose and/or each pipe/spillway etc.), Water level of storage dam	1	1	2
Dam-Intake by NIA and MWSS	- Establishing local database and data transfer system • Inflow, Outflow (Intake vol., release vol. to downstream), Water level of dam	2 (AMRIS, MWSS)	4 (UPRIIS, PDRIS, TASMORIS, Porac-Gumain)	6
HMS (Key st. only)	- Assessment of existing data and site conditions - Installation of automatic gauge(water level and rainfall) and cable facilities for discharge measurement - Establishing data transfer system • Water level, Rainfall - Discharge measurement and establishment of H-Q curve	0	1	1
PAGASA flood warning system	- Establishing data transfer system (optional) • Water level, Rainfall	0	1	1

Source: JICA Study Team

(2) Project Cost

The initial investment cost is roughly estimated by assuming the following.

- Unit cost for installation of automatic gauge station and cable facilities for discharge measurement with data transfer facilities = 5.0Mil.Pesos/st.
- Unit cost for installation of local database and data transfer facilities = 0.25Mil.Pesos/st.
- Unit cost for installation of main database and data transfer facilities = 0.50Mil.Pesos/st.
- The cost for software and system development is assumed to be 25% of the installation cost for the facilities.
- The estimated initial investment cost is 10Mil. Pesos.

The O&M cost is roughly estimated by assuming the following.

- Annual maintenance cost for the installed facilities is assumed to be 0.5% of the initial investment cost.
- Unit cost for data transfer = 0.075Mil.Pesos/st./year
- Unit cost for observer for HMS = 0.012Mil.Pesos/st./year
- Unit cost for operator for data input and transfer = 0.12Mil.Pesos/st./year
- Unit cost for discharge measurement = 0.05Mil.Pesos/ st./year
- The estimated annual O&M cost is 2.0Mil. Pesos/year

(3) Proposed Implementation Schedule

It is proposed that the project be implemented firstly in Umiray-Angat system as a pilot project. Then, the remaining area in Pampanga river basin should be covered by the project after getting the lesson and learned from the pilot project.

(4) Advantage and Disadvantage of the Project

(a) Advantage

- The monitored data may be utilized for controlling water use permit.
- The accumulated monitoring data will benefit significantly for the preparation of the next river basin management planning so as to grade-up the spiral of IWRM process.

(b) Disadvantage

- Additional budget and human resources will be required for implementation of the project, especially for O&M of the project.

H.4.3.4 IS-C-04: Capacity Development of NWRB and Relevant Agencies on Water Allocation and Distribution

To recover the inadequate reliability of water supply in Angat-Umiray system, it is indispensible to improve water allocation including refinement of water use permit. The capacity development of NWRB and Relevant Agencies on Water Allocation and Distribution is proposed as one of conceptual projects, in order to improve the water governance by NWRB.

The operation of hydropower plant should be well balanced for other functions of the storage dam such as flood control, water use for irrigation and municipal water supply. The proper regulation of operation of hydropower plant is also one of the topics to be dealt with in the project.

The project is also to prepare for the expected increase of conflict among water users in the entire Pampanga river basin and even in the entire country in long-term on the basis of the experience in Angat-Umiray system.

Two phases are considered for implementation for total 5years. In the 1st phase, Angat-Umiray system will be mainly dealt with as a pilot area. Based on the experience in 1st phase, 2nd phase will be implemented for the entire Pampanga river basin or nation-wide activity.

(1) Expected Outputs

The expected outputs of the project are as follows.

- Improvement of water permitting system, especially for irrigation water use, in Angat-Umiray system,
- Enhanced Capacity of NWRB and relevant agencies on operation of water allocation and its monitoring in Angat-Umiray system,
- Identification of critical area for water conflict in the nationwide considering possible future climate change,
- Preparation of framework for application of the refined methodology for water allocation and water permitting system to the identified critical areas, and
- Recommendation on improvement of institution and legislation, through the activities on the project.

(2) Project Activities

The necessary project activities are proposed as follows.

(a) Strengthened capacity of NWRB on water allocation and water permitting system in Angat-Umiray system

- Review on the existing water permitting system including the methodology and practice on its amendment,
- Clarification and evaluation of water demand in Angat-Umiray system, especially for irrigation water demand,
- Clarification of existing water resources development plan and evaluation of water

resource potential including water balance simulation in Angat-Umiray system,
- Examination of appropriate water use permit for irrigation water use considering actual irrigation activities,
- Proposal of refined methodology on water allocation and water permitting system including the methodology on amendment and modification on the existing water use permit,
- Stakeholder consultation on the proposed methodology on water allocation and water permitting system, and
- Preparation of a draft guideline for the refined methodology on water allocation and water permitting system through the activities in Angat-Umiray system.

(b) Enhanced capacity of NWRB and relevant agencies on operation of water allocation and its monitoring in Angat-Umiray system

- Review on existing meteo-hydrological data, monitoring data as well as the existing monitoring system in Angat-Umiray system,
- Installation of necessary measuring devices and simple information communication system for monitoring and effective control of water allocation in Angat-Umiray system,
- Preparation of database for storing and sharing the monitored data in Angat-Umiray system,
- Monitoring of meteo-hydrological condition and water use by stakeholders and information sharing among stakeholders on the monitored data in Angat-Umiray system,
- Water balance simulation for examination on operation rule of the reservoir in Angat-Umiray system,
- Preparation of general operation rule of the reservoir in Angat-Umiray system, considering the existing water resources potential and water demand,
- Implementation of real-time water allocation through technical working group (TWG) based on the general operation rule and the monitored data in Angat-Umiray system, and
- Preparation of a draft guideline for operation of water allocation and its monitoring through the activities in Angat-Umiray system.

(c) Developed capacity of NWRB on identification of critical area for water conflict in the nationwide considering possible future climate change

- Review on existing water use permit and water resources in the nationwide,
- Study on vulnerability of water resources due to possible future climate change in the nationwide,
- Identification on critical areas for water conflict in the nationwide based on the existing water use permit, the expected future water demand and water resources potential, and
- Stakeholder consultation on the critical areas for water conflict in the nationwide.

(d) Developed capacity of NWRB to implement the proposed new methodology on water allocation and water permitting system in the nationwide

- Application of the refined methodology for water allocation and water permitting system to some of the critical areas,
- Preparation of the revised guideline for the refined methodology on water allocation and water permitting system for the nationwide,
- Stakeholder consultation on the revised guideline,
- Preparation of roadmap for improvement of water allocation and water permitting system in the nationwide, and
- IEC on the water permitting system including the refined methodology in the nationwide.

(e) Recommendation on improvement of institution and legislation, through the activities on the project

- Review on existing law and legislation related to water use permit,
- Clarification on the on-going activities on revising Water Code,

- Identification on necessary improvement of law and legislation for refinement of water allocation and water permitting system,
- Identification of necessary improvement of organizational framework on operation of water allocation, and
- Recommendation on improvement of institution and legislation.

(3) Project Proponent

- Main C/P agency: NWRB
- Main agencies to be involved: NIA, MWSS, NPC, Relevant LGUs

(4) Necessary Input and Budget

Input on technical assistance by foreign expert team for 5years should be considered. The necessary budget is tentatively estimated at 300Mil. Pesos (60Mil.Pesos/year).

H.4.4 Preliminary Study on Alternative Approaches to Specific Issues on Water Resources Development, Allocation and Distribution

H.4.4.1 General

As described in *Sector Report J: Guideline for Formulation of IWRM Plan*, the IWRM Plan shall take the following fundamental rules:

- The feasibility study shall be included as a part of the project and undertaken before commencement of the physical project works.
- The outline of the project features together with the project investment cost required shall be provisionally assumed talking the conceptual alternative approaches into account, and
- The preliminary study on the particular project(s) may be carried out to assume the most-likely optimum plan, when the project(s) is judged to prominently influential to the entire IWRM Plan and at the same time, the basic information for the preliminary study are available.

Based on the rules, the preliminary study on Project for Recovery of Reliability of Water Supply in Angat-Umiray System (IS-C-02) is conducted in the present study.

H.4.4.2 Background and Purpose of Proposed Project

To achieve the goals for sector for agriculture/irrigation and fishery and sector for municipal water supply, sanitation and sewerage, there is sometimes conflict between the sectors. The reduced cost for water supply is an important theme for both improving water supply quality and increasing necessary water supply capacity. The surface water resources in Pampanga river basin has already been widely utilized for irrigation. Because the less costly options are usually developed earlier, the remaining options are getting costly and costly. Therefore, the reallocation of the irrigation water, which uses less costly water source, to municipal water is usually the best option in terms of the reduced cost for municipal water supply by surface water source. However, the reduction of irrigation area with the reallocation of irrigation water use is completely opposite direction of the goal for agriculture/irrigation sector.

The irrigation water for AMRIS was conditionally reallocated to municipal water use for Metro Manila in 1988. It has caused a severe conflict between municipal water users and irrigation water users. Recently, the water shortage happens in almost every two years in Angat-Umiray system. It has been clarified that the main cause of the conflict is the increase of water allocation to municipal water use without adequate water resources development. New water resources development is really necessary just to recover the reliability of the water supply for the present water demand. There are also several issues on the water allocation as shown in Chapter H.4.1.3 (Details on complicated situation of the water allocation is described in Chapter H.2.5).

Bulacan Treated Bulk Water Supply Project is proposed to address the deterioration of groundwater water quality due to salt-water intrusion in Bulacan. The project will deliver the treated surface

water to WDs in Bulacan. The most possible water source of the project is Angat-Umiray system, based on the MOU among MWSS, LWUA and Bulacan Government in 1992. On the other hand, the most promising water resources development in Angat-Umiray system in the near future is Sumag River Diversion Project. The results of water balance simulation show that no significant change from the present condition on the reliability of water supply would be expected even if Bulacan starts its abstraction of 2.7m^3/s from Ipo Dam after the completion of the Sumag intake. However, there will still be water shortage in almost every two years in Angat-Umiray system.

The reliability of water supply for both municipal water use and irrigation water use in Angat-Umiray system should be recovered as soon as possible, to secure reliable drinking water source for people in Metro Manila and Bulacan as well as to secure the irrigation product and associated income for famers in AMRIS. This section discusses the future direction of recovery of reliability of water supply in Angat-Umiray system with several possible options and alternatives by their combination.

The bitter experience on the conflict in Angat-Umiray system should not be repeated in other areas in Pampanga river basin. To deal with the existing problems in Angat-Umiray system will be good lessons and learned for preparing the expected increase of the conflict on water allocation in Pampanga river basin.

H.4.4.3 Preliminary Study on Project for Recovery of Reliability of Water Supply in Angat-Umiray System (IS-C-02)

(1) Basic Concept

The basic concept for the project is set as follows.

(a) Target

- To recover the reliability of water supply for both MWSS and AMRIS
- To prepare surface water source for Bulacan Treated Bulk Water Supply Project with reasonable reliability

(b) Strategy for Irrigation

(i) Irrigation Area in AMRIS

To achieve the goal of agricultural/irrigation sector in Pampanga river basin, it is required to expand irrigation area as much as possible. On the other hand, to secure reliable water source for bulk water supply for Bulacan is also important to achieve the goal in the sector of municipal water supply. However, the water resource in Angat-Umiray system is quite limited. Considering these conditions, the strategy on dealing with the irrigation area in AMRIS for the project is set as follows.

- The current irrigation area in AMRIS should not be reduced unless there is special intention by NIA to reduce it.
- All efforts within its on-firm activities should be made to reduce the irrigation water demand but maintaining the current irrigation area and yield.

(ii) Conveyance by Pumps for Irrigation Water

It is usually costly to utilize pumps for delivery of irrigation water, which causes high operation and maintenance cost and high irrigation service fee for farmers. The conveyance of irrigation water by pumps should be avoided.

(c) Planning Conditions

(i) Target reliability of water supply

- Municipal water supply：1/10years

- Irrigation water supply：1/5years

(ii) Discharge data for checking reliability of water supply

- Duration of simulation: 50years (1958 – 2007)
- Unit of time step: monthly
- Inflow to Angat storage dam: Observed inflow (1968-2007) and simulated runoff (1958-1967)
- Discharge in tributary: simulated runoff
- Inflow from Umiray-Angat trans-basin tunnel: Average monthly inflow during 2001-2003 and 2006-2007 for existing condition, Incremental inflow by Sumag intake is given considering its catchment area.

(iii) Flood operation rule

It is assumed that there will be no change in flood control volume as well as flood operation rule.

(iv) Municipal water demand

The following municipal water demand is assumed.

- Municipal water demand for MWSS = 46m^3/s
- Municipal water demand for Bulacan Treated Bulk Water Supply= 2.7m^3/s

(v) Irrigation water demand

The current irrigation area of AMRIS should be assessed based on the latest information such as landuse map and CLUP. However, at this moment, the following irrigation area shown by NIA is used as the current irrigation area for the present alternative study.

- 26,000ha in dry season and 20,355ha in wet season

Diversion water requirement for the current irrigation area in AMRIS should be determined by discussion with NIA. At this moment of the study, unfortunately, the study team could not obtain the proposed diversion water requirement with considering effective rainfall by NIA. Therefore, the following diversion water requirement estimated by the study team is tentatively employed for the present alternative study.

Table H. 4.4.1 Diversion Water Requirement in AMRIS for Alternative Study

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec	Ave.
DWR (m^3/s)	41.3	41.7	32.2	9.7	0.0	25.5	9.9	1.2	5.4	10.1	18.8	34.2	19.2

Source : JICA Study Team

(vi) Environmental flow

10% of dependable flow in quasi-natural condition is secured as a first priority at the following locations.

- Release point from main turbine of Angat hydropower plant in Angat River
- Downstream of Bustos Dam in Angat River
- Downstream of proposed Bayabas storage dam in Bayabas River

(vii) Condition of water resources facilities before the implementation of project

It is assumed that the current water resources facilities such as Angat storage dam, Umiray-Angat trans-basin tunnel, Umiray intake, Ipo Dam and Bustos Dam will

be kept in good condition. It is also assumed that Sumag intake in Umiray River will be completed.

(2) Right and Responsibility

According to Article.22 of Water Code, the study team considers that there is the following right and responsibility on Angat-Umiray system.

- First applicant has higher priority in normal condition.
  - 1st priority: NIA, 2nd priority: Municipal (MWSS & Bulacan) except for Umiray-Angat trans-basin scheme
  - 1st priority: Municipal (MWSS & Bulacan) for Umiray-Angat trans-basin scheme
- In case of emergency, municipal water has highest priority
  - 1st priority: Municipal (MWSS & Bulacan), 2nd : NIA
- When water shortage is recurrent, the appropriator for municipal water use (if it is later applicant) has to prepare alternate water source.
  - MWSS has to prepare the alternate water source to recover the reliability of water supply for the current demand.
  - Bulacan has to prepare additional water source to augment the reliability of water supply.

According to Article.20 of Water Code, the study team considers that there is the following responsibility on irrigation water use.

- The granted water should be utilized only for beneficial use in the right amount.
  - AMRIS has to determine the right amount of water demand (diversion water requirement) for irrigation purpose.
  - The water demand without effective rainfall is not the right amount. Only the right amount should be secured as the first applicant.

(3) Possible Options for Recovery of Reliability of Water Supply and Screening

There are three categories of possible options for recovery of reliability of water supply in Angat-Umiray system. Two categories are options in Pampanga river basin, and another is option outside Pampanga river basin. The possible options are shown in Table H.4.4.2. Among the possible options, four (4) options are selected for further alternative study, considering the basic strategy shown in Chapter 4.4.3(1) (b) in the present study. The details for each possible option are described below.

Table H. 4.4.2 Possible Options

	Category	Option	Selection
Options in Pampanga River Basin	A: Options to Increase Water Resources Potential in Angat-Umiray System	A-1: Bayabas storage dam	Selected
	B: Options to Decrease Irrigation Water Demand at Bustos Dam	B-1: Balintingon storage dam and conveyance to AMRIS	Selected
		B-2: Conveyance excess water from UPRIIS to AMRIS	
		B-3: Upgrading and improvement of irrigation facilities and water management of AMRIS	Selected
		B-4: Direct abstraction of surface water of Pampanga River at around Apalit and conveyance by pumps to AMRIS	
		B-5. Water saving technology (WST)	
Options outside Pampanga River Basin	C: Options to Reduce MWSS Water Demand at Ipo Dam	C-1: Reduction of MWSS water demand from Ipo Dam by other water sources outside Pampanga river basin such as Laiban Dam	Selected

Source : JICA Study Team

(a) Option A-1: Bayabas storage dam

The construction of Bayabas storage dam in Bayabas River, a tributary of Angat River, with 110m in height and 144MCM in effective storage volume, was originally proposed in World Bank project[14)] in 1994. This is only possible option to increase water resources potential in Angat-Umiray system (see Figure H.4.4.1).

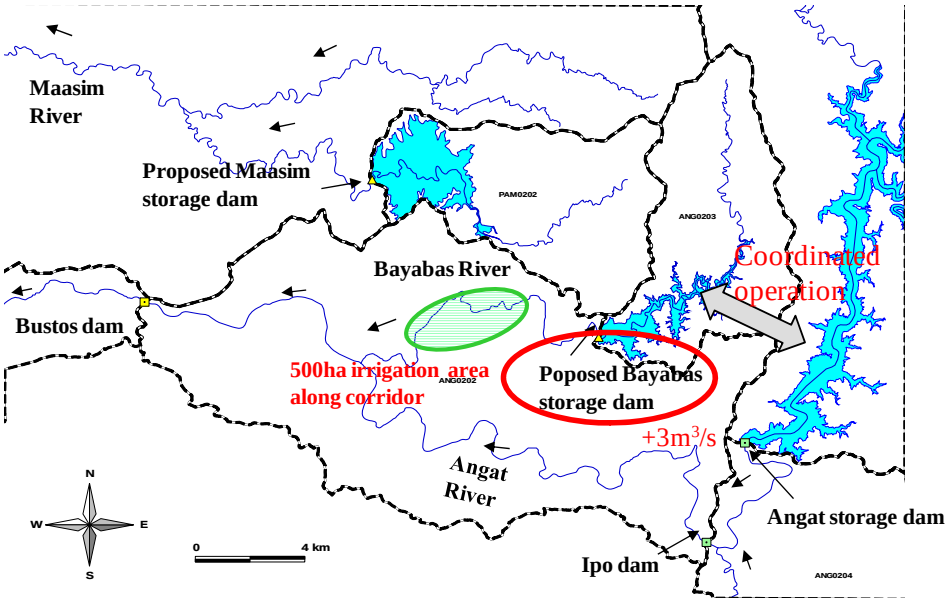
Bayabas storage dam could be utilized to supply irrigation water to AMRIS only when the water level in the Angat storage dam is very low and in critical condition. The water resources potential in Bayabas storage dam itself is about $3m^3/s$. However, coordination on releases from the two dams is essential to mitigate the effect of restricted releases from Angat storage dam to AMRIS at water level lower than 180 m above mean sea water level in Angat storage dam.

According to the previous World Bank project in 1994 with pre-F/S level study, it is necessary to provide irrigation water to irrigation area of about 500ha along corridor of Bayabas River, prior to supplying irrigation water to AMRIS.

The latest geological study for the proposed Bayabas Dam site and its watershed, which was conducted by MGB together with provincial government of Bulacan, revealed that there is a potential risk of severe erosion at just upstream area of the proposed dam site[35)].

The severe erosion is being observed in the Buhai housing project area, which could be mainly because of unregulated site development by the project. The latest geological study proposed to relocate the dam site to upstream area, although it may bring about significant reduction of the storage volume. In the present study, however, it is assumed that the originally proposed dam site could be still usable and/or almost same storage volume could be kept even if the dam site is relocated.

To utilize this option, proper institutional arrangement would be required. Water use permit has been granted to the Bulacan government in 2004 at this site, so it is necessary to review the water use permits granted to different stakeholders such us NIA, MWSS and Bulacan and the first water right given to NIA at Bustos dam located at the downstream of the proposed Bayabas Dam in order to avoid water use conflicts.



Source: JICA Study Team

Figure H. 4.4.1 Proposed Bayabas Storage Dam

(b) Option B-1: Balintingon storage dam and conveyance to AMRIS

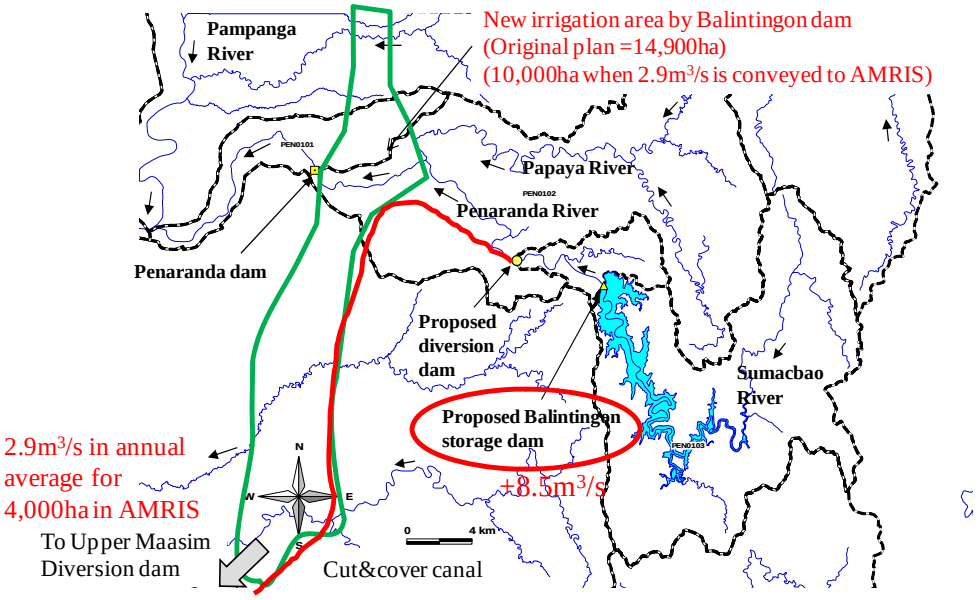
This option was proposed to convey the stored water in the proposed Balintingon storage dam, with 138m in height and 488MCM in effective storage volume, to upper Maasim diversion dam in Maasim River to mitigate the water shortage in AMRIS. It was confirmed that this option would be technically possible by the previous study by CALENERGY[36] in 2006 (see Figure 5.2.2).

In the study, the following three options for conveyance were examined: 1) Rehabilitation and expansion of existing UPRIIS division-4 CX-3 canal from Peneranda diversion dam. 2) New construction of cut& cover canal from proposed diversion dam, 3) New construction of tunnel from proposed diversion dam. Among this, rehabilitation and expansion of existing UPRIIS division-4 CX-3 canal was recommended because of the lowest cost. However, according to NIA, it is actually difficult to connect the existing CX-3 canal to upper Massim diversion dam. The present study recommends the construction of cut and cover canal to convey water from UPRIIS to upper Maasim Dam.

To utilize the water in Peneranda River, in which Balintingon storage dam is proposed to be constructed, proper institutional arrangement on how to deal with the existing water use permit granted to NIA at Penaranda Dam and expected newly applied water use permit for Balintingon storage dam would be one of important issues. The total water use permit granted at Peñaranda Dam is 27m^3/s which is almost equal to annual average discharge in the dam. This shows that there will be no water available for the Balintingon storage dam if 27m^3/s is granted throughout the year at Peñaranda dam.

UPRIIS division-4 has already existing water use permit in Peñaranda River, which should be first prioritized over other users. It is estimated that with the existing actual water use by UPRIIS division-4, the maximum available water for allocation for other users is only about 8.5 m^3/s in annual average.

From upper Maasim diversion dam in Maasim River, only 4,000ha can be supplied by gravity, according to NIA. In this case, 2.9m^3/s in annual average would be conveyed to AMRIS and be supplied to 4,000ha in AMRIS. The remained 22,000ha in AMRIS would be supplied from Bustos Dam.



Source: JICA Study Team

Figure H. 4.4.2 Proposed Balintingon Storage Dam and Conveyance to AMRIS

Balintingon storage dam was originally proposed for increasing new irrigation area as one of the proposed projects in agriculture/irrigation sector (Code: AI-P-01), which means that there would be potential conflict between the original ideas to increase new irrigation area and the idea to mitigate the shortage of water in Angat-Umiray system. In case that 2.9m^3/s in annual average would be conveyed to AMRIS, the new irrigation area by Balintingon storage dam would be reduced to 10,000ha, although the original plan is 14,900ha. The reduction of new irrigation area is opposite direction to achieve the goal in agricultural sector. Considering these conditions, it could be difficult to realize this option. Proper institutional arrangement is necessary.

(c) Option B-2: Conveyance excess water from UPRIIS to AMRIS

This option is similar to Option B-1. Instead of getting water from the proposed Balintingon storage dam, the excess water from UPRIIS of about 1.5m^3/s will be conveyed to lower Maasim Dam in Maasim River to irrigate 2,000 hectares in AMRIS. The remaining 24,000 hectares will be irrigated from Bustos dam.

However, the excess water will be available only when the expansion of new irrigation area in UPRIIS division-5 will be canceled or reduced. To cancel and/or reduce the development of new irrigation area in UPRIIS division-5 is not realistic, because the diversion facilities such as new canal called as “Super diversion canal”, which was optimized and designed assuming full development of the new irrigation area, has already been completed by the Casecan Project Phase-1. Reduction of the irrigation area contradicts the goal of the agricultural sector, and considering the investment by the Casecnan Project Phase 1, the present study does not recommend this option.

This option can be considered as only temporary measure to lessen the effect of irrigation water shortage in AMRIS for the mean time that the Casecnan Project Phase 2 is not yet implemented.

(d) Option B-3: Upgrading and improvement of irrigation facilities and water management of AMRIS

This option is to upgrade the main canals in AMRIS by concrete lining in order to reduce the conveyance loss in the canals. By the concrete lining of the main canals, 5% of diversion water requirement would be reduced by preventing leakage from canals.

In this case, water demand in AMRIS is reduced by an annual average of 1.0m^3/s.

It should be noted that this option was initially proposed as one of conceptual projects in agriculture/irrigation sector. The following activities should be included.

- Concrete lining of main canals
- Improvement of water control facilities,
- Provision of water discharge measurement device and control system
- Real time monitoring and communication system with Angat dam
- Capacity building of the irrigators' associations

(e) Option B-4: Direct abstraction of surface water of Pampanga River at around Apalit and conveyance by pumps to AMRIS

This option was considered by MWSS as one of possible options for alternate source of Angat-Umiray system. The water is abstracted at around Apalit in Pampanga River and it is conveyed to AMRIS by pumps.

This option, however, requires huge amount of energy for pumping, causing extremely high operation and maintenance cost. In addition, it has been estimated that the possible water volume to be directly abstracted from Pampanga River at around Cong Dadong dam with 1/5years safety level for all water users in the downstream reach in driest month in a drought year is just less than 2.5m^3/s, based on the water balance study presented in Chapter H.3.3.2. Referring the strategy for irrigation shown in Chapter H.4.4.3(1) (b), this option is not selected for further alternative study.

(f) Option B-5: Water saving technology (WST)

Department of Agriculture Administrative Order No.25-2009 "Guidelines for the Adaptation of Water Saving Technologies (WST) in Irrigated Rice Production Systems in the Philippines" enhances water saving technology (WST) for preparing to uncertainty on water resources due to possible climate change in future. According to it, 15-35% reduction of irrigation water allocation could be saved without significant yield reduction. In the agriculture/irrigation sector, Introduction of Water Saving Irrigation Technology (Code: AI-C-02) has been proposed as one of conceptual projects.

However, the WST is still experimental and the effect on reduction of total diversion water requirement in a scale of entire irrigation system has not yet been clearly measured. Therefore, there is a high risk of reduction of irrigation product (equivalent to reduction of the irrigation area) at this moment, when one assumes the reduction of diversion water requirement as one of planning options. Referring the strategy for irrigation shown in Chapter H.4.3.3(1) (b), this option is not selected for further alternative study.

This option could be used as one of self-defending measures by AMRIS to lessen the risk of water shortage for irrigation water supply, until a standard methodology for future planning on reduction of water demand by the WST will be established

(g) Option C-1: Reduction of MWSS water demand from Ipo Dam by other water sources outside Pampanga river basin such as Laiban Dam

According to the master plan for water supply in Metro Manila in 2005[31)], Laiban Dam and Kanan No.2 Dam will be constructed by 2015 and 2021, respectively. These dams will be basically utilized for future increase of water demand in Metro Manila.

The water demand estimated in the master plan assumed the projected non-revenue water ratio as shown in Table H.4.4.3. The physical losses ratio was assumed to be 85% of the non-revenue water ratio, and the total system water demand at water source was estimated by adding the physical losses to the total water demand.

Table H. 4.4.3 Projected Non Revenue Ratio in MWSS Master Plan in 2005

	2010	2015	2020	2025
NRW Ratio (%)	45	34	31	30
Physical Losses Ratio (%)	38	29	26	26

Source: MWSS Master Plan in 2005

According to the annual report on 2008 of Manila Water Company Inc.[37)], one of the concessionaries, the non-revenue water ratio in its service area was already reduced to less than 20% in 2008 by its remarkable effort. It is less than the projected one for 2025 in the master plan in 2005. If Manilad Water Service Inc., another concessionaire, will be able to perform with the similar way, the non-revenue water ratio in Metro Manila will be at least 20% in 2025, which is 10% less than the predicted one.

Considering the expected lower non-revenue water ratio in future, some excess water may appear after Laiban Dam and/or Kanan No.2 Dam will be completed. When the non-revenue water ratio is 10% less, about 6-7m^3/s of excess water after the completion of Laiban Dam can be expected. In this case, MWSS may be able to reduce the demand from Ipo Dam.

The Laiban Dam project is supposed to be implemented by BOT scheme with San Miguel Company. However, MWSS terminated the negotiations for the joint venture proposal of San Miguel Company on March 4, 2010. At this moment, it is very unclear what will be the long-term water source for MWSS service area, especially for 2015. The other possible options are Kaliwa low dam, Agos Dam and Kanan No.2 Dam, based on the master plan in 2005. However, it is expect that any new water source development may not catch up with the expected demand in 2015, if Laiban Dam will not be implemented as it is planned. This is not only simply the problem for Angat-Umiray system but also the crucial issues on drinking water supply for people in Metro Manila in future. According to MWSS, as of October 2010, MWSS is still exploring the revised future water demand-supply plan for its service area. Although there are many uncertainties on the Option C-1, at this moment of the study, it is assumed that Laiban Dam represents the Option C-1 for further discussion.

(4) Comparison of Selected Options

The cost for raw water is roughly estimated for selected options, referring the previous studies. The cost includes the development and O&M cost for storage and conveyance and does not include the cost for water treatment. The cost is converted to annual cost, assuming the interst rate of 10% and project life time of 50 years.

Table H.4.4.4 shows the cost for each option. The unit cost for Option B-3: Upgrading AMRIS is the cheapest. The unit cost for other options is almost same with 7-8.5pesos/m^3.

Table H. 4.4.4 Cost for Selected Options

Option	Unit Cost (pesos/m^3)	Water quantity (m^3/s)	Water quantity (MCM/year)	Annual cost (mil pesos/ year)	Remarks
Option A-1: Bayabas	7.1	3.0	95	675	Annualized cost for construction and O&M O&M cost =0.5% of construction cost Cost for rehabilitation of degradated slopes is not included.
Option B-1: Balintingon	8.6	8.5	268	2,294	Annualized cost for construction and O&M O&M cost =0.5% of construction cost
Option B-3: Upgrading AMRIS	5.3	1.0	32	168	Annualized cost for construction and O&M US$1,000/ha x 26,000ha is assumed. O&M cost =0.5% of construction cost
Option C-1: Laiban	8.5	21	662	5,653	Annualized cost for construction and O&M O&M cost =0.5% of construction cost

Note: 1) Price level is converted to 2009.
2) To calculate annual cost, discount rate of 10% and 50 years project duration are assumed.
Source: JICA Study Team

Table H. 4.4.5 Comparison among Selected Options

Case	Unit Cost (pesos/m^3)	Maximum Quantity (Annual Average) (m^3/s)	Socio-Environment	Institutional Arrangement	Technical Viability
Option A-1: Bayabas	7.1	3.0	Resettlement is minimal. Environmental flow could be concern.	**Water use permit has been granted to Bulacan Gov. It is necessary to review the water use permit granted to NIA, Bulacan and MWSS.**	**Geological condition must be investigated carefully.**
Option B-1: Balintingon	8.6	2.9 (for gravity distribution of irrigation water in AMRIS)	**Number of Resettlement is order of 1,000 families.**	**Proper arrangement with exiting water use permit at Penaranda Dam is required. Conveyance of water to AMRIS requires agreement of Nueva Ecija and Bulacan.**	**Conveyance method should be carefully studied more.**
Option B-2: Upgrading AMRIS	5.3	1.0	No significant problem	No significant problem	No significant problem
Option C-1: *Laiban*	*8.5*	(21)	**Resettlement (4,300 families) is a big issue for implementation of Laiban Dam.**	**The proposed BOT scheme with San Miguel Company was canceled on March 4, 2010.**	No significant problem

Source: JICA Study Team

Table H.4.4.5 summarizes the comparison among options from several different points of view. The most economical and less problematic option is Option B-3: Upgrading AMRIS. However, the maximum quantity of this option is quite limited. The Option A-1: Bayabas has less problem in socio-environment. However, technical viability and necessary institutional arrangement are negative aspects. Both Option B-1: Balintingon and Option C-1: Laiban have negative aspects in socio-environment due to large number of resettlement.

(5) All Selected Options in Pampanga River Basin

Based on the water balance study, by application of all selected options in Pampanga river basin, municipal water supply would increase to 51.3m^3/s and AMRIS irrigation area will be maintained at 26,000 hectares during dry season. The additional 2.6m^3/s can be used for future municipal water supply. The annual cost for implementing all available options in Pampanga is estimated at 1,626 mil pesos/year. Table H.4.4.6 shows the summary of available municipal water supply when all selected options in Pampanga river basin is applied.

Table H. 4.4.6 Summary of Available Municipal Water Supply with All Selected Options in Pampanga River Basin

Case	Combination of Options	Annual Average Water Demand (m^3/s)		Restriction of Water Release in Angat Dam	Safety Level		Safety Level OK or NG	Annual Cost[3] (Mil pesos /year)
		Municipal from Ipo	AMRIS from Bustos		Municipal	AMRIS		
Existing	-	46.0	19.2	When WL<180m, no release for AMRIS.	1/10years	<1/2years	NG	-
Near Future with Sumag	-	48.7	19.2	When WL<180m, no release for AMRIS.	1/10years	<1/2years	NG	-
ALL Selected Options in Pampanga	Upgrading AMRIS + Bayabas[1] + Balintingon ($2.9m^3/s$)[2]	**51.3**	15.4	When WL<180m, no release for AMRIS.	1/10years	1/5years	OK	1,626

Remarks:
1) Coordinated operation is necessary. When WL<184m, Bayabas releases for AMRIS.
2) 4,000ha of 26,000ha in AMRIS is supplied by Balintingon. New irrigation area from Balintingon storage dam is 10,000ha (14,900ha in original plan).
3) To calculate the annual cost, discount rate of 10% and project life of 50 years is assumed.
Source: JICA Study Team

(6) Alternatives

When the target is to recover the reliability of water supply as shown below, it is not necessary to implement all options.

- Municipal water demand =48.7m^3/s (46m^3/s for MWSS and 2.7m^3/s for Bulacan)
- Irrigation area in AMRIS =26,000ha (dry season), 20,355ha (wet season)

The alternatives for the recovery of the reliability of water supply have been prepared by combining the options including options outside Pampanga river basin. Except for the alternative with Option A-1: Bayabas, if the restriction of water release when water level is less than 180m above mean sea level is not removed, much higher investment is required. Therefore, the alternatives without the Option A-1: Bayabas assumes a precondition that the restriction of water release when water level is less than 180m above mean sea level is removed. This precondition would be possible to be accepted after the water source outside Pampanga river basin such as Laiban Dam will be completed, because two different water sources can mitigate the risk of shortage of municipal water during severe drought condition. Otherwise, it may be risky to share all storage volume less than 180m above mean sea level by municipal water use and irrigation water use.

- Alternative-1
  - Option B-3: Upgrading AMRIS + Option A-1: Bayabas
- Alternative-2
  - Option B-3: Upgrading AMRIS + Option B-1: Balintingon ($2.9m^3/s$) + Option C-1: Laiban ($0.5m^3/s$)
- Alternative-3
  - Option B-3: Upgrading AMRIS + Option C-1: Laiban ($3.1m^3/s$)
- Alternative-4
  - Option C-1: Laiban ($4.0m^3/s$) only

The attained safety levels, necessary condition of water release in Angat storage dam as well as necessary annual cost for each alternative are summarized in Table H.4.4.7. The attained safety levels have been checked based on the water balance study.

Table H. 4.4.7 Summary of Attained Safety Levels, Necessary Conditions of Water Release in Angat Storage Dam as well as Necessary Annual Cost

Case	Combination of Options	Annual Average Water Demand (m^3/s)		Restriction of Water Release in Angat Dam	Safety Level		Safety Level OK or NG	Annual Cost[3] (Mil pesos /year)
		Municipal from Ipo	AMRIS from Bustos		Municipal	AMRIS		
ALT-1	Upgrading AMRIS + Bayabas[1]	48.7	18.2	When WL<180m, no release for AMRIS.	1/10years	1/5years	OK	843
ALT-2	Upgrading AMRIS + Balintingon ($2.9m^3/s$)[2] + Laiban ($0.5m^3/s$)	48.2	15.4	**Restriction of 180m above mean sea level should be removed.**	1/10years	1/5years	OK	1,085
ALT-3	Upgrading AMRIS + Laiban ($3.1m^3/s$)	45.6	18.2	**Restriction of 180m above mean sea level should be removed.**	1/10years	1/5years	OK	1,002
ALT-4	Laiban ($4.0m^3/s$)	44.7	19.2	**Restriction of 180m above mean sea level should be removed.**	1/10years	1/5years	OK	1,077

Remarks:
1) Coordinated operation is necessary. When WL<184m, Bayabas releases for AMRIS.
2) 4,000ha of 26,000ha in AMRIS is supplied by Balintingon. New irrigation area from Balintingon storage dam is 10,000ha (14,900ha in original plan).
3) To calculate the annual cost, discount rate of 10% and project life of 50 years is assumed.
Source: JICA Study Team

(7) Effect on Hydropower Generation

The effect on hydropower generation is checked for the alternatives, using the results of the water balance simulation. The followings are assumed for estimating hydropower generation.

- When water level is higher than flood operation rule curve (212m in dry season, 210m in wet season)
  - 1st priority: Main turbine (Assumed capacity = $150m^3/s$)
  - 2nd priority: Auxiliary turbine (Assumed capacity = $50m^3/s$)
  - 3rd priority: Lower tunnel or Spillway
- When water level is lower than flood operation rule curve (212m in dry season, 210m in wet season)
  - Release is based on water requirement by NIA and MWSS
  - For release to MWSS, priority is given to auxiliary turbine.

The estimated impact on hydropower generation is summarized in Table H.4.4.8. It is observed that in all cases, hydropower generation will increase from the present condition. In general, the more municipal water demand at Ipo Dam is reduced, the more hydropower is generated. The incremental benefit from hydropower generation in Alternative-3 and 4 is almost equivalent to the annual cost for Option B-3: Upgrading AMRIS.

Table H. 4.4.8 Impact on Hydropower Generation

Case	Combination of Options	Mean Water Volume			Mean Generated Energy			Benefit[3] (Mil pesos /year)	Incremental Benefit (Mil pesos /year)
		Main (Mil m^3 /year)	Aux (Mil m^3 /year)	Total (Mil m^3 /year)	Main (GWh/ year)	Aux (GWh /year)	Total (GWh /year)		
Existing	-	920	1,285	2,205	283	264	547	3,828	0
Near Future with Sumag	-	907	1,367	2,274	279	279	558	3,906	79
ALT-1	Upgrading AMRIS + Bayabas[1]	815	1,428	2,243	253	295	548	3,838	10
ALT-2	Upgrading AMRIS + Balintingon ($2.9m^3/s$)[2] + Laiban ($0.5m^3/s$)	902	1,370	2,272	279	283	563	3,940	113
ALT-3	Upgrading AMRIS + Laiban ($3.1\ m^3/s$)	917	1,352	2,270	284	285	569	3,982	155
ALT-4	Laiban ($4.0\ m^3/s$)	992	1,275	2,267	306	267	573	4,009	182

Remarks:
1) Coordinated operation is necessary. When WL<184m, Bayabas releases for AMRIS.
2) 4,000ha of 26,000ha in AMRIS is supplied by Balintingon. New irrigation area from Balintingon storage dam is 10,000ha (14,900ha in original plan).
3) 7pesos /kWh is assumed.
Source: JICA Study Team

(8) Evaluation of Alternatives

To evaluate the alternatives, the comparisons among options shown in Chapter 4.4.3 (4) as well as the impact on hydropower generation have been referred. The overall evaluation on alternatives is presented in Table H.4.4.9.

All alternatives have some difficulties in institutional arrangement. Alternative-2 which includes the Option B-1: Balintingon and Option C-1: Laiban has many negative aspects compared to other alternatives. Therefore, this alternative is not recommended at this moment for the recovery of the reliability of water supply in Angat-Umiray system.

Alternative-1 is the least cost option. However, there are negative aspects in institutional arrangement and technical viability. Alterentaive-3 and 4 have advantages on incremental benefit by hydropower generation and technical viability. However, the negative socio-environmental impact and difficulty in institutional arrangement due to the cancelation of San Miguel Company on BOT scheme to implement Laiban Dam project is severe disadvantage for these alternatives.

At this moment of the study, the study team conditionally recommends Alternative-1, based on the overall evaluation. The technical variability of Alterenative-1 will have to be clarified by further study and proper institutional arrangement should be considered for implementation of this alternative.

Table H. 4.4.9 Overall Evaluation on Alternatives

Case	Combination of Options	Annual Cost (Mil pesos /year)	Incremental Benefit by Hydropower Generation	Negative Socio-Environ. Impact	Difficulty in Institutional Arrangement	Technical Viability	Necessity of Sharing Storage Volume less than 180m above mean sea level by AMRIS and Municipal Water Users	Total
ALT-1	Upgrading AMRIS ＋Bayabas[1)]	**843**	Fair	**Mid**	High	Low (need additional study)	**No**	**Conditionally Recommended**
ALT-2	Upgrading AMRIS + Balintingon ($2.9m^3/s$)[2)] + Laiban ($0.5m^3/s$)	1,085	Fair	High	High	Low (need additional study)	Necessary	
ALT-3	Upgrading AMRIS + Laiban ($3.1m^3/s$)	1,002	**High**	High	High	**High**	Necessary	
ALT-4	Laiban ($4.2m^3/s$)	1,077	**High**	High	High	**High**	Necessary	

Remarks:
1) Coordinated operation is necessary. When WL<184m, Bayabas releases for AMRIS.
2) 4,000ha of 26,000ha in AMRIS is supplied by Balintingon. New irrigation area from Balintingon storage dam is 10,000ha (14,900ha in original plan).
3) To calculate the annual cost, discount rate of 10% and project life of 50 years is assumed.
Source: JICA Study Team

(9) Recommendation

Based on the preliminary study, the study team tentatively recommends conducting the following feasibility study as a next step.

Feasibility Study on Recovery of Reliability of Water Supply in Angat-Umiray System

- Scopes
  - ➢ Study on irrigation water demand in AMRIS
  - ➢ F/S level engineering study on the following options
    - ✓ Bayabas storage dam
    - ✓ Upgrading and improvement of irrigation facilities and water management of AMRIS
  - ➢ Confirmation on the followings
    - ✓ Progress of water resources development outside Pampanga river basin such as Laiban Dam project
    - ✓ Progress of other water resources and irrigation development projects in Pampanga river basin
    - ✓ Municipal water demand and necessary surface water volume for Bulacan Province toward 2025
  - ➢ Water balance study including revision of rule curves
  - ➢ Institutional arrangement for project implementation
  - ➢ EIA study
  - ➢ Selection of best alternative

  - Project evaluation
  - Preparation of implementation plan
- Main C/P agency: NWRB
- Main agencies to be involved: NIA, MWSS, NPC, Bulacan Government

As shown in the problems and issues in water resources development, allocation and distribution, it is judged that the water governance in Angat-Umiray system should be improved, in parallel with the implementation of the project for Recovery of Reliability of Water Supply in Angat-Umiray System. The Capacity Development of NWRB and Relevant Agencies on Water Allocation and Distribution (Code: IS-C-04) is proposed to prepare for expected increase of conflict among water users, especially between municipal and irrigation water users. At this moment of the study, the study team tentatively recommends that the initial stage of the capacity development be conducted in Angat-Umiray system as a pilot area.

References

1) NEDA: Medium-Term Philippine Development Plan, 2004-2010, 2004.
2) NWRB: IWRM Plan Framework in Philippines, 2006.
3) NWRB, Water Code of the Philippines, 1976.
4) NWRB, Water Code of the Philippines and the Amended Implementing Rules and Regulations, 2005.
5) NWRB: Resolution No.05-0388, March 22, 1988.
6) NWRB: Resolution No.0-0, August 25, 1989.
7) NWRB: Resolution No.003-0109, January 21, 2009.
8) NWRB/JICA:Dams in the Philippines, 2000.
9) ADB, MWSS: Umiray-Angat Transbasin Study, Feasibility Study, Main Report Vol.1, 1992.
10) NIA-UPRIIS: Pantabangan Dam, Briefing Kit.
11) NWRB/JICA: Master Plan Study on Water Resources Management in the Republic of the Philippines, Final Report, Vol III-1, Supporting Report, Part-D, 1998.
12) NWRB: Survey/Inventory on Water Impounding Reservoirs, 1978.
13) Prov. Gov. Nueva Ecija: Pre-Feasibility Study Report of Water Impounding Projects in the Province of Nueva Ecija, 1994
14) NIA/NWRB/World Bank: Water Resources Development Project, Draft Final Report, Task5, Pre-feasibility study for additional water supply to AMRIS main report, 1994.
15) NIA: Balintingon Reservoir Multipurpose Project, Feasibility Study, Vol. I, Main Report, 1983.
16) CALENERGY: Balintingon Multipurpose Project, Prefeasibility Study Report, 2006.
17) NIA/JICA: Feasibility Study Report on the Gumain River Irrigation Project, 1985.
18) NIA:Balog-Balog Multipurpose Project, Feasibility Study, Main Report, 1980.
19) CDC: Clark Special Economic Zone Water Resources Study, Final Report, 2000.
20) DOE: National Energy Plan, 2006.
21) GOP: Republic Act No.9136, An Act Ordaining Reforms in the Electric Power Industry, Amending for the Purpose Certain Laws and for Other Purposes, 2001.
22) DOE: Power Sector Situationer, 2007.
23) NPC: The Angat Hydroelectric Power Plant, 2004.
24) ADB, MWSS: Umiray-Angat Transbasin Study, Feasibility Study, Appendix B-Reservoir Operation, 1992.
25) NIA: Definitive Development Plan, Irrigation Component of the Casecnan Multipurpose Irrigation and Power Project (CMIPP-IC) under the Central Luzon Irrigation Project (CLIP), Appendix-I, Meteorology and Hydrology, 2000.
26) NIA: Definitive Development Plan, Irrigation Component of the Casecnan Multipurpose Irrigation and Power Project (CMIPP-IC) under the Central Luzon Irrigation Project (CLIP), Main Report, 2000.
27) http://modsim.engr.colostate.edu/
28) PAGASA/NIA/NPC: Flood Operation Rule (Draft) for Angat Dam, 1984.
29) MWSS: Replay to the request of data and information to JICA Study Team, 2009.
30) MWSS: Umiray-Angat Transbasin Tunnel Rehabilitation Project, Phase 2, Main Report, 2009.
31) MWSS, SKM: Water Supply, Sewage, and Sanitation Master Plan for Metro Manila, Volume1 Summary, Final Report, 2005.
32) NWRC: Unpublished documents, 1982.
33) NSCB: Gross Regional Domestic Product, Base Year1985, 2005-2007, 2008.
34) Tennant,D: Instream flow regimens for fish, wildlife, recreation and related environmental resources Fisheries,Vol.1, pp.6-10, 1976.
35) MGB-Region III/Provincial Government of Bulacan: Report on the Geological Assessment of the Proposed Bayabas Dam Project in Brgy. Bayabas, Dona Remedios Trinidad (DRT), Bulacan, 2004.
36) CALENERGY: Balintingon Multipurpose Project, Prefeasibility Study Report, 2006.
37) Manila Water Company Inc.: 2008 Annual Report, 2008.

Annex-Tables

Annex-T H.2.2.1 Water Permits for Each Sub-Basin

Surface Water (Unit =m^3/s)

Sub-Basin	Domestic/ Municipal	MWSS	Irrigation	NIA	Power generation	Fisheries	Livestock	Industrial	Recreation	Other purpose	Total excl. Power generation	Total
PAM01	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PAM02	0.001	0.000	4.216	2.250	0.000	0.000	0.000	0.095	0.000	0.000	6.562	6.562
PAM03	0.000	0.000	0.396	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.396	0.396
PAM04	0.000	0.000	1.948	19.875	0.000	0.000	0.000	0.000	0.000	0.000	21.823	21.823
PAM05	0.000	0.000	0.695	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.695	0.695
PAN01	0.000	0.000	0.825	118.000	45.000	0.000	0.000	0.000	0.000	0.000	118.825	163.825
RCH01	0.000	0.000	14.043	12.000	0.000	0.004	0.000	0.000	0.000	0.000	26.047	26.047
PEN01	0.000	0.000	0.847	29.250	0.000	0.000	0.000	0.000	0.000	0.000	30.097	30.097
COR01	0.000	0.000	4.177	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.177	4.177
ANG01	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ANG02	3.497	4.166	0.079	40.000	0.000	0.006	0.000	0.021	0.000	0.000	47.769	47.769
ANG03	0.000	24.494	0.000	0.000	58.000	0.000	0.000	0.000	0.000	0.000	24.494	82.494
PAS01	0.000	0.000	3.072	6.910	0.000	0.000	0.000	0.000	0.000	0.000	9.982	9.982
UMIRAY	1.900	17.576	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19.476	19.476
AURORA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CASECNAN	0.000	0.000	0.000	26.397	0.000	0.000	0.000	0.000	0.000	0.000	26.397	26.397
TARLAC	0.000	0.000	0.000	29.000	0.000	0.000	0.000	0.000	0.000	0.000	29.000	29.000
Total	5.398 (1.5%)	46.236 (12.6%)	30.299 (8.3%)	283.682 (77.6%)	103.000	0.010 (0.0%)	0.000 (0.0%)	0.116 (0.0%)	0.000 (0.0%)	0.000 (0.0%)	365.741 (100.0%)	468.741

Groundwater (Unit =m^3/s)

Sub-Basin	Domestic/ Municipal	MWSS	Irrigation	NIA	Power generation	Fisheries	Livestock	Industrial	Recreation	Other purpose	Total excl. Power generation	Total
PAM01	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.015
PAM02	0.296	0.000	0.009	0.000	0.000	0.000	0.001	0.048	0.016	0.008	0.378	0.378
PAM03	0.088	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.088	0.088
PAM04	0.564	0.000	0.016	0.000	0.000	0.000	0.000	0.003	0.000	0.003	0.587	0.587
PAM05	0.033	0.000	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.063	0.063
PAN01	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RCH01	1.297	0.000	0.601	1.426	0.000	0.000	0.002	0.285	0.051	0.082	3.743	3.743
PEN01	0.123	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.130	0.130
COR01	0.000	0.000	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.031
ANG01	0.172	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.184	0.184
ANG02	0.417	0.000	0.002	0.000	0.000	0.000	0.016	0.000	0.000	0.049	0.484	0.484
ANG03	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PAS01	0.801	0.000	0.426	0.000	0.000	0.018	0.000	0.802	0.006	0.087	2.140	2.140
Total	3.806 (48.5%)	0.000 (0.0%)	1.122 (14.3%)	1.426 (18.2%)	0.000	0.018 (0.2%)	0.019 (0.2%)	1.149 (14.7%)	0.073 (0.9%)	0.229 (2.9%)	7.842 (100.0%)	7.842

Source: JICA Study Team based on NWRB

Annex-T H.2.2.2(1/2) Water Permits for Each Municipality/City

Surface Water (Unit =m^3/s)

City Mun	Province	Total Area (km^2)	Area inside the study area (km^2)	Ratio	Domestic/ Municipal	MWSS	Irrigation	NIA	Power generation	Fisheries	Livestock	Industrial	Recreation	Other purpose	Total excl. Power generation	Total
Angat	Bulacan	58.56	52.59	0.898	0.001	0.000	0.015	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.022	0.022
Baliuag	Bulacan	43.63	43.63	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bulacan	Bulacan	69.38	11.19	0.161	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bustos	Bulacan	40.48	17.74	0.438	0.000	0.000	0.000	40.000	0.000	0.000	0.000	0.000	0.000	0.000	40.000	40.000
Calumpit	Bulacan	46.52	46.52	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dona Remedios Trinidad	Bulacan	878.91	854.25	0.972	3.497	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.497	3.497
Guiguinto	Bulacan	24.80	1.64	0.066	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hagonoy	Bulacan	94.58	94.55	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Malolos City	Bulacan	72.58	72.58	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Norzagaray	Bulacan	246.57	206.82	0.839	0.000	28.660	0.000	0.000	58.000	0.000	0.000	0.021	0.000	0.000	28.681	86.681
Pandi	Bulacan	50.39	1.39	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Paombong	Bulacan	45.83	45.83	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Plaridel	Bulacan	35.44	20.04	0.565	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pulilan	Bulacan	43.62	43.62	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
San Ildefonso	Bulacan	166.53	166.53	1.000	0.000	0.000	0.067	2.250	0.000	0.000	0.000	0.000	0.000	0.000	2.317	2.317
San Miguel	Bulacan	235.92	235.92	1.000	0.000	0.000	0.184	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.184	0.184
San Rafael	Bulacan	104.95	104.95	1.000	0.000	0.000	0.104	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.104	0.104
Santa Maria	Bulacan	78.65	0.75	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aliaga	Nueva Ecija	92.17	92.17	1.000	0.000	0.000	1.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.100	1.100
Bongabon	Nueva Ecija	229.40	224.53	0.979	0.000	0.000	0.066	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.066	0.066
Cabanatuan City	Nueva Ecija	198.18	198.18	1.000	0.000	0.000	0.664	0.800	0.000	0.000	0.000	0.000	0.000	0.000	1.464	1.464
Cabiao	Nueva Ecija	113.48	113.48	1.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.500
Carranglan	Nueva Ecija	739.39	692.95	0.937	0.000	0.000	0.845	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.845	0.845
Gabaldon	Nueva Ecija	252.52	252.22	0.999	0.000	0.000	1.679	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.679	1.679
Gapan	Nueva Ecija	164.50	164.50	1.000	0.000	0.000	0.081	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.081	0.081
Gen Mamerto Natividad	Nueva Ecija	98.01	98.01	1.000	0.000	0.000	0.148	16.000	0.000	0.000	0.000	0.000	0.000	0.000	16.148	16.148
General Tinio	Nueva Ecija	580.85	580.04	0.999	0.000	0.000	0.573	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.573	0.573
Guimba	Nueva Ecija	219.23	137.29	0.626	0.000	0.000	1.619	0.000	0.000	0.004	0.000	0.000	0.000	0.000	1.623	1.623
Jaen	Nueva Ecija	90.45	90.45	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Laur	Nueva Ecija	221.35	221.35	1.000	0.000	0.000	2.498	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.498	2.498
Licab	Nueva Ecija	60.42	60.42	1.000	0.000	0.000	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.040
Llanera	Nueva Ecija	114.25	114.25	1.000	0.000	0.000	0.214	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.214	0.214
Lupao	Nueva Ecija	142.66	129.69	0.909	0.000	0.000	1.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.111	1.111
Science City Of Munoz	Nueva Ecija	142.44	142.44	1.000	0.000	0.000	0.153	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.153	0.153
Palayan City	Nueva Ecija	136.11	136.11	1.000	0.000	0.000	0.439	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.439	0.439
Pantabangan	Nueva Ecija	421.05	421.05	1.000	0.000	0.000	0.082	118.000	45.000	0.000	0.000	0.000	0.000	0.000	118.082	163.082
Penaranda	Nueva Ecija	78.53	78.53	1.000	0.000	0.000	0.360	29.250	0.000	0.000	0.000	0.000	0.000	0.000	29.610	29.610
Quezon	Nueva Ecija	68.33	68.33	1.000	0.000	0.000	0.049	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.049
Rizal	Nueva Ecija	123.88	123.88	1.000	0.000	0.000	0.523	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.523	0.523
San Antonio	Nueva Ecija	156.90	156.90	1.000	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.042
San Isidro	Nueva Ecija	58.07	58.07	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
San Jose City	Nueva Ecija	161.75	161.75	1.000	0.000	0.000	0.557	6.000	0.000	0.000	0.000	0.000	0.000	0.000	6.557	6.557
San Leonardo	Nueva Ecija	51.69	51.69	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Santa Rosa	Nueva Ecija	116.52	116.52	1.000	0.000	0.000	0.438	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.438	0.438
Santo Domingo	Nueva Ecija	82.69	82.69	1.000	0.000	0.000	0.425	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.425	0.425
Talavera	Nueva Ecija	135.06	135.06	1.000	0.000	0.000	0.000	9.075	0.000	0.000	0.000	0.000	0.000	0.000	9.075	9.075
Talugtug	Nueva Ecija	73.46	38.82	0.528	0.000	0.000	0.068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.068	0.068
Zaragosa	Nueva Ecija	71.98	71.98	1.000	0.000	0.000	1.578	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.578	1.578
Angeles City	Pampanga	62.80	62.80	1.000	0.000	0.000	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.045	0.045
Apalit	Pampanga	60.10	60.10	1.000	0.000	0.000	0.046	0.000	0.000	0.000	0.000	0.095	0.000	0.000	0.141	0.141
Arayat	Pampanga	176.68	176.68	1.000	0.000	0.000	1.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.400	1.400
Bacolor	Pampanga	74.24	74.24	1.000	0.000	0.000	0.095	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.095	0.095
Candaba	Pampanga	208.20	208.20	1.000	0.000	0.000	1.892	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.892	1.892
Floridablanca	Pampanga	120.94	83.39	0.690	0.000	0.000	0.000	6.910	0.000	0.000	0.000	0.000	0.000	0.000	6.910	6.910
Guagua	Pampanga	48.93	48.93	1.000	0.000	0.000	0.197	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.197	0.197
Lubao	Pampanga	155.02	148.79	0.960	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mabalacat	Pampanga	145.73	140.22	0.962	0.000	0.000	0.918	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.918	0.918
Macabebe	Pampanga	102.36	102.36	1.000	0.000	0.000	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.075	0.075
Magalang	Pampanga	104.53	104.53	1.000	0.000	0.000	0.464	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.464	0.464
Masantol	Pampanga	45.94	45.94	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mexico	Pampanga	122.01	122.01	1.000	0.000	0.000	1.877	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.877	1.877
Minalin	Pampanga	45.45	45.45	1.000	0.000	0.000	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.030
Porac	Pampanga	293.31	291.96	0.995	0.000	0.000	0.092	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.092	0.092
City Of San Fernando	Pampanga	68.57	68.57	1.000	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.125
San Luis	Pampanga	55.25	55.25	1.000	0.000	0.000	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.335	0.335
San Simon	Pampanga	59.93	59.93	1.000	0.000	0.000	0.278	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.278	0.278
Santa Ana	Pampanga	40.44	40.44	1.000	0.000	0.000	0.145	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.145	0.145
Santa Rita	Pampanga	23.19	23.19	1.000	0.000	0.000	0.193	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.193	0.193
Santo Tomas	Pampanga	14.46	14.46	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sasmuan	Pampanga	44.80	44.76	0.999	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bamban	Tarlac	250.57	146.51	0.585	0.000	0.000	1.490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.490	1.490
Capas	Tarlac	422.30	133.94	0.317	0.000	0.000	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.041	0.041
Concepcion	Tarlac	221.46	221.46	1.000	0.000	0.000	4.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.333	4.333
La Paz	Tarlac	116.65	116.65	1.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.008
Tarlac City	Tarlac	261.08	132.07	0.506	0.000	0.000	0.000	29.000	0.000	0.000	0.000	0.000	0.000	0.000	29.000	29.000
Victoria	Tarlac	112.08	83.35	0.744	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Alfonso Castada	Nueva Vizcaya	569.80	143.60	0.252	0.000	0.000	0.000	26.397	0.000	0.000	0.000	0.000	0.000	0.000	26.397	26.397
General Nakar	Quezon	1438.15	30.23	0.021	1.900	17.576	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19.476	19.476
Total					5.398	46.236	30.299	283.682	103.000	0.010	0.000	0.116	0.000	0.000	365.741	468.741

Source: JICA Study Team based on NWRB

Annex-T H.2.2.2(2/2) Water Permits for Each Municipality/City

Groundwater (Unit =m^3/s)

City Mun	Province	Total Area (km^2)	Area inside the study area (km^2)	Ratio	Domestic/ Municipal	MWSS	Irrigation	NIA	Power generation	Fisheries	Livestock	Industrial	Recreation	Other purpose	Total excl. Power generation	Total
Angat	Bulacan	58.56	52.59	0.898	0.011	0.000	0.002	0.000	0.000	0.000	0.016	0.000	0.000	0.049	0.077	0.077
Baliuag	Bulacan	43.63	43.63	1.000	0.146	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.148	0.148
Bulacan	Bulacan	69.38	11.19	0.161	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bustos	Bulacan	40.48	17.74	0.438	0.168	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.168	0.168
Calumpit	Bulacan	46.52	46.52	1.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.017
Dona Remedios Trinidad	Bulacan	878.91	854.25	0.972	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Guiguinto	Bulacan	24.80	1.64	0.066	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hagonoy	Bulacan	94.58	94.55	1.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.015
Malolos City	Bulacan	72.58	72.58	1.000	0.157	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.169	0.169
Norzagaray	Bulacan	246.57	206.82	0.839	0.068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.068	0.068
Pandi	Bulacan	50.39	1.39	0.028	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.031
Paombong	Bulacan	45.83	45.83	1.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Plaridel	Bulacan	35.44	20.04	0.565	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.034
Pulilan	Bulacan	43.62	43.62	1.000	0.046	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.060	0.060
San Ildefonso	Bulacan	166.53	166.53	1.000	0.064	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.064	0.064
San Miguel	Bulacan	235.92	235.92	1.000	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.040	0.040
San Rafael	Bulacan	104.95	104.95	1.000	0.058	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.016	0.000	0.075	0.075
Santa Maria	Bulacan	78.65	0.75	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aliaga	Nueva Ecija	92.17	92.17	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bongabon	Nueva Ecija	229.40	224.53	0.979	0.033	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.041	0.041
Cabanatuan City	Nueva Ecija	198.18	198.18	1.000	0.512	0.000	0.008	0.000	0.000	0.000	0.000	0.001	0.000	0.008	0.529	0.529
Cabiao	Nueva Ecija	113.48	113.48	1.000	0.068	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.069	0.069
Carranglan	Nueva Ecija	739.39	692.95	0.937	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gabaldon	Nueva Ecija	252.52	252.22	0.999	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.012
Gapan	Nueva Ecija	164.50	164.50	1.000	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.022
Gen Mamerto Natividad	Nueva Ecija	98.01	98.01	1.000	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.022
General Tinio	Nueva Ecija	580.85	580.04	0.999	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.042
Guimba	Nueva Ecija	219.23	137.29	0.626	0.037	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.087	0.087
Jaen	Nueva Ecija	90.45	90.45	1.000	0.046	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.046	0.046
Laur	Nueva Ecija	221.35	221.35	1.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Licab	Nueva Ecija	60.42	60.42	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Llanera	Nueva Ecija	114.25	114.25	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lupao	Nueva Ecija	142.66	129.69	0.909	0.000	0.000	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.054
Science City Of Munoz	Nueva Ecija	142.44	142.44	1.000	0.078	0.000	0.034	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.116	0.116
Palayan City	Nueva Ecija	136.11	136.11	1.000	0.004	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.019
Pantabangan	Nueva Ecija	421.05	421.05	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Penaranda	Nueva Ecija	78.53	78.53	1.000	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059	0.059
Quezon	Nueva Ecija	68.33	68.33	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.002
Rizal	Nueva Ecija	123.88	123.88	1.000	0.000	0.000	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.021
San Antonio	Nueva Ecija	156.90	156.90	1.000	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.014
San Isidro	Nueva Ecija	58.07	58.07	1.000	0.037	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.037
San Jose City	Nueva Ecija	161.75	161.75	1.000	0.034	0.000	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.057	0.057
San Leonardo	Nueva Ecija	51.69	51.69	1.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.009	0.009
Santa Rosa	Nueva Ecija	116.52	116.52	1.000	0.017	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.019
Santo Domingo	Nueva Ecija	82.69	82.69	1.000	0.018	0.000	0.003	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.023	0.023
Talavera	Nueva Ecija	135.06	135.06	1.000	0.022	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.034	0.034
Talugtug	Nueva Ecija	73.46	38.82	0.528	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.016
Zaragosa	Nueva Ecija	71.98	71.98	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Angeles City	Pampanga	62.80	62.80	1.000	0.471	0.000	0.000	0.000	0.000	0.018	0.000	0.000	0.024	0.086	0.600	0.600
Apalit	Pampanga	60.10	60.10	1.000	0.033	0.000	0.005	0.000	0.000	0.000	0.000	0.047	0.000	0.000	0.084	0.084
Arayat	Pampanga	176.68	176.68	1.000	0.025	0.000	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.054
Bacolor	Pampanga	74.24	74.24	1.000	0.008	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.045	0.045
Candaba	Pampanga	208.20	208.20	1.000	0.031	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.069	0.069
Floridablanca	Pampanga	120.94	83.39	0.690	0.120	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.158	0.158
Guagua	Pampanga	48.93	48.93	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lubao	Pampanga	155.02	148.79	0.960	0.005	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.043	0.043
Mabalacat	Pampanga	145.73	140.22	0.962	0.229	0.000	0.041	0.000	0.000	0.000	0.000	0.213	0.024	0.000	0.507	0.507
Macabebe	Pampanga	102.36	102.36	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Magalang	Pampanga	104.53	104.53	1.000	0.089	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.108	0.108
Masantol	Pampanga	45.94	45.94	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mexico	Pampanga	122.01	122.01	1.000	0.038	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.064	0.064
Minalin	Pampanga	45.45	45.45	1.000	0.001	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.006
Porac	Pampanga	293.31	291.96	0.995	0.055	0.000	0.006	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.071	0.071
City Of San Fernando	Pampanga	68.57	68.57	1.000	0.117	0.000	0.050	0.000	0.000	0.000	0.000	0.777	0.000	0.021	0.964	0.964
San Luis	Pampanga	55.25	55.25	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
San Simon	Pampanga	59.93	59.93	1.000	0.019	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.022
Santa Ana	Pampanga	40.44	40.44	1.000	0.000	0.000	0.146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.146	0.146
Santa Rita	Pampanga	23.19	23.19	1.000	0.017	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.029
Santo Tomas	Pampanga	14.46	14.46	1.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.017
Sasmuan	Pampanga	44.80	44.76	0.999	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bamban	Tarlac	250.57	146.51	0.585	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.030
Capas	Tarlac	422.30	133.94	0.317	0.020	0.000	0.011	0.299	0.000	0.000	0.000	0.000	0.000	0.000	0.330	0.330
Concepcion	Tarlac	221.46	221.46	1.000	0.015	0.000	0.170	0.187	0.000	0.000	0.000	0.000	0.000	0.000	0.372	0.372
La Paz	Tarlac	116.65	116.65	1.000	0.000	0.000	0.147	0.246	0.000	0.000	0.000	0.000	0.000	0.000	0.393	0.393
Tarlac City	Tarlac	261.08	132.07	0.506	0.567	0.000	0.016	0.594	0.000	0.000	0.000	0.072	0.000	0.054	1.302	1.302
Victoria	Tarlac	112.08	83.35	0.744	0.000	0.000	0.011	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.111
Alfonso Castada	Nueva Vizcaya	569.80	143.60	0.252	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
General Nakar	Quezon	1438.15	30.23	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total					3.806	0.000	1.122	1.426	0.000	0.018	0.019	1.149	0.073	0.229	7.842	7.842

Source: JICA Study Team based on NWRB

Annex-T H.2.3.1 H-V-A relationship for Angat and Pantabangan Storage Dams

Angat Storage Dam

Elevation (m)	Volume (MCM)	Veff (MCM)	Area (km2)	Utility Rate_Main (m3/KWh)	Utility Rate_Aux (m3/KWh)
140	100.0		4.0		
150	110.0		6.5		
160	180.0	0.0	8.3	5.39	8.71
170	273.0	93.0	10.1	4.72	7.17
180	386.0	206.0	12.2	4.13	6.06
184	437.0	257.0	13.5	3.97	5.70
188	492.3	312.3	14.2	3.81	5.38
192	552.0	372.0	15.5	3.65	5.06
196	616.0	436.0	16.5	3.49	4.82
200	684.0	504.0	17.7	3.33	4.58
204	758.4	578.4	18.7	3.25	4.35
208	836.1	656.1	19.9	3.17	4.19
210	876.0	696.0		3.13	4.11
212	918.0	738.0	21.3	3.09	4.03
214	961.0	781.0	21.9	3.05	3.95
216	1,005.4	825.4	22.7	3.01	3.87
217	1,030.0	850.0		2.99	3.83

Pantabangan Storage Dam

Elevation (m)	Volume (MCM)	Veff (MCM)	Area (km2)
170	225.0	0.0	
180	410.0	185.0	
190	721.0	496.0	
200	1,100.0	875.0	
210	1,620.0	1,395.0	
216	1,978.0	1,753.0	
221	2,308.0	2,083.0	
230	3,000.0	2,775.0	69.62

Annex-T H.2.3.2 Identified Possible Large Storage Dam Sites in Previous Studies

Code	Site	River	Province	Location		Drain-age area (km^2)	Dam height (m)	Gross Res. Volume (MCM)	Purpose				Agency	Status
				Latitude	Longitude				I	P	FC	M&I		
01	BAYABAS	BAYABAS	BULACAN	14-56-53	121-06-32	52	110	144	X				NWRB/NIA	pre F/S completed
02	SALAPANGAN	SALAPANGAN	BULACAN	15-01-56	121-00-35	52	30	N/A	X		X		CLCVA	
03	MAASIM	MAASIM	BULACAN	15-00-09	121-01-53	53	47	95	X				NWRB/NIA	pre F/S completed
04	BARDIAS # 1	BULU	BULACAN	15-14-36	121-02-30	44	30	N/A	X		X		CLCVA	
05	MT. BISCAL	BULU	BULACAN	15-13-59	121-06-00	45	97	N/A	X	X	X		CLCVA	
06	MADLUM	MADLUM	BULACAN	15-11-27	121-06-06	76	80	N/A	X	X	X		CLCVA	
07	BALINTINGON	SUMACBAO	NUEVA ECIJA	15-17-11	121-10-26	224	138	488	X	X			NIA	F/S completed
08	ANTIPAS	ANTIPAS	NUEVA ECIJA	15-31-40	121-15-10	38	90	105	X	X			Prov. Gov. Nueva Ecija	Studied in Ref-1
09	BUGNAM	BUGNAM	NUEVA ECIJA	15-26-53	121-16-22	39	77	N/A	X		X		NIA	
10	SANTOR	SANTOR	NUEVA ECIJA	15-25-30	121-21-30	68	89	98	X	X			Prov. Gov. Nueva Ecija	Studied in Ref-1
11	LOWER CABU	CABU	NUEVA ECIJA	15-27-18	121-07-00	71	55	70	X	X			Prov. Gov. Nueva Ecija	Studied in Ref-1
12	PAPAYA	CHICO	NUEVA ECIJA	15-21-39	121-10-26	124	86	N/A	X	X	X		NIA	
13	MARINAT	MARINAT	NUEVA ECIJA	15-33-32	121-08-38	44	50	N/A	X	X	X		CLVCA	
14	KALAANAN	DIGMALA	NUEVA ECIJA	15-39-35	121-12-05	89	94	N/A	X	X	X		NIA	
15	CANAAN	BANCO	NUEVA ECIJA	15-41-49	121-10-18	71	31	N/A	X		X		NIA	
16	UP MARINGALO	MARINGALO	NUEVA ECIJA	15-59-16	120-59-30	38	40	N/A	X		X		NIA	
17	MARINGALO	TALAVERA	NUEVA ECIJA	15-56-23	121-00-36	52	54	N/A	X		X		NIA	
18	SULA	BULSA	TARLAC	15-27-22	120-22-27	290	39	N/A	X		X		NIA	
19	BALOG-BALOG	BULSA	TARLAC	15-25-52	120-21-16	289	114	575	X	X	X		NIA	F/S completed
20	O'DONNEL	BANGAT	TARLAC	15-19-20	120-27-48	44	60	N/A	X		X		NIA	
21	O'DONNEL #1	O'DONNEL	TARLAC	15-17-02	120-22-49	40	70	N/A	X		X		CLCVA	
22	SAN NICOLAS	MARIMLA	TARLAC	15-15-18	120-32-57	76	60	N/A	X		X		CLCVA	
23	BAMBAN	MALAGO	TARLAC	15-14-03	120-28-16	36	30	N/A	X		X		CLCVA	
24	DOLORES	BAMBAN	TARLAC	15-14-20	120-33-30	35	30	N/A	X	X	X		CLCVA	
25	GUMAIN	GUMAIN	PAMPANGA	15-01-33	120-27-28	118	108	95	X				CLCVA	F/S completed
26	PENARANDA	PENARANDA	NUEVA ECIJA	15-22-26	121-04-34	N/A	47	70	X	X			Prov. Gov. Nueva Ecija	Studied in Ref-1
27	BACAO	BACAO	NUEVA ECIJA	15-16-30	121-09-30	N/A	21	14	X	X			Prov. Gov. Nueva Ecija	Studied in Ref-1
28	DANGLAN	DANGLAN	NUEVA ECIJA	15-27-30	121-21-32	N/A	47	6	X	X			Prov. Gov. Nueva Ecija	Studied in Ref-1

Purpose: I = Irrigation, P = Hydroposer, FC = Flood control, M&I = Municipal and Industrial

Agency: NIA=National Irrigation Administration, CLCVA = Central Luzon Cagayan Valley Authority

Ref-1: Pre-Feasubility Study Report of Water Impaounding Projects in the Province of Nueva Ecija, 1994

Source:

- NWRB/JICA: Master Plan Study on Water Resources Management in the Republic of the Philippines, Final Report, Vol III-1, Supporting Report, Part-D, 1998.
- NWRB: Survey/Inventory on Water Impounding Reservoirs, 1978.
- Prov. Gov. Nueva Ecija: Pre-Feasibility Study Report of Water Impounding Projects in the Province of Nueva Ecija, 1994

Annex-T H.2.3.3 H-V-A relationship for Proposed Storage Dams

Proposed Bayabas Storage Dam

Elevation (m)	Volume (MCM)	Veff (MCM)	Area (km2)
100	0.0		0.000
120	2.8		0.277
140	13.7	3.7	0.814
160	38.2	28.2	1.634
180	82.4	72.4	2.787
187	103.9	93.9	3.353
190	114.3	104.3	3.596
190.66	116.7	106.7	3.649
200	154.3	144.3	4.404
203.46	170.2	160.2	4.800
210	204.0	194.0	5.548
220	265.2	255.2	6.692

Proposed Maasim Storage Dam

Elevation (m)	Volume (MCM)	Veff (MCM)	Area (km2)
40	0.0		0.00
50	1.5		0.31
55	5.0	0.0	1.21
60	8.5	3.5	2.12
70	48.0	43.0	4.71
80	100.0	95.0	9.00
81.63	110.0	105.0	9.70
87			

Proposed Balintingon Storage Dam

Elevation (m)	Volume (MCM)	Veff (MCM)	Area (km2)
100	0.0		0.80
120	32.0		1.60
142	84.0	0.0	4.00
150	111.0	27.0	5.50
160	150.0	66.0	7.10
170	222.0	138.0	9.10
180	317.0	233.0	11.50
190	412.0	328.0	14.30
202	572.0	488.0	17.00
204	600.0	516.0	17.80
206			

Proposed Gumain Storage Dam

Elevation (m)	Volume (MCM)	Veff (MCM)	Area (km2)
60	0.0		0.00
80	3.0		0.30
100	11.0	0.0	0.80
110	21.0	10.0	1.10
120	31.0	20.0	1.50
130	50.0	39.0	1.80
140	70.0	59.0	2.40
150	97.0	86.0	3.10
153.5	110.0	99.0	3.36
157.5	124.0	113.0	3.70
160	132.0	121.0	3.90

Proposed Balog-Balog Storage Dam

Elevation (m)	Volume (MCM)	Veff (MCM)	Area (km2)
138	0.0		0.00
180	50.0	0.0	3.00
200	170.0	120.0	7.20
210	246.0	196.0	9.80
220	340.0	290.0	12.70
230	475.0	425.0	15.50
238	625.0	575.0	17.60
240.5	670.0	620.0	18.60
245.5			

Annex-T H.2.4.1 List of Exiting Power Plants for Luzon Grid

Plant	Capacity (MW)		Location	Proponent	Owner	Type of Contract	Original Year Commissioned
	Installed	Dependable	Mun/City				
Coal	**3783.00**	**3055.70**					
Pagbilao Unit 1	364.00	364.00	Pagbilao, Quezon	TeaM Energy	NPC-IPP	BOT-ECA	3/7/1996
Pagbilao Unit 2	364.00	364.00	Pagbilao, Quezon	TeaM Energy	NPC-IPP	BOT-ECA	5/26/1996
Calaca 1	300.00	142.93	Calaca, Batangas	Calaca Holdco Inc.	NON-NPC		9/5/1984
Calaca 2	300.00	160.71	Calaca, Batangas	Calaca Holdco Inc.	NON-NPC		6/5/1995
Masinloc I	300.00	203.81	Masinloc, Zambales	AES Transpower Pte. Ltd	NON-NPC		6/18/1998
Masinloc II	300.00	165.37	Masinloc, Zambales	AES Transpower Pte. Ltd	NON-NPC		12/1/1998
Sual I	647.00	590.87	Sual, Pangasinan	TeaM Energy	NPC-IPP	BOT-ECA	10/23/1999
Sual II	647.00	562.01	Sual, Pangasinan	TeaM Energy	NPC-IPP	BOT-ECA	10/5/1999
Quezon Power	511.00	460.00	Mauban, Quezon	Quezon Power Phils.	NON-NPC		5/1/2000
APEC	50.00	42.00	Mabalacat, Pampanga	Asia Pacific Energy Corp.	NON-NPC		7/1/2006
Diesel	**783.08**	**678.09**					
Enron Subic 2	116.00	114.46	Olongapo, Zambales	Enron Power Corp. (USA)	NPC-IPP	BOT-ECA	2/22/1994
Duracom Unit 1 & 2	133.38	113.00	Navotas, Metro Manila	First Private Power Corp.	NON-NPC		9/1/1995
East Asia Diesel (Duracom Unit 3 & 4)	109.00	109.00	Navotas, Metro Manila	East Asia Diesel Power Corp.	NON-NPC		9/1/1995
Angeles PI DPP	30.00	30.00	Angeles City	Angeles Electric Corporation	NON-NPC		12/5/1994
FPPC- Bauang Dsl	235.20	225.33	Bauang, La Union	First Private Power Corp.	NPC-IPP	BOT-ECA	8/30/1994
FCVC DPP	25.60	23.70	Cabanatuan City	Cabanatuan Electric Corp.	NON-NPC		1/15/1996
Tarlac Electric	18.90	12.60	Capas, Tarlac	Tarlac Electric Inc.	NON-NPC		6/17/1905
Trans Asia Power	52.00	50.00	La Union	Trans Asia Power	NON-NPC		
Magellan Cogen (CEPZA)	63.00	0.00	Rosario, Cavite	Magellan Cogen Utilities	NON-NPC		7/1/1995 1/1/1997
Natural Gas	**2834.00**	**2565.42**					
San Antonio	3.00	3.00	Echague, Isabela	Non-NPC	NON-NPC		7/1/1994
Sta. Rita Natural Gas	1060.00	1000.00	Sta. Rita, Batangas	First Gas Power Corp	NON-NPC		6/2000 10/2001
Ilijan	1271.00	1062.42	Ilijan, Batangas City	KEPCO (Ilijan)	NPC-IPP	BOT-ECA/GSPA	6/5/2002
First Gas B (San Lorenzo)	500.00	500.00	Sta. Rita, Batangas	First Gas Power Corp	NON-NPC		9/1/2002
Gas Turbine	**930.00**	**600.73**					
Hopewell GT	310.00	0.00	Navotas, Metro Manila	Mirant (Navotas) Corp.	NPC	BOT-ECA	8/16/1990 3/18/1993
Limay CCGT	620.00	600.73	Limay, Bataan	ABB/Marubeni/Kawasaki Consortium	NPC-IPP	BTO-OMR	5/14/1993 , 12/10/1994
Geothermal	**885.72**	**439.43**					
MakBan 1	63.20	58.13	Calauan, Laguna	NPC	NPC		4/26/1979
MakBan 2	63.20	43.84	Calauan, Laguna	NPC	NPC		7/25/1979
MakBan 3	63.20	56.10	Calauan, Laguna	NPC	NPC		4/22/1980
MakBan 4	63.20	58.39	Calauan, Laguna	NPC	NPC		6/25/1980
MakBan 5	55.00	14.87	Calauan, Laguna	NPC	NPC		6/5/1984
MakBan 6	55.00	0.00	Calauan, Laguna	NPC	NPC		9/10/1984
MakBan 7 (D)	20.00	18.25	Calauan, Laguna	NPC	NPC		10/16/1995
MakBan 8(D)	20.00	12.50	6 Calauan, Laguna	NPC	NPC		11/12/1995
MakBan 9(E)	20.00	17.10	Calauan, Laguna	NPC	NPC		5/22/1996
Makban 10(E)	20.00	12.54	Calauan, Laguna	NPC	NPC		5/27/1996
Bac Man I-1	55.00	23.24	Bacon, Sorsogon	NPC	NPC		9/10/1993
Bac Man I-2	55.00	0.00	Bacon, Sorsogon	NPC	NPC		12/12/993
Bac Man II-1	20.00	0.00	Bacon, Sorsogon	NPC	NPC		3/15/1994
Bac Man II (Botong)	20.00	10.34	Bacon, Sorsogon	NPC	NPC		3/17/1998
Tiwi 1	59.00	13.53	Tiwi, Albay	NPC	NPC		1/11/1979
Tiwi 2	59.00	26.36	Tiwi, Albay	NPC	NPC		5/25/1979
Tiwi 3	43.69	0.00	Tiwi, Albay	NPC	NPC		1/8/1980
Tiwi 4	0.00	0.00	Tiwi, Albay	NPC	NPC		4/1/1980
Tiwi 5	57.00	43.66	Tiwi, Albay	NPC	NPC		12/20/1981
Tiwi 6	57.00	29.03	Tiwi, Albay	NPC	NPC		3/16/1984
MakBan Ormat	15.73	0.00	Bitin, Bay Laguna	Ormat Inc. USA	NON-NPC	BTO	2/28/1994
Manito	1.50	1.50	Albay	Non-NPC	NON-NPC		10/1/1998
Manito	1.50	1.50	Albay	Non-NPC	NON-NPC		10/1/1998
Hydro	**2,281.22**	**2,034.86**					
Large Hydroelectric Plants	**2,246.85**	**2,005.55**					
San Roque	345	345	San Manuel,Pangasinan	San Roque Corporation	NPC-IPP	BOT-PPA	5/1/2003
HEDCOR	18.35	8.98	Banengbeng,Benguet	Hydro Electric Dev't. Corp. (Phils.)	NPC-IPP	BOO-EPSA	1/1/1993
Kalayaan 1 & 2	354	354	Kalayaan, Laguna	Electric Power Development Co.	NPC-IPP	BROT-PPA	8/13/1982 4/25/1982
Kalayaan 3 & 4	355	355	Kalayaan, Laguna	Electric Power Development Co.	NPC-IPP	BROT-PPA	5/1/2004
Magat	360	317	Ramon, Isabela	SN Aboitiz Power, Inc.	NON-NPC	Privatized Dec 14, 2006	8/14/1983 10/24/1983
Caliraya	23.5	23.5	Lumban, Laguna	Electric Power Development Co.	NPC-IPP	BROT-PPA	1942 / 1947 / 1950
Botocan	23	21.94	Kalayaan,Laguna	Electric Power Development Co.	NPC-IPP	BROT-PPA	1946-48
Angat	246	205.24	Norzagaray, Bulacan	NPC	NPC		10/16/1967 6/16/1986
Pantabangan-Masiway	112	111	Pantabangan, Nueva Ecija	First Gen Hydro Power Corp.	NON-NPC	privatized Sep 8, 2006	4/1/1977 5/1/1977, 2/27/1981
Ambuklao	75	0	Bokud, Benguet	SN Aboitiz Power, Inc.	NON-NPC		12/23/1956
Binga	100	78.82	Itogon, Benguet	SN Aboitiz Power, Inc.	NON-NPC		1/19/1960
Bakun	70	35.06	Alilem, Ilocos Sur	HEDCOR (Bakun)	NPC-IPP	BOT-PPA	2/6/2001 10/10/2000
Casecnan	165	150	Pantabangan, Nueva Ecija	NIA Philippines	NPC-IPP	BOT-PPA	4/5/2002
Small Hydroelectric Plants	**34.37**	**29.31**					
Cawayan	0.4	0.4	Guinlajon, Sorsogon	SORECO II	NON-NPC	Privatized June 2005	6/1/2002
Buhi-Barit	1.8	1.8	Buhi, Camarines Sur	People's Energy Inc.	NON-NPC	Privatized Jan 2005	9/1/1957
NIA-Baligatan	6	6	Benguet	NON-NPC	NON-NPC		1979
NMHC	12.4	7.34	Bakun, Benguet	NMHC	NPC-IPP	BOO-EPSA	1/1/1993
Aqua Grande	4.5	4.5	Pagudpod,Ilocos Norte	INEC	Non-NPC		1983
Amburayan	0.2	0.2	Supiden,La Union	LUELCO	Non-NPC		1991
Dawara	0.53	0.53	Suyo,Ilocos Sur	ISECO	Non-NPC		1981
Bachelor	0.75	0.75	Natividad,Pangasinan	PANELCO III	Non-NPC		1983
Philex	0.5	0.5	Itogon,Benguet	Philex Mining Corp.	Non-NPC		1988
Club John Hay	0.56	0.56	Baguio City	Non-NPC			
Magat A&B	2.52	2.5	2 Ramon, Isabela	ISELCO I	Non-NPC		1984, 1985
Tumauini	0.25	0.25	Tumauini,Isabela	ISELCO II	Non-NPC		1992
Dulangan	1.6	1.6	Oriental Mindoro	ORMECO	Non-NP		1990
Balugbog	0.65	0.65	Nagcarlan,Laguna	Phil. Power Dev.Co.	Non-NPC		1930
Palapaquin	0.4	0.4	Sn Pablo,Laguna	Phil. Power Dev.Co.	Non-NPC		1930
San Juan River	0.15	0.15	Kalayaan,Laguna	Kalayaan Ice Plant	Non-NPC		
Inarihan	0.96	0.96	Naga,Camarines Sur	Bicol Hydropower Corp.	Non-NPC		1998
Yabo	0.2	0.2	Pili,Camarines Sur	PROSAMAPI Coop.	Non-NPC		
Oil Thermal	**650**	**645.83**					
Malaya 1	300	300	Pililla, Rizal	NPC	NPC-IPP	ROM-ECA	9/15/1995
Malaya 2	350	345.83	Pililla, Rizal	NPC	NPC-IPP	ROM-ECA	9/15/1995
Wind	**25**	**8.75**					
North Wind Power	25	8.75	Bangui Bay,Ilocos Norte	North Wind Power Dev.Corp.	NON-NPC		June 2005
TOTAL LUZON	**12,172.02**	**10,028.80**					

Source: Power Sector Situationer, 2007

Annex-T H.2.4.2 Indicative Hydropower Development Projects

Region	Project	Location	Potential Capacity (MW)	Year Available
CAR	Pasil HEP	Kalinga	22	2011
	Talubin MHP	Mt. Province	5.6	2012
	Can-eo MHP	Mt. Province	5.9	2012
	Agbulu HEP*	Apayao	360	2012
	Nalatang HEP*	Benguet	75	2014
	Binongan HEP*	Abra	175	2014
I	Upper Agno MHP*	Pangasinan	5	2008
II	Adalam HEP	Quirino	46	2010
	Diduyon HEP*	Quirino	345	2011
	Abuan HEP*	Isabela	60	2013
	Ilaguen HEP*	Isabela	88	2014
III	Dinalugan MHP	Aurora	0.5	2007
	Debutunan MHP	Aurora	0.5	2010
IV-A	Kanan HEP*	Infanta, Quezon	113	2008
IV-B	Batang-Batang MHP	Palawan	3.5	2006
	Langogan MHP*	Palawan	6.8	2010
	Babuyan Island MHP*	Palawan	5.6	2010
	Catuiran HEP*	Mindoro Oriental	18	2011
	Aglubang HEP*	Mindoro Oriental	13.6	2011
	Cabinbin MHP*	Palawan	0.8	2013
V	Kapipian MHP	Catanduanes	3	2006
	Colasi MHP*	Camarines	0.96	2008
	Dugui MHP*	Catanduanes	3.5	2009
	Cawayan II MHP*	Sorsogon	2.5	2012
	Hitoma MHP*	Catanduanes	3	2012
VI	Igbolo MHP*	Iloilo	4	2010
	Timbaban HEP*	Aklan	23.5	2011
	Villasiga HEP*	Antique	16.5	2012
VII	Pacuan HEP	Negros Oriental	33	2007
	Siaton MHP*	Negros Oriental	5.4	2011
	Okoy HEP*	Negros Oriental	12	2012
	Sicopong HEP*	Negros Oriental	17.8	2012
VIII	Bugtong MHP*	Samar	1	2009
	Amandaraga MHP*	Eastern Samar	4	2012
IX	Lower Dapitan MHP	Zamboanga Norte	3.8	2006
	Salug Daku 1 MHP*	Zamboanga Sur	2.5	2008
	Salug Daku 2 MHP	Zamboanga Sur	2.5	2008
	Middle Dapitan MHP	Zamboanga Norte	4.4	2008
	Salug Daku 3 MHP	Zamboanga Sur	6	2010
	Salug Daku 4 MHP	Zamboanga Sur	6	2010
	Upper Dapitan MHP	Zamboanga Norte	3.6	2011
	Ingin MHP*	Zamboanga Norte	3	2012
X	Tuasan MHP	Camiguin	0.5	2008
	Larangan MHP	Misamis Occidental	8.5	2008
	Culaman MHP	Bukidnon	10	2008
	Odiongan 3 MHP*	Misamis Oriental	10	2008
	Cabulig MHP*	Misamis Oriental	3.5	2009
	Tagoloan HEP*	Bukidnon	68	2010
	Impasugong HEP	Bukidnon	68	2010
	Odiongan 2 MHP*	Misamis Oriental	5	2012
	Liangan HEP	Lanao Norte	11.9	2012
	Bulanog Batang HEP*	Bukidnon	132	2012
	Agus III HEP*	Lanao Norte/Sur	225	2014

Note: * with feasibility study

Source: National Energy Plan, 2006

Annex-T H.3.1.1 Explanation of the Control Points

Control Point	Drainage Area (km^2)	Most Downstream Catchment	River System	Description
P0	159.2	PAM01	Pampanga Main	Residual catchment which is directly drained to Manila Bay
P1	7818.7	PAM0201	Pampanga Main	Calumpit
P2	6308.1	PAM0203	Pampanga Main	Cong Dadong diversion dam
P3	3406.2	PAM03	Pampanga Main	Pampanga river before confluence with Rio Chico river
P4	2796.7	PAM0401	Pampanga Main	Pampanga river before confluence with Peneranda river
P5	2025.6	PAM0402	Pampanga Main	Bongabong diversion dam
P6	1286.0	PAM0501	Pampanga Main	Pampanga river before confluence with Coronell river
P7	901.3	PAM0502	Pampanga Main	Rizal diversion dam
P8	869.8	PAM0503	Pampanga Main	Masiway dam
P9	849.4	PAN01	Pampanga Main	Pantabangan storage dam
P10	52.6	PAM0202	Pampanga Main	Proposed site for Massim storage dam
P11	2895.3	RCH0101	Pampanga Main	Rio Chico river before confluence with Pampanga river
P12	709.4	RCH0103	Pampanga Main	Talavera river before confluence with Baliwag river
P13	301.1	RCH0104	Pampanga Main	Talavera diversion dam
P14	696.4	RCH0102	Pampanga Main	Baliwag river before confluence with Talavera river
P15	569.7	PEN0101	Pampanga Main	Penaranda river before confluence with Pampanga river
P16	518.5	PEN0102	Pampanga Main	Penaranda diversion dam
P17	248.8	PEN0103	Pampanga Main	Proposed diversion dam at downstream of proposed Balintingon storage dam
P18	712.0	COR01	Pampanga Main	Coronell river before confluence with Pampanga river
A0	193.5	ANG01	Angat	Residual catchment which is directly drained to Manila Bay
A1	891.7	ANG0201	Angat	Downstream end of the Angat River,
A2	845.7	ANG0202	Angat	Bustos diversion dam
A3	617.6	ANG0204	Angat	Ipo dam
A4	545.9	ANG03	Angat	Angat Storage dam
A5	52.1	ANG0203	Angat	Proposed site for Bayabas storage dam
S0	137.7	PAS0101	Pasac	Residual catchment which is directly drained to Manila Bay
S1	1233.6	PAS0102 & PAS0104	Pasac	Pasac river after confluence with Gumain river
S2	398.4	PAS0103	Pasac	Pasac river after confluence of Abacan river and San Fernando river
S3	637.0	PAS0104	Pasac	Guagua river after confluence with Gumain river
S4	295.1	PAS0105	Pasac	Gumain river after confluence with Porac river
S5	115.6	PAS0106	Pasac	Porac diversion dam
S6	132.3	PAS0107	Pasac	Gumain diversion dam
S7	117.9	PAS0108	Pasac	Proposed site for Gumain storgae dam
R1	67.9	T_AUR	Trans-basin	Diversion point of Aurola trans-basin
C1	569.9	T_CAS	Trans-basin	Diversion point of Casecnan trans-basin
T1	287.6	T_TAL01	Trans-basin	Smoris diverion dam
T2	524.3	T_TAL02	Trans-basin	Bulsa diverison dam
T3	288.7	T_TAL03	Trans-basin	Proposed site for Balog-Balog storage dam
U1_1	130.5	T_UMI01	Trans-basin	Diversion point for Umiray-Angat Trans-basin
U1_2	5.9	T_UMI02	Trans-basin	Diversion point for Umiray-Angat Trans-basin (not yet completed)
U1_3	24.7	T_UMI03	Trans-basin	Diversion point for Umiray-Angat Trans-basin (not yet completed)

Source: JICA Study Team

Annex-T H.3.1.2 Surface Water Resources Potential in Quasi-Natural Condition

Control Point	Drainage Area (km^2)	Probable Annual Average Discharge (m^3/s)			Probable Minimum Monthly Discharge (m^3/s)			Dependable flow (m^3/s)
		1/2	1/5	1/10	1/2	1/5	1/10	
P0	159.2	4.09	3.01	2.67	0.14	0.06	0.04	0.25
P1	7,818.7	279.05	201.02	179.32	24.76	17.05	15.60	39.55
P2	6,308.1	231.94	168.95	149.47	22.67	15.73	14.58	35.49
P3	3,406.2	132.03	102.37	87.82	16.03	11.87	11.17	25.02
P4	2,796.7	102.58	73.71	61.23	11.80	7.52	6.72	19.04
P5	2,025.6	80.59	59.89	48.17	10.85	7.17	6.30	16.70
P6	1,286.0	47.17	32.95	26.05	4.12	2.44	2.17	7.33
P7	901.3	34.31	23.42	19.17	2.98	1.79	1.53	5.21
P8	869.8	33.42	22.92	18.78	2.92	1.75	1.50	5.08
P9	849.4	32.77	22.53	18.47	2.88	1.73	1.48	4.99
P10	52.6	2.41	1.79	1.53	0.06	0.03	0.02	0.12
P11	2,895.3	106.13	66.07	60.62	5.78	3.32	3.07	8.50
P12	709.4	27.02	19.84	16.10	3.21	2.17	1.94	4.30
P13	301.1	14.90	11.18	9.12	2.72	1.91	1.81	3.49
P14	696.4	22.97	17.31	13.52	0.65	0.27	0.16	1.30
P15	569.7	30.09	23.33	22.39	4.12	3.49	3.32	5.33
P16	518.5	29.06	22.50	21.62	4.12	3.49	3.31	5.31
P17	248.8	19.69	15.03	14.41	4.00	3.32	2.94	4.62
P18	712.0	32.51	25.48	20.72	6.02	4.72	3.75	9.24
A0	193.5	4.78	3.37	2.85	0.03	>0.01	>0.01	0.12
A1	891.7	71.01	59.30	55.92	7.56	4.80	3.76	19.31
A2	845.7	70.04	58.84	55.71	7.56	4.80	3.70	19.03
A3	617.6	61.21	51.80	49.25	6.95	4.76	3.49	17.45
A4	545.9	56.39	47.82	45.34	6.72	4.64	3.33	16.97
A5	52.1	2.97	2.19	2.06	0.08	0.04	0.03	0.18
S0	137.7	2.67	1.78	1.35	1.28	0.92	0.70	1.30
S1	1,233.6	37.57	28.01	26.51	18.45	14.79	12.53	19.91
S2	398.4	9.76	6.85	5.64	5.29	3.50	2.91	5.32
S3	637.0	24.50	18.15	16.69	10.57	8.76	8.08	12.15
S4	295.1	14.71	10.64	9.26	5.66	4.50	3.76	6.29
S5	115.6	5.18	3.60	3.19	2.17	1.72	1.52	2.43
S6	132.3	8.04	5.93	4.99	2.80	2.16	1.78	3.07
S7	117.9	7.51	5.54	4.61	2.59	2.03	1.70	2.86
R1	67.9	3.80	3.01	2.68	0.83	0.68	0.56	1.52
T1	287.6	15.00	12.67	10.15	0.60	0.40	0.31	1.33
T2	524.3	29.08	23.34	20.63	1.03	0.67	0.48	2.43
T3	288.7	19.14	16.05	13.77	0.63	0.40	0.30	1.44

Source: JICA Study Team

Annex-T H.3.1.3 Surface Water Resources Potential (Equivalent to 80% Reliability) with Existing and Proposed Storage Dams at Control Points

Control Point	Drainage Area (km^2)	Qausi-Natural (m^3/s)	with Existing storage dams w/o trans-basin (m^3/s)	with Existing storage dams w/ trans-basin (m^3/s)	with Existing storage dams + Proposed storage dams (m^3/s)
P0	159.2	0.25	0.25	0.25	0.25
P1	7,818.7	39.55	71.47	95.57	111.64
P2	6,308.1	35.49	67.41	91.51	105.20
P3	3,406.2	25.02	56.94	81.04	94.72
P4	2,796.7	19.04	50.96	75.06	75.06
P5	2,025.6	16.70	48.63	72.73	72.73
P6	1,286.0	7.33	39.25	63.35	63.35
P7	901.3	5.21	37.13	61.23	61.23
P8	869.8	5.08	37.00	61.10	61.10
P9	849.4	4.99	37.00	61.10	61.10
P10	52.6	0.12	0.12	0.12	2.50
P11	2,895.3	8.50	8.50	8.50	8.50
P12	709.4	4.30	4.30	4.30	4.30
P13	301.1	3.49	3.49	3.49	3.49
P14	696.4	1.30	1.30	1.30	1.30
P15	569.7	5.33	5.33	5.33	19.01
P16	518.5	5.31	5.31	5.31	18.99
P17	248.8	4.62	4.62	4.62	18.30
P18	712.0	9.24	9.24	9.24	9.24
A0	193.5	0.12	0.12	0.12	0.12
A1	891.7	19.31	53.24	64.44	69.56
A2	845.7	19.03	52.96	64.16	69.28
A3	617.6	17.45	51.38	62.58	64.78
A4	545.9	16.97	50.90	62.10	64.30
A5	52.1	0.18	0.18	0.18	3.10
S0	137.7	1.30	1.30	1.30	1.30
S1	1,233.6	19.91	19.91	19.91	23.54
S2	398.4	5.32	5.32	5.32	5.32
S3	637.0	12.15	12.15	12.15	15.79
S4	295.1	6.29	6.29	6.29	9.92
S5	115.6	2.43	2.43	2.43	2.43
S6	132.3	3.07	3.07	3.07	6.71
S7	117.9	2.86	2.86	2.86	6.50
T1	287.6	1.33	1.33	1.33	1.33
T2	524.3	2.43	2.43	2.43	19.99
T3	288.7	1.44	1.44	1.44	19.00

Source: JICA Study Team

Annex-T H.3.1.4 Groundwater Resources Potential

CityMun	Province	Total Area (km^2)	Area inside the Study Area (km^2)	Ratio	Annual Total Prec-ipitation (mm/y)	Annual Total PET (mm/y)	Annual Total Rech._H (mm/y)	Annual Total Rech._L (mm/y)	Sub-Area 1 (km^2)	Sub-Area 2 (km^2)	Sub-Area 3 (km^2)	Saltwater Encroa-ched Area (km^2)	Ratio of Restricted Area by Aquifer Conidtion	Ratio of Restricted Aeea by Salt-watei Intrusion	GWP_H		GWP_L		SWE_H		SWE_L	
															(mm/y)	(MCM/y)	(mm/y)	(MCM/y)	(mm/y)	(MCM/y)	(mm/y)	(MCM/y)
Angat	Bulacan	58.56	52.59	0.898	1,897	1,379	228	95	45.0	13.5	0.0	0.0	0.130	0.000	198	10.4	82	4.3	0	0.0	0	0.0
Baliuag	Bulacan	43.63	43.63	1.000	1,660	1,399	199	83	43.6	0.0	0.0	0.0	0.000	0.000	199	8.7	83	3.6	0	0.0	0	0.0
Bulacan	Bulacan	69.38	11.19	0.161	1,906	1,411	229	95	0.0	0.0	0.0	69.4	0.000	1.000	229	2.6	95	1.1	229	2.6	95	1.1
Bustos	Bulacan	40.48	17.74	0.438	1,746	1,395	209	87	40.5	0.0	0.0	0.0	0.000	0.000	209	3.7	87	1.5	0	0.0	0	0.0
Calumpit	Bulacan	46.52	46.52	1.000	1,723	1,411	207	86	2.7	0.0	0.0	43.9	0.000	0.943	207	9.6	86	4.0	195	9.1	81	3.8
Dona Remedios Trinidad	Bulacan	878.91	854.25	0.972	3,511	1,228	421	176	0.0	251.7	627.2	0.0	0.875	0.000	52	44.8	22	18.7	0	0.0	0	0.0
Guiguinto	Bulacan	24.80	1.64	0.066	1,928	1,406	231	96	3.1	0.0	0.0	21.7	0.000	0.875	231	0.4	96	0.2	202	0.3	84	0.1
Hagonoy	Bulacan	94.58	94.55	1.000	1,764	1,414	212	88	0.0	0.0	0.0	94.6	0.000	1.000	212	20.0	88	8.3	212	20.0	88	8.3
Malolos City	Bulacan	72.58	72.58	1.000	1,833	1,409	220	92	7.0	0.0	0.0	65.6	0.000	0.904	220	16.0	92	6.7	199	14.4	83	6.0
Norzagaray	Bulacan	246.57	206.82	0.839	3,306	1,234	397	165	17.3	60.6	168.7	0.0	0.823	0.000	70	14.5	29	6.0	0	0.0	0	0.0
Pandi	Bulacan	50.39	1.39	0.028	1,876	1,391	225	94	47.2	0.0	0.0	3.2	0.000	0.063	225	0.3	94	0.1	14	0.0	6	0.0
Paombong	Bulacan	45.83	45.83	1.000	1,785	1,412	214	89	0.0	0.0	0.0	45.8	0.000	1.000	214	9.8	89	4.1	214	9.8	89	4.1
Plaridel	Bulacan	35.44	20.04	0.565	1,831	1,405	220	92	35.4	0.0	0.0	0.0	0.000	0.000	220	4.4	92	1.8	0	0.0	0	0.0
Pulilan	Bulacan	43.62	43.62	1.000	1,748	1,405	210	87	43.6	0.0	0.0	0.0	0.000	0.000	210	9.1	87	3.8	0	0.0	0	0.0
San Ildefonso	Bulacan	166.53	166.53	1.000	1,785	1,379	214	89	128.8	37.8	0.0	0.0	0.128	0.000	187	31.1	78	13.0	0	0.0	0	0.0
San Miguel	Bulacan	235.92	235.92	1.000	1,781	1,380	214	89	151.2	84.8	0.0	0.0	0.203	0.000	170	40.2	71	16.7	0	0.0	0	0.0
San Rafael	Bulacan	104.95	104.95	1.000	1,720	1,386	206	86	98.5	6.5	0.0	0.0	0.035	0.000	199	20.9	83	8.7	0	0.0	0	0.0
Santa Maria	Bulacan	78.65	0.75	0.010	1,987	1,389	238	99	78.6	0.0	0.0	0.1	0.000	0.001	238	0.2	99	0.1	0	0.0	0	0.0
Aliaga	Nueva Ecija	92.17	92.17	1.000	1,676	1,401	201	84	0.0	0.0	92.2	0.0	0.000	0.000	201	18.5	84	7.7	0	0.0	0	0.0
Bongabon	Nueva Ecija	229.40	224.53	0.979	2,102	1,250	252	105	162.2	0.0	67.2	0.0	0.554	0.000	113	25.3	47	10.5	0	0.0	0	0.0
Cabanatuan City	Nueva Ecija	198.18	198.18	1.000	1,764	1,390	212	88	0.0	27.1	171.1	0.0	0.048	0.000	202	39.9	84	16.6	0	0.0	0	0.0
Cabiao	Nueva Ecija	113.48	113.48	1.000	1,505	1,397	181	75	0.0	0.0	113.5	0.0	0.000	0.000	181	20.5	75	8.5	0	0.0	0	0.0
Carranglan	Nueva Ecija	739.39	692.95	0.937	2,309	1,146	277	115	735.6	0.0	3.8	0.0	0.779	0.000	61	42.4	26	17.7	0	0.0	0	0.0
Gabaldon	Nueva Ecija	252.52	252.22	0.999	2,354	1,180	282	118	233.8	17.6	1.1	0.0	0.749	0.000	71	17.9	30	7.4	0	0.0	0	0.0
Gapan	Nueva Ecija	164.50	164.50	1.000	1,709	1,373	205	85	0.0	63.7	100.8	0.0	0.135	0.000	177	29.2	74	12.2	0	0.0	0	0.0
Gen Mamerto Natividad	Nueva Ecija	98.01	98.01	1.000	1,641	1,382	197	82	0.0	0.0	98.0	0.0	0.000	0.000	197	19.3	82	8.0	0	0.0	0	0.0
General Tinio	Nueva Ecija	580.85	580.04	0.999	2,637	1,236	316	132	268.3	291.5	21.0	0.0	0.536	0.000	147	85.1	61	35.5	0	0.0	0	0.0
Guimba	Nueva Ecija	219.23	137.29	0.626	1,702	1,404	204	85	0.0	0.0	219.2	0.0	0.000	0.000	204	28.0	85	11.7	0	0.0	0	0.0
Jaen	Nueva Ecija	90.45	90.45	1.000	1,524	1,396	183	76	0.0	0.0	90.4	0.0	0.000	0.000	183	16.5	76	6.9	0	0.0	0	0.0
Laur	Nueva Ecija	221.35	221.35	1.000	1,858	1,289	223	93	20.5	163.1	37.7	0.0	0.329	0.000	150	33.1	62	13.8	0	0.0	0	0.0
Licab	Nueva Ecija	60.42	60.42	1.000	1,526	1,404	183	76	0.0	0.0	60.4	0.0	0.000	0.000	183	11.1	76	4.6	0	0.0	0	0.0
Llanera	Nueva Ecija	114.25	114.25	1.000	1,744	1,376	209	87	1.1	0.0	113.1	0.0	0.008	0.000	208	23.7	87	9.9	0	0.0	0	0.0
Lupao	Nueva Ecija	142.66	129.69	0.909	2,028	1,348	243	101	19.9	0.0	122.7	0.0	0.109	0.000	217	28.1	90	11.7	0	0.0	0	0.0
Science City Of Munoz	Nueva Ecija	142.44	142.44	1.000	1,915	1,385	230	96	0.0	0.0	142.4	0.0	0.000	0.000	230	32.7	96	13.6	0	0.0	0	0.0
Palayan City	Nueva Ecija	136.11	136.11	1.000	1,656	1,352	199	83	0.0	91.2	45.0	0.0	0.233	0.000	152	20.7	63	8.6	0	0.0	0	0.0
Pantabangan	Nueva Ecija	421.05	421.05	1.000	1,990	1,268	239	99	420.5	0.0	0.5	0.0	0.782	0.000	52	21.9	22	9.1	0	0.0	0	0.0
Penaranda	Nueva Ecija	78.53	78.53	1.000	1,700	1,376	204	85	0.0	30.4	48.2	0.0	0.135	0.000	177	13.9	74	5.8	0	0.0	0	0.0
Quezon	Nueva Ecija	68.33	68.33	1.000	1,658	1,403	199	83	0.0	0.0	68.3	0.0	0.000	0.000	199	13.6	83	5.7	0	0.0	0	0.0
Rizal	Nueva Ecija	123.88	123.88	1.000	1,677	1,361	201	84	48.8	0.0	75.0	0.0	0.309	0.000	139	17.2	58	7.2	0	0.0	0	0.0
San Antonio	Nueva Ecija	156.90	156.90	1.000	1,573	1,399	189	79	0.0	0.0	156.9	0.0	0.000	0.000	189	29.6	79	12.3	0	0.0	0	0.0
San Isidro	Nueva Ecija	58.07	58.07	1.000	1,496	1,392	179	75	0.0	0.0	58.1	0.0	0.000	0.000	179	10.4	75	4.3	0	0.0	0	0.0
San Jose City	Nueva Ecija	161.75	161.75	1.000	1,900	1,354	228	95	19.3	0.0	142.5	0.0	0.093	0.000	207	33.4	86	13.9	0	0.0	0	0.0
San Leonardo	Nueva Ecija	51.69	51.69	1.000	1,605	1,389	193	80	0.0	0.0	51.7	0.0	0.000	0.000	193	10.0	80	4.1	0	0.0	0	0.0
Santa Rosa	Nueva Ecija	116.52	116.52	1.000	1,688	1,390	203	84	0.0	30.4	86.1	0.0	0.091	0.000	184	21.5	77	8.9	0	0.0	0	0.0
Santo Domingo	Nueva Ecija	82.69	82.69	1.000	1,793	1,396	215	90	0.0	0.0	82.7	0.0	0.000	0.000	215	17.8	90	7.4	0	0.0	0	0.0
Talavera	Nueva Ecija	135.06	135.06	1.000	1,849	1,391	222	92	0.0	0.0	135.1	0.0	0.000	0.000	222	30.0	92	12.5	0	0.0	0	0.0
Talugtug	Nueva Ecija	73.46	38.82	0.528	1,890	1,385	227	95	0.0	0.0	73.5	0.0	0.000	0.000	227	8.8	95	3.7	0	0.0	0	0.0
Zaragosa	Nueva Ecija	71.98	71.98	1.000	1,471	1,403	177	74	0.0	0.0	72.0	0.0	0.000	0.000	177	12.7	74	5.3	0	0.0	0	0.0
Angeles City	Pampanga	62.80	62.80	1.000	2,212	1,354	265	111	50.1	12.7	0.0	0.0	0.203	0.000	212	13.3	88	5.5	0	0.0	0	0.0
Apalit	Pampanga	60.10	60.10	1.000	1,667	1,407	200	83	38.3	0.0	0.0	21.7	0.000	0.362	200	12.0	83	5.0	72	4.4	30	1.8
Arayat	Pampanga	176.68	176.68	1.000	1,703	1,369	204	85	127.6	49.1	0.0	0.0	0.278	0.000	148	26.1	61	10.9	0	0.0	0	0.0
Bacolor	Pampanga	74.24	74.24	1.000	1,905	1,398	229	95	74.2	0.0	0.0	0.0	0.000	0.000	229	17.0	95	7.1	0	0.0	0	0.0
Candaba	Pampanga	208.20	208.20	1.000	1,424	1,399	171	71	208.2	0.0	0.0	0.0	0.000	0.000	171	35.6	71	14.8	0	0.0	0	0.0
Floridablanca	Pampanga	120.94	83.39	0.690	2,278	1,394	273	114	79.0	41.9	0.0	0.0	0.347	0.000	179	14.9	74	6.2	0	0.0	0	0.0
Guagua	Pampanga	48.93	48.93	1.000	1,771	1,409	212	89	41.1	0.0	0.0	7.8	0.000	0.160	212	10.4	89	4.3	34	1.7	14	0.7
Lubao	Pampanga	155.02	148.79	0.960	1,761	1,416	211	88	72.9	0.0	0.0	82.2	0.000	0.530	211	31.4	88	13.1	112	16.7	47	6.9
Mabalacat	Pampanga	145.73	140.22	0.962	2,403	1,306	288	120	76.9	68.9	0.0	0.0	0.473	0.000	152	21.3	63	8.9	0	0.0	0	0.0
Macabebe	Pampanga	102.36	102.36	1.000	1,693	1,415	203	85	0.0	0.0	0.0	102.4	0.000	1.000	203	20.8	85	8.7	203	20.8	85	8.7
Magalang	Pampanga	104.53	104.53	1.000	2,033	1,389	244	102	104.5	0.0	0.0	0.0	0.000	0.000	244	25.5	102	10.6	0	0.0	0	0.0
Masantol	Pampanga	45.94	45.94	1.000	1,712	1,414	205	86	0.0	0.0	0.0	45.9	0.000	1.000	205	9.4	86	3.9	205	9.4	86	3.9
Mexico	Pampanga	122.01	122.01	1.000	1,892	1,397	227	95	122.0	0.0	0.0	0.0	0.000	0.000	227	27.7	95	11.5	0	0.0	0	0.0
Minalin	Pampanga	45.45	45.45	1.000	1,683	1,411	202	84	8.7	0.0	0.0	36.8	0.000	0.809	202	9.2	84	3.8	163	7.4	68	3.1
Porac	Pampanga	293.31	291.96	0.995	2,660	1,268	319	133	85.5	207.9	0.0	0.0	0.709	0.000	93	27.2	39	11.3	0	0.0	0	0.0
City Of San Fernando	Pampanga	68.57	68.57	1.000	1,935	1,396	232	97	68.6	0.0	0.0	0.0	0.000	0.000	232	15.9	97	6.6	0	0.0	0	0.0
San Luis	Pampanga	55.25	55.25	1.000	1,507	1,402	181	75	55.2	0.0	0.0	0.0	0.000	0.000	181	10.0	75	4.2	0	0.0	0	0.0
San Simon	Pampanga	59.93	59.93	1.000	1,615	1,406	194	81	59.9	0.0	0.0	0.0	0.000	0.000	194	11.6	81	4.8	0	0.0	0	0.0
Santa Ana	Pampanga	40.44	40.44	1.000	1,594	1,401	191	80	40.4	0.0	0.0	0.0	0.000	0.000	191	7.7	80	3.2	0	0.0	0	0.0
Santa Rita	Pampanga	23.19	23.19	1.000	1,858	1,402	223	93	23.2	0.0	0.0	0.0	0.000	0.000	223	5.2	93	2.2	0	0.0	0	0.0
Santo Tomas	Pampanga	14.46	14.46	1.000	1,740	1,408	209	87	9.3	0.0	0.0	5.1	0.000	0.354	209	3.0	87	1.3	74	1.1	31	0.4
Sasmuan	Pampanga	44.80	44.76	0.999	1,663	1,415	200	83	0.3	0.0	0.0	44.5	0.001	0.992	199	8.9	83	3.7	198	8.9	82	3.7
Bamban	Tarlac	250.57	146.51	0.585	2,714	1,268	326	136	11.1	0.4	239.0	0.0	0.955	0.000	15	2.2	6	0.9	0	0.0	0	0.0
Capas	Tarlac	422.30	133.94	0.317	2,626	1,321	315	131	76.0	118.5	227.8	0.0	0.692	0.000	97	13.0	40	5.4	0	0.0	0	0.0
Concepcion	Tarlac	221.46	221.46	1.000	1,888	1,395	227	94	220.4	0.0	1.1	0.0	0.005	0.000	225	49.9	94	20.8	0	0.0	0	0.0
La Paz	Tarlac	116.65	116.65	1.000	1,559	1,404	187	78	116.7	0.0	0.0	0.0	0.000	0.000	187	21.8	78	9.1	0	0.0	0	0.0
Tarlac City	Tarlac	261.08	132.07	0.506	1,920	1,397	230	96	232.8	28.2	0.0	0.0	0.059	0.000	217	28.6	90	11.9	0	0.0	0	0.0
Victoria	Tarlac	112.08	83.35	0.744	1,687	1,409	202	84	112.1	0.0	0.0	0.0	0.000	0.000	202	16.9	84	7.0	0	0.0	0	0.0
Total																**1476.3**		**615.1**		**126.5**		**52.7**

Source: JICA Study Team

Annex-T H.3.2.1 Present and Projected Municipal Water Demand by City/Municipality in the Study Area

Source: JICA Study Team

(unit: m^3/day)

Province	City / Municipality	Water Demand (m^3/day)																									
		2008									2015									2025							
		Urban				Rural				Total	Urban				Rural				Total	Urban				Rural				Total
		Level 3	Level 2	Level 1	SubTotal	Level 3	Level 2	Level 1	SubTotal		Level 3	Level 2	Level 1	SubTotal	Level 3	Level 2	Level 1	SubTotal		Level 3	Level 2	Level 1	SubTotal	Level 3	Level 2	Level 1	SubTotal	
Bulacan	Angat	2,589	0	0	2,589	1,798	0	1,191	2,989	5,578	3,087	0	0	3,087	2,134	0	1,528	3,662	6,750	3,907	0	0	3,907	2,705	0	2,082	4,787	8,694
	Baliuag	14,641	0	3,782	18,423	0	0	0	0	18,423	20,621	0	3,725	24,345	0	0	0	0	24,345	40,025	0	0	40,025	0	0	0	0	40,025
	Bulacan	189	0	0	189	1,169	0	177	1,346	1,535	225	0	0	225	1,388	0	227	1,614	1,840	285	0	0	285	1,759	0	309	2,068	2,353
	Bustos	1,359	0	0	1,359	1,636	0	485	2,122	3,480	1,620	0	0	1,620	1,942	0	623	2,565	4,185	2,050	0	0	2,050	2,462	0	848	3,310	5,360
	Calumpit	18,419	0	179	18,598	0	0	0	0	18,598	22,634	0	0	22,634	0	0	0	0	22,634	28,640	0	0	28,640	0	0	0	0	28,640
	Doña Remedios Trinidad	0	0	0	0	2,797	0	63	2,860	2,860	0	0	0	0	3,320	0	80	3,400	3,400	0	0	0	0	4,208	0	109	4,318	4,318
	Guiguinto	427	0	229	655	0	0	0	0	655	645	0	243	889	0	0	0	0	889	1,727	0	0	1,727	0	0	0	0	1,727
	Hagonoy	21,811	0	843	22,653	0	0	0	0	22,653	28,923	0	82	29,005	0	0	0	0	29,005	36,903	0	0	36,903	0	0	0	0	36,903
	Malolos City	20,162	0	7,331	27,492	0	0	0	0	27,492	29,191	0	7,550	36,741	0	0	0	0	36,741	65,179	0	0	65,179	0	0	0	0	65,179
	Norzagaray	5,900	0	0	5,900	4,896	0	1,421	6,317	12,217	7,035	0	0	7,035	5,811	0	1,823	7,635	14,670	8,902	0	0	8,902	7,367	0	2,484	9,851	18,752
	Pandi	318	0	2	320	0	0	0	0	320	385	0	0	385	0	0	0	0	385	488	0	0	488	0	0	0	0	488
	Paombong	1,952	0	0	1,952	6,077	0	297	6,374	8,326	2,327	0	0	2,327	7,213	0	381	7,593	9,920	2,945	0	0	2,945	9,143	0	519	9,662	12,606
	Plaridel	7,716	0	1,023	8,739	0	0	0	0	8,739	10,504	0	856	11,359	0	0	0	0	11,359	16,491	0	0	16,491	0	0	0	0	16,491
	Pulilan	606	0	5,045	5,652	0	0	0	0	5,652	2,686	0	5,732	8,417	0	0	0	0	8,417	24,839	0	0	24,839	0	0	0	0	24,839
	San Ildefonso	2,843	0	0	2,843	2,276	0	3,320	5,596	8,439	3,390	0	0	3,390	2,701	0	4,261	6,962	10,352	4,289	0	0	4,289	3,424	0	5,805	9,229	13,519
	San Miguel	5,541	0	0	5,541	5,809	0	3,812	9,621	15,162	6,607	0	0	6,607	6,894	0	4,893	11,786	18,394	8,360	0	0	8,360	8,739	0	6,665	15,404	23,765
	San Rafael	1,733	0	0	1,733	2,102	0	3,251	5,353	7,086	2,067	0	0	2,067	2,495	0	4,173	6,667	8,734	2,615	0	0	2,615	3,162	0	5,685	8,847	11,462
	Santa Maria	227	0	48	275	0	0	0	0	275	316	0	46	362	0	0	0	0	362	571	0	0	571	0	0	0	0	571
Nueva Ecija	Aliaga	2,756	0	1,701	4,457	0	0	965	965	5,422	3,980	0	1,713	5,693	0	0	1,159	1,159	6,852	10,524	0	0	10,524	0	0	1,452	1,452	11,976
	Bongabon	602	0	0	602	1,178	1,010	2,420	4,609	5,211	672	0	0	672	1,309	1,133	2,908	5,350	6,023	783	0	0	783	1,526	1,331	3,643	6,501	7,283
	Cabanatuan City	36,308	4	3,318	39,629	0	1	778	779	40,408	45,746	4	2,175	47,925	0	1	935	936	48,861	60,715	0	0	60,715	0	1	1,172	1,173	61,888
	Cabiao	2,378	220	3,076	5,674	0	10	145	155	5,829	4,053	243	3,360	7,656	0	12	174	186	7,842	16,274	0	0	16,274	0	14	218	232	16,506
	Carranglan	0	0	883	883	0	0	847	847	1,730	310	0	943	1,252	0	0	1,018	1,018	2,270	3,604	0	0	3,604	0	0	1,275	1,275	4,878
	Gabaldon	0	695	264	959	0	813	309	1,122	2,080	263	769	801	1,834	0	911	371	1,283	3,116	3,063	0	0	3,063	0	1,070	465	1,536	4,599
	Gapan	4,245	497	2,406	7,148	0	289	1,397	1,686	8,834	6,178	550	2,781	9,510	0	324	1,679	2,002	11,512	16,757	0	0	16,757	0	380	2,103	2,483	19,240
	Gen Mamerto Natividad	1,224	3	62	1,288	0	54	1,280	1,333	2,621	1,525	3	22	1,549	0	60	1,538	1,598	3,147	1,849	0	0	1,849	0	71	1,926	1,997	3,846
	General Tinio	2,469	69	385	2,923	0	150	840	990	3,913	3,184	76	369	3,629	0	168	1,010	1,178	4,806	4,974	0	0	4,974	0	197	1,265	1,462	6,436
	Guimba	2,210	0	15	2,225	0	20	2,446	2,466	4,691	2,519	0	0	2,519	0	22	2,939	2,961	5,480	2,931	0	0	2,931	0	26	3,683	3,708	6,639
	Jaen	2,473	16	495	2,985	0	67	2,100	2,167	5,152	3,215	18	447	3,680	0	75	2,523	2,599	6,278	5,280	0	0	5,280	0	89	3,161	3,250	8,530
	Laur	1,306	39	95	1,440	0	360	875	1,235	2,675	1,646	43	81	1,771	0	404	1,051	1,455	3,226	2,196	0	0	2,196	0	474	1,317	1,791	3,987
	Licab	988	0	0	988	338	0	833	1,172	2,159	1,102	0	0	1,102	376	0	1,001	1,377	2,480	1,283	0	0	1,283	438	0	1,255	1,693	2,975
	Llanera	287	14	230	531	0	81	1,369	1,450	1,981	436	15	245	697	0	91	1,645	1,736	2,433	1,352	0	0	1,352	0	107	2,061	2,168	3,520
	Lupao	0	0	126	126	0	0	1,596	1,596	1,722	44	0	135	179	0	0	1,918	1,918	2,097	514	0	0	514	0	0	2,403	2,403	2,917
	Science City of Munoz	5,689	0	0	5,689	799	497	1,531	2,827	8,516	6,350	0	0	6,350	887	558	1,839	3,284	9,635	7,390	0	0	7,390	1,034	655	2,304	3,994	11,383
	Palayan City	2,071	0	0	2,071	144	168	990	1,302	3,373	2,312	0	0	2,312	160	188	1,189	1,538	3,850	2,690	0	0	2,690	187	221	1,490	1,898	4,588
	Pantabangan	0	0	0	0	0	1,560	205	1,765	1,765	0	0	0	0	0	1,749	246	1,995	1,995	0	0	0	0	0	2,054	308	2,363	2,363
	Penaranda	0	0	0	0	3,012	74	348	3,433	3,433	0	0	0	0	3,346	83	418	3,847	3,847	0	0	0	0	3,901	97	524	4,522	4,522
	Quezon	0	0	550	550	0	0	1,269	1,269	1,819	193	0	587	780	0	0	1,525	1,525	2,304	2,244	0	0	2,244	0	0	1,910	1,910	4,154
	Rizal	0	3	411	414	0	17	2,309	2,326	2,741	145	3	442	590	0	19	2,774	2,794	3,384	1,688	0	0	1,688	0	23	3,476	3,499	5,187
	San Antonio	2,639	25	291	2,955	0	202	2,328	2,530	5,486	3,349	28	230	3,607	0	227	2,797	3,024	6,631	4,688	0	0	4,688	0	266	3,505	3,771	8,460
	San Isidro	3,424	98	1,567	5,089	0	0	0	0	5,089	4,778	108	1,617	6,503	0	0	0	0	6,503	11,123	0	0	11,123	0	0	0	0	11,123
	San Jose City	9,499	0	0	9,499	11,622	0	0	11,622	21,121	10,603	0	0	10,603	12,913	0	0	12,913	23,516	12,338	0	0	12,338	15,054	0	0	15,054	27,392
	San Leonardo	3,475	498	799	4,772	0	389	624	1,013	5,785	4,669	551	1,094	6,315	0	436	750	1,186	7,501	9,198	0	0	9,198	0	512	940	1,452	10,650
	Santa Rosa	309	0	0	309	3,895	208	1,519	5,622	5,930	345	0	0	345	4,327	233	1,825	6,386	6,730	401	0	0	401	5,045	274	2,287	7,605	8,006
	Santo Domingo	817	21	1,985	2,823	0	6	550	555	3,379	1,705	23	2,105	3,833	0	6	660	667	4,500	9,225	0	0	9,225	0	8	827	835	10,060
	Talavera	8,166	0	3,214	11,379	0	0	498	498	11,877	11,153	0	3,124	14,277	0	0	598	598	14,876	23,725	0	0	23,725	0	0	750	750	24,475
	Talugtug	241	0	0	241	96	0	461	556	797	269	0	0	269	106	0	553	660	929	313	0	0	313	124	0	693	817	1,130
	Zaragosa	800	141	730	1,670	0	195	1,012	1,206	2,877	1,273	156	855	2,283	0	218	1,216	1,434	3,717	4,420	0	0	4,420	0	257	1,523	1,780	6,200
Pampanga	Angeles City	50,523	0	3,136	53,659	0	0	0	0	53,659	63,744	0	1,456	65,200	0	0	0	0	65,200	80,091	0	0	80,091	0	0	0	0	80,091
	Apalit	11,922	0	2,150	14,073	0	0	0	0	14,073	15,542	0	1,864	17,406	0	0	0	0	17,406	24,778	0	0	24,778	0	0	0	0	24,778
	Arayat	0	0	1,257	1,257	0	0	4,976	4,976	6,232	445	0	1,355	1,800	0	0	6,036	6,036	7,836	5,239	0	0	5,239	0	0	7,649	7,649	12,888
	Bacolor	1,282	23	112	1,418	0	151	732	883	2,301	1,635	26	90	1,751	0	171	888	1,059	2,810	2,237	0	0	2,237	0	204	1,125	1,328	3,566
	Candaba	2,197	0	0	2,197	925	57	4,000	4,982	7,179	2,476	0	0	2,476	1,038	64	4,853	5,955	8,431	2,915	0	0	2,915	1,224	76	6,150	7,450	10,364
	Floridablanca	5,205	0	0	5,205	4,495	0	819	5,314	10,519	5,866	0	0	5,866	5,042	0	993	6,035	11,901	6,904	0	0	6,904	5,946	0	1,258	7,204	14,108
	Guagua	11,684	47	2,620	14,351	0	0	0	0	14,351	15,424	53	2,415	17,892	0	0	0	0	17,892	26,558	0	0	26,558	0	0	0	0	26,558
	Lubao	5,784	8	1,372	7,163	0	25	4,291	4,316	11,479	7,658	9	1,265	8,931	0	28	5,206	5,234	14,165	13,414	0	0	13,414	0	33	6,597	6,630	20,044
	Mabalacat	30,127	0	2,359	32,486	0	0	4	4	32,490	38,184	0	1,395	39,579	0	0	5	5	39,584	49,796	0	0	49,796	0	0	6	6	49,803
	Macabebe	1,558	0	0	1,558	7,001	0	940	7,940	9,499	1,756	0	0	1,756	7,853	0	1,140	8,993	10,749	2,067	0	0	2,067	9,260	0	1,445	10,704	12,772
	Magalang	0	0	4,176	4,176	0	0	1,539	1,539	5,715	1,479	0	4,503	5,982	0	0	1,867	1,867	7,849	17,409	0	0	17,409	0	0	2,366	2,366	19,775
	Masantol	0	0	950	950	0	0	1,803	1,803	2,754	337	0	1,025	1,361	0	0	2,188	2,188	3,549	3,962	0	0	3,962	0	0	2,772	2,772	6,734
	Mexico	5,669	0	1,850	7,520	0	0	4,148	4,148	11,668	7,684	0	1,779	9,463	0	0	5,032	5,032	14,495	15,234	0	0	15,234	0	0	6,377	6,377	21,610
	Minalin	2,809	0	0	2,809	555	0	1,119	1,674	4,483	3,166	0	0	3,166	623	0	1,358	1,980	5,146	3,726	0	0	3,726	734	0	1,720	2,455	6,181
	Porac	3,363	468	2,153	5,984	0	426	1,960	2,386	8,370	5,048	523	2,547	8,118	0	482	2,378	2,860	10,978	14,803	0	0	14,803	0	573	3,013	3,586	18,389
	City of San Fernando	24,788	3,689	5,688	34,165	0	111	170	281	34,446	33,659	4,126	7,973	45,758	0	125	207	332	46,090	67,358	0	0	67,358	0	149	262	411	67,769
	San Luis	0	0	1,593	1,593	0	0	1,091	1,091	2,685	564	0	1,718	2,283	0	0	1,324	1,324	3,606	6,643	0	0	6,643	0	0	1,677	1,677	8,320
	San Simon	3,127	0	0	3,127	1,510	0	1,136	2,646	5,774	3,525	0	0	3,525	1,694	0	1,379	3,072	6,597	4,148	0	0	4,148	1,997	0	1,747	3,744	7,892
	Santa Ana	589	2,083	1,394	4,066	0	0	0	0	4,066	1,741	2,330	3,053	7,123	0	0	0	0	7,123	12,671	0	0	12,671	0	0	0	0	12,671
	Santa Rita	1,160	0	1,874	3,034	0	0	0	0	3,034	2,102	0	1,977	4,079	0	0	0	0	4,079	9,352	0	0	9,352	0	0	0	0	9,352
	Santo Tomas	4,837	0	774	5,611	0	0	0	0	5,611	6,271	0	650	6,921	0	0	0	0	6,921	9,643	0	0	9,643	0	0	0	0	9,643
	Sasmuan	0	0	402	402	0	0	1,019	1,019	1,421	142	0	434	576	0	0	1,236	1,236	1,812	1,676	0	0	1,676	0	0	1,567	1,567	3,243
Tarlac	Bamban	1,330	0	1,267	2,597	0	0	424	424	3,021	2,085	0	1,308	3,393	0	0	512	512	3,905	6,955	0	0	6,955	0	0	644	644	7,599
	Capas	1,107	0	0	1,107	1,449	0	1,214	2,663	3,770	1,240	0	0	1,240	1,616	0	1,465	3,081	4,321	1,449	0	0	1,449	1,892	0	1,843	3,735	5,184
	Concepcion	8,140	0	109	8,249	0	0	4,626	4,626	12,876	9,505	0	0	9,505	0	0	5,579	5,579	15,085	11,108	0	0	11,108	0	0	7,020	7,020	18,129
	La Paz	1,657	0	171	1,828	0	0	2,536	2,536	4,364	2,102	0	121	2,223	0	0	3,059	3,059	5,282	2,874	0	0	2,874	0	0	3,849	3,849	6,723
	Tarlac City	11,788	0	2,534	14,323	0	0	2,844	2,844	17,166	15,421	0	2,270	17,691	0	0	3,430	3,430	21,121	25,865	0	0	25,865	0	0	4,316	4,316	30,180
	Victoria	1,019	0	0	1,019	86	0	1,861	1,947	2,966	1,142	0	0	1,142	96	0	2,245	2,340	3,482	1,334	0	0	1,334	112	0	2,824	2,936	4,271
Total		392,474	8,659	79,027	480,160	65,666	6,939	89,114	161,718	641,878	514,224	9,658	80,556	604,438	75,283	7,790	108,627	191,700	796,138	899,963	0	0	899,963	91,444	9,161	138,672	239,277	1,139,240

	Bulacan	106,432	0	18,482	124,914	28,561	0	14,015	42,576	167,490	142,263	0	18,233	160,497	33,897	0	17,988	51,885	212,382	248,214	0	0	248,214	42,970	0	24,507	67,477	315,691
	Nueva Ecija	94,375	2,340	22,602	119,317	21,084	6,169	31,844	59,097	178,414	122,018	2,592	23,126	147,735	23,425	6,918	38,262	68,605	216,340	221,541	0	0	221,541	27,309	8,126	47,937	83,373	304,913
	Pampanga	166,626	6,319	33,861	206,806	14,486	770	29,748	45,004	251,810	218,447	7,066	35,499	261,012	16,249	871	36,088	53,209	314,221	380,623	0	0	380,623	19,160	1,035	45,732	65,928	446,551
	Tarlac	25,041	0	4,081	29,123	1,535	0	13,506	15,041	44,164	31,496	0	3,698	35,194	1,712	0	16,289	18,001	53,195	49,585	0	0	49,585	2,004	0	20,496	22,500	72,085
	Total	392,474	8,659	79,027	480,160	65,666	6,939	89,114	161,718	641,878	514,224	9,658	80,556	604,438	75,283	7,790	108,627	191,700	796,138	899,963	0	0	899,963	91,444	9,161	138,672	239,277	1,139,240

Annex-T H.3.2.2 Present and Projected Industrial Water Demand for Surface Water Source

Water Balance Catchment	Industrial Water Demand (2008)		Industrial Water Demand (2025)	
	(m^3/s)	(MCM/y)	(m^3/s)	(MCM/y)
ANG01	0.000	0.000	0.000	0.000
ANG0201	0.000	0.000	0.000	0.000
ANG0202	0.021	0.662	0.026	0.811
ANG0203	0.000	0.000	0.000	0.000
ANG0204	0.000	0.000	0.000	0.000
ANG03	0.000	0.000	0.000	0.000
COR01	0.000	0.000	0.000	0.000
PAM01	0.000	0.000	0.000	0.000
PAM0201	0.095	2.996	0.116	3.669
PAM0202	0.000	0.000	0.000	0.000
PAM0203	0.000	0.000	0.000	0.000
PAM03	0.000	0.000	0.000	0.000
PAM0401	0.000	0.000	0.000	0.000
PAM0402	0.000	0.000	0.000	0.000
PAM0501	0.000	0.000	0.000	0.000
PAM0502	0.000	0.000	0.000	0.000
PAM0503	0.000	0.000	0.000	0.000
PAN01	0.000	0.000	0.000	0.000
PAS0101	0.000	0.000	0.000	0.000
PAS0102	0.000	0.000	0.000	0.000
PAS0103	0.000	0.000	0.000	0.000
PAS0104	0.000	0.000	0.000	0.000
PAS0105	0.000	0.000	0.000	0.000
PAS0106	0.000	0.000	0.000	0.000
PAS0107	0.000	0.000	0.000	0.000
PAS0108	0.000	0.000	0.000	0.000
PEN0101	0.000	0.000	0.000	0.000
PEN0102	0.000	0.000	0.000	0.000
PEN0103	0.000	0.000	0.000	0.000
RCH0101	0.000	0.000	0.000	0.000
RCH0102	0.000	0.000	0.000	0.000
RCH0103	0.000	0.000	0.000	0.000
RCH0104	0.000	0.000	0.000	0.000
Total	0.116	3.658	0.142	4.481

Source: JICA Study Team

Annex-T H.3.2.3 Present and Projected Industrial Water Demand for Groundwater Source

CityMun	Province	Total Area (km^2)	Area inside the study area (km^2)	Ratio	Industrial Water Demand (2008)		Industrial Water Demand (2025)	
					(m^3/s)	(MCM/y)	(m^3/s)	(MCM/y)
Angat	Bulacan	58.56	52.59	0.898	0.000	0.000	0.000	0.000
Baliuag	Bulacan	43.63	43.63	1.000	0.002	0.060	0.002	0.073
Bulacan	Bulacan	69.38	11.19	0.161	0.000	0.000	0.000	0.000
Bustos	Bulacan	40.48	17.74	0.438	0.000	0.000	0.000	0.000
Calumpit	Bulacan	46.52	46.52	1.000	0.000	0.007	0.000	0.009
Dona Remedios Trinidad	Bulacan	878.91	854.25	0.972	0.000	0.000	0.000	0.000
Guiguinto	Bulacan	24.80	1.64	0.066	0.000	0.000	0.000	0.000
Hagonoy	Bulacan	94.58	94.55	1.000	0.000	0.000	0.000	0.000
Malolos City	Bulacan	72.58	72.58	1.000	0.011	0.360	0.014	0.440
Norzagaray	Bulacan	246.57	206.82	0.839	0.000	0.000	0.000	0.000
Pandi	Bulacan	50.39	1.39	0.028	0.000	0.000	0.000	0.000
Paombong	Bulacan	45.83	45.83	1.000	0.000	0.000	0.000	0.000
Plaridel	Bulacan	35.44	20.04	0.565	0.000	0.000	0.000	0.000
Pulilan	Bulacan	43.62	43.62	1.000	0.014	0.433	0.017	0.530
San Ildefonso	Bulacan	166.53	166.53	1.000	0.000	0.000	0.000	0.000
San Miguel	Bulacan	235.92	235.92	1.000	0.000	0.000	0.000	0.000
San Rafael	Bulacan	104.95	104.95	1.000	0.001	0.036	0.001	0.044
Santa Maria	Bulacan	78.65	0.75	0.010	0.000	0.000	0.000	0.000
Aliaga	Nueva Ecija	92.17	92.17	1.000	0.000	0.000	0.000	0.000
Bongabon	Nueva Ecija	229.40	224.53	0.979	0.000	0.000	0.000	0.000
Cabanatuan City	Nueva Ecija	198.18	198.18	1.000	0.001	0.032	0.001	0.039
Cabiao	Nueva Ecija	113.48	113.48	1.000	0.000	0.000	0.000	0.000
Carranglan	Nueva Ecija	739.39	692.95	0.937	0.000	0.000	0.000	0.000
Gabaldon	Nueva Ecija	252.52	252.22	0.999	0.000	0.000	0.000	0.000
Gapan	Nueva Ecija	164.50	164.50	1.000	0.000	0.000	0.000	0.000
Gen Mamerto Natividad	Nueva Ecija	98.01	98.01	1.000	0.000	0.000	0.000	0.000
General Tinio	Nueva Ecija	580.85	580.04	0.999	0.000	0.000	0.000	0.000
Guimba	Nueva Ecija	219.23	137.29	0.626	0.000	0.000	0.000	0.000
Jaen	Nueva Ecija	90.45	90.45	1.000	0.000	0.000	0.000	0.000
Laur	Nueva Ecija	221.35	221.35	1.000	0.000	0.000	0.000	0.000
Licab	Nueva Ecija	60.42	60.42	1.000	0.000	0.000	0.000	0.000
Llanera	Nueva Ecija	114.25	114.25	1.000	0.000	0.000	0.000	0.000
Lupao	Nueva Ecija	142.66	129.69	0.909	0.000	0.000	0.000	0.000
Science City Of Munoz	Nueva Ecija	142.44	142.44	1.000	0.000	0.000	0.000	0.000
Palayan City	Nueva Ecija	136.11	136.11	1.000	0.000	0.000	0.000	0.000
Pantabangan	Nueva Ecija	421.05	421.05	1.000	0.000	0.000	0.000	0.000
Penaranda	Nueva Ecija	78.53	78.53	1.000	0.000	0.000	0.000	0.000
Quezon	Nueva Ecija	68.33	68.33	1.000	0.000	0.000	0.000	0.000
Rizal	Nueva Ecija	123.88	123.88	1.000	0.000	0.000	0.000	0.000
San Antonio	Nueva Ecija	156.90	156.90	1.000	0.000	0.000	0.000	0.000
San Isidro	Nueva Ecija	58.07	58.07	1.000	0.000	0.000	0.000	0.000
San Jose City	Nueva Ecija	161.75	161.75	1.000	0.000	0.000	0.000	0.000
San Leonardo	Nueva Ecija	51.69	51.69	1.000	0.002	0.063	0.002	0.077
Santa Rosa	Nueva Ecija	116.52	116.52	1.000	0.000	0.000	0.000	0.000
Santo Domingo	Nueva Ecija	82.69	82.69	1.000	0.000	0.000	0.000	0.000
Talavera	Nueva Ecija	135.06	135.06	1.000	0.000	0.000	0.000	0.000
Talugtug	Nueva Ecija	73.46	38.82	0.528	0.000	0.000	0.000	0.000
Zaragosa	Nueva Ecija	71.98	71.98	1.000	0.000	0.000	0.000	0.000
Angeles City	Pampanga	62.80	62.80	1.000	0.000	0.000	0.000	0.000
Apalit	Pampanga	60.10	60.10	1.000	0.047	1.466	0.057	1.796
Arayat	Pampanga	176.68	176.68	1.000	0.000	0.000	0.000	0.000
Bacolor	Pampanga	74.24	74.24	1.000	0.000	0.000	0.000	0.000
Candaba	Pampanga	208.20	208.20	1.000	0.000	0.000	0.000	0.000
Floridablanca	Pampanga	120.94	83.39	0.690	0.000	0.000	0.000	0.000
Guagua	Pampanga	48.93	48.93	1.000	0.000	0.000	0.000	0.000
Lubao	Pampanga	155.02	148.79	0.960	0.000	0.000	0.000	0.000
Mabalacat	Pampanga	145.73	140.22	0.962	0.213	6.711	0.261	8.220
Macabebe	Pampanga	102.36	102.36	1.000	0.000	0.000	0.000	0.000
Magalang	Pampanga	104.53	104.53	1.000	0.000	0.000	0.000	0.000
Masantol	Pampanga	45.94	45.94	1.000	0.000	0.000	0.000	0.000
Mexico	Pampanga	122.01	122.01	1.000	0.000	0.000	0.000	0.000
Minalin	Pampanga	45.45	45.45	1.000	0.000	0.000	0.000	0.000
Porac	Pampanga	293.31	291.96	0.995	0.010	0.315	0.012	0.386
City Of San Fernando	Pampanga	68.57	68.57	1.000	0.777	24.494	0.951	30.001
San Luis	Pampanga	55.25	55.25	1.000	0.000	0.000	0.000	0.000
San Simon	Pampanga	59.93	59.93	1.000	0.000	0.000	0.000	0.000
Santa Ana	Pampanga	40.44	40.44	1.000	0.000	0.000	0.000	0.000
Santa Rita	Pampanga	23.19	23.19	1.000	0.000	0.000	0.000	0.000
Santo Tomas	Pampanga	14.46	14.46	1.000	0.000	0.000	0.000	0.000
Sasmuan	Pampanga	44.80	44.76	0.999	0.000	0.000	0.000	0.000
Bamban	Tarlac	250.57	146.51	0.585	0.000	0.000	0.000	0.000
Capas	Tarlac	422.30	133.94	0.317	0.000	0.000	0.000	0.000
Concepcion	Tarlac	221.46	221.46	1.000	0.000	0.000	0.000	0.000
La Paz	Tarlac	116.65	116.65	1.000	0.000	0.000	0.000	0.000
Tarlac City	Tarlac	261.08	132.07	0.506	0.072	2.259	0.088	2.767
Victoria	Tarlac	112.08	83.35	0.744	0.000	0.000	0.000	0.000
Total					1.149	36.236	1.407	44.382

Source: JICA Study Team

Annex-T H.3.2.4 Estimated Diversion Water Demands for Existing CISs and Small Scale Irrigations

Water Balance Catchment	River	Diversion Water Requirement (m^3/s)											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec
ANG01		0.06	0.07	0.04	0.00	0.02	0.07	0.02	0.01	0.02	0.04	0.04	0.05
ANG0201		0.05	0.05	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.03	0.04
ANG0202	Angat R.	0.06	0.06	0.04	0.00	0.01	0.04	0.01	0.01	0.01	0.02	0.04	0.05
	Other River	0.05	0.05	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.03	0.04
ANG0203		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ANG0204		0.03	0.04	0.02	0.00	0.01	0.04	0.01	0.01	0.01	0.02	0.02	0.03
ANG03		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COR01		2.79	3.02	1.70	0.00	0.75	2.93	1.09	0.61	0.68	1.77	1.90	2.26
PAM01	Pampanga R.	0.41	0.45	0.25	0.00	0.07	0.27	0.10	0.06	0.06	0.16	0.28	0.33
	Other River	0.50	0.54	0.31	0.00	0.14	0.53	0.20	0.11	0.12	0.32	0.34	0.41
PAM0201	Pampanga R.	4.65	5.04	2.84	0.00	0.78	3.05	1.14	0.64	0.71	1.84	3.16	3.76
	Other River	4.77	5.17	2.91	0.00	1.28	5.01	1.86	1.05	1.16	3.03	3.24	3.86
PAM0202		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAM0203		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAM03		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAM0401	Pampanga R.	0.14	0.15	0.09	0.00	0.02	0.09	0.03	0.02	0.02	0.06	0.10	0.12
	Other River	0.19	0.20	0.11	0.00	0.05	0.20	0.07	0.04	0.05	0.12	0.13	0.15
PAM0402	Pampanga R.	0.16	0.17	0.10	0.00	0.03	0.10	0.04	0.02	0.02	0.06	0.11	0.13
	Other River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAM0501		1.22	1.32	0.74	0.00	0.33	1.28	0.48	0.27	0.30	0.77	0.83	0.98
PAM0502		0.10	0.11	0.06	0.00	0.03	0.10	0.04	0.02	0.02	0.06	0.07	0.08
PAM0503		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAN01		0.74	0.80	0.45	0.00	0.20	0.78	0.29	0.16	0.18	0.47	0.50	0.60
PAS0101		0.05	0.06	0.03	0.00	0.01	0.06	0.02	0.01	0.01	0.03	0.04	0.04
PAS0102	Pampanga R.	0.41	0.45	0.25	0.00	0.07	0.27	0.10	0.06	0.06	0.16	0.28	0.33
	Other River	0.23	0.25	0.14	0.00	0.06	0.25	0.09	0.05	0.06	0.15	0.16	0.19
PAS0103		2.35	2.54	1.43	0.00	0.63	2.46	0.92	0.52	0.57	1.49	1.59	1.90
PAS0104		1.27	1.38	0.78	0.00	0.34	1.34	0.50	0.28	0.31	0.81	0.86	1.03
PAS0105		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAS0106		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAS0107		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAS0108		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PEN0101		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PEN0102	Penaranda R.	0.18	0.20	0.11	0.00	0.03	0.12	0.04	0.02	0.03	0.07	0.12	0.15
	Other River	0.08	0.09	0.05	0.00	0.02	0.09	0.03	0.02	0.02	0.05	0.06	0.07
PEN0103		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCH0101		6.23	6.75	3.80	0.00	1.67	6.54	2.43	1.37	1.52	3.96	4.23	5.04
RCH0102		2.90	3.14	1.77	0.00	0.78	3.04	1.13	0.64	0.71	1.84	1.97	2.34
RCH0103	Talavera R.	1.44	1.56	0.88	0.00	0.24	0.95	0.35	0.20	0.22	0.57	0.98	1.17
	Other River	0.45	0.49	0.28	0.00	0.12	0.47	0.18	0.10	0.11	0.29	0.31	0.36
RCH0104		0.09	0.10	0.06	0.00	0.02	0.09	0.04	0.02	0.02	0.06	0.06	0.07

Source :Estimated by the Study Team

Annex-T H.3.2.5 Estimated Diversion Water Demand for Projected Future CISs and Small Scale Irrigations

Water Balance Catchment	River	Diversion Water Requirement (m^3/s)											
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep	Oct.	Nov.	Dec
ANG01		0.17	0.18	0.10	0.00	0.04	0.17	0.06	0.04	0.04	0.11	0.11	0.13
ANG0201		0.08	0.08	0.05	0.00	0.02	0.08	0.03	0.02	0.02	0.05	0.05	0.06
ANG0202	Angat R.	0.11	0.12	0.07	0.00	0.02	0.07	0.03	0.02	0.02	0.04	0.08	0.09
	Other River	0.12	0.13	0.07	0.00	0.03	0.13	0.05	0.03	0.03	0.08	0.08	0.10
ANG0203		0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
ANG0204		0.03	0.04	0.02	0.00	0.01	0.04	0.01	0.01	0.01	0.02	0.02	0.03
ANG03		0.05	0.05	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.03	0.04
COR01		3.71	4.02	2.26	0.00	1.00	3.89	1.45	0.82	0.91	2.35	2.52	3.00
PAM01	Pampanga R.	0.54	0.59	0.33	0.00	0.09	0.36	0.13	0.07	0.08	0.22	0.37	0.44
	Other River	2.22	2.41	1.36	0.00	0.60	2.33	0.87	0.49	0.54	1.41	1.51	1.80
PAM0201	Pampanga R.	4.81	5.21	2.93	0.00	0.81	3.15	1.17	0.66	0.73	1.91	3.26	3.89
	Other River	5.00	5.42	3.05	0.00	1.34	5.25	1.95	1.10	1.22	3.17	3.39	4.04
PAM0202		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAM0203		0.66	0.71	0.40	0.00	0.18	0.69	0.26	0.14	0.16	0.42	0.45	0.53
PAM03		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAM0401	Pampanga R.	0.32	0.35	0.20	0.00	0.05	0.21	0.08	0.04	0.05	0.13	0.22	0.26
	Other River	0.05	0.06	0.03	0.00	0.01	0.05	0.02	0.01	0.01	0.03	0.03	0.04
	Pampanga R.	0.16	0.17	0.10	0.00	0.03	0.10	0.04	0.02	0.02	0.06	0.11	0.13
PAM0402	Other River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAM0501		1.38	1.49	0.84	0.00	0.37	1.44	0.54	0.30	0.34	0.87	0.93	1.11
PAM0502		0.10	0.11	0.06	0.00	0.03	0.10	0.04	0.02	0.02	0.06	0.07	0.08
PAM0503		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAN01A		0.79	0.85	0.48	0.00	0.21	0.83	0.31	0.17	0.19	0.50	0.53	0.64
PAS0101		0.05	0.06	0.03	0.00	0.01	0.06	0.02	0.01	0.01	0.03	0.04	0.04
PAS0102	Pampanga R.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other River	0.52	0.56	0.32	0.00	0.14	0.54	0.20	0.11	0.13	0.33	0.35	0.42
PAS0103		3.04	3.29	1.86	0.00	0.82	3.19	1.19	0.67	0.74	1.93	2.06	2.46
PAS0104		1.27	1.38	0.78	0.00	0.34	1.34	0.50	0.28	0.31	0.81	0.86	1.03
PAS0105		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAS0106		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAS0107		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAS0108		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PEN0101		0.03	0.04	0.02	0.00	0.01	0.03	0.01	0.01	0.01	0.02	0.02	0.03
PEN0102	Penaranda R.	0.05	0.05	0.03	0.00	0.01	0.03	0.01	0.01	0.01	0.02	0.03	0.04
	Other River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PEN0103		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCH0101		10.15	11.00	6.20	0.00	2.73	10.66	3.97	2.23	2.48	6.45	6.90	8.21
RCH0102		4.30	4.66	2.62	0.00	1.15	4.51	1.68	0.94	1.05	2.73	2.92	3.48
RCH0103	Talavera R.	1.44	1.56	0.88	0.00	0.24	0.95	0.35	0.20	0.22	0.57	0.98	1.17
	Other River	0.50	0.54	0.30	0.00	0.13	0.52	0.19	0.11	0.12	0.32	0.34	0.40
RCH0104		0.09	0.10	0.06	0.00	0.02	0.09	0.04	0.02	0.02	0.06	0.06	0.07

Source :Estimated by the Study Team

Annex-T H.3.2.6 Estimated Irrigation Water Demand for Groundwater Source by Municipality/City

CityMun	Province	Total Area (km^2)	Area inside the Study Area (km^2)	Ratio	Others Water Use Permit (m^3/s)	NIA Water Use Permit (m^3/s)	Demand Others (2008) (m^3/s)	Demand NIA (2008) (m3/s)	New Area (2025) (ha)	Demand_ New Area (2025) (m3/s)	Demand (2008)		Demand (2025)	
											(m^3/s)	(MCM/y)	(m^3/s)	(MCM/y)
Angat	Bulacan	58.56	52.59	0.898	0.002	0.000	0.000	0.000		0.000	0.000	0.014	0.000	0.014
Baliuag	Bulacan	43.63	43.63	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Bulacan	Bulacan	69.38	11.19	0.161	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Bustos	Bulacan	40.48	17.74	0.438	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Calumpit	Bulacan	46.52	46.52	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Dona Remedios Trinidad	Bulacan	878.91	854.25	0.972	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Guiguinto	Bulacan	24.80	1.64	0.066	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Hagonoy	Bulacan	94.58	94.55	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Malolos City	Bulacan	72.58	72.58	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Norzagaray	Bulacan	246.57	206.82	0.839	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Pandi	Bulacan	50.39	1.39	0.028	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Paombong	Bulacan	45.83	45.83	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Plaridel	Bulacan	35.44	20.04	0.565	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Pulilan	Bulacan	43.62	43.62	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
San Ildefonso	Bulacan	166.53	166.53	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
San Miguel	Bulacan	235.92	235.92	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
San Rafael	Bulacan	104.95	104.95	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Santa Maria	Bulacan	78.65	0.75	0.010	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Aliaga	Nueva Ecija	92.17	92.17	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Bongabon	Nueva Ecija	229.40	224.53	0.979	0.009	0.000	0.002	0.000		0.000	0.002	0.061	0.002	0.061
Cabanatuan City	Nueva Ecija	198.18	198.18	1.000	0.008	0.000	0.002	0.000		0.000	0.002	0.060	0.002	0.060
Cabiao	Nueva Ecija	113.48	113.48	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Carranglan	Nueva Ecija	739.39	692.95	0.937	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Gabaldon	Nueva Ecija	252.52	252.22	0.999	0.012	0.000	0.003	0.000		0.000	0.003	0.086	0.003	0.086
Gapan	Nueva Ecija	164.50	164.50	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Gen Mamerto Natividad	Nueva Ecija	98.01	98.01	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
General Tinio	Nueva Ecija	580.85	580.04	0.999	0.000	0.000	0.000	0.000	108	0.041	0.000	0.000	0.041	1.291
Guimba	Nueva Ecija	219.23	137.29	0.626	0.050	0.000	0.011	0.000		0.000	0.011	0.357	0.011	0.357
Jaen	Nueva Ecija	90.45	90.45	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Laur	Nueva Ecija	221.35	221.35	1.000	0.001	0.000	0.000	0.000		0.000	0.000	0.007	0.000	0.007
Licab	Nueva Ecija	60.42	60.42	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Llanera	Nueva Ecija	114.25	114.25	1.000	0.000	0.000	0.000	0.000	220	0.083	0.000	0.000	0.083	2.629
Lupao	Nueva Ecija	142.66	129.69	0.909	0.054	0.000	0.012	0.000	300	0.114	0.012	0.387	0.126	3.972
Science City Of Munoz	Nueva Ecija	142.44	142.44	1.000	0.034	0.000	0.008	0.000		0.000	0.008	0.240	0.008	0.240
Palayan City	Nueva Ecija	136.11	136.11	1.000	0.015	0.000	0.003	0.000		0.000	0.003	0.104	0.003	0.104
Pantabangan	Nueva Ecija	421.05	421.05	1.000	0.000	0.000	0.000	0.000	1,210	0.459	0.000	0.000	0.459	14.462
Penaranda	Nueva Ecija	78.53	78.53	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Quezon	Nueva Ecija	68.33	68.33	1.000	0.000	0.000	0.000	0.000	180	0.068	0.000	0.000	0.068	2.151
Rizal	Nueva Ecija	123.88	123.88	1.000	0.021	0.000	0.005	0.000		0.000	0.005	0.150	0.005	0.150
San Antonio	Nueva Ecija	156.90	156.90	1.000	0.014	0.000	0.003	0.000		0.000	0.003	0.100	0.003	0.100
San Isidro	Nueva Ecija	58.07	58.07	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
San Jose City	Nueva Ecija	161.75	161.75	1.000	0.022	0.000	0.005	0.000		0.000	0.005	0.159	0.005	0.159
San Leonardo	Nueva Ecija	51.69	51.69	1.000	0.007	0.000	0.002	0.000		0.000	0.002	0.050	0.002	0.050
Santa Rosa	Nueva Ecija	116.52	116.52	1.000	0.002	0.000	0.000	0.000		0.000	0.000	0.014	0.000	0.014
Santo Domingo	Nueva Ecija	82.69	82.69	1.000	0.003	0.000	0.001	0.000		0.000	0.001	0.018	0.001	0.018
Talavera	Nueva Ecija	135.06	135.06	1.000	0.007	0.000	0.002	0.000		0.000	0.002	0.050	0.002	0.050
Talugtug	Nueva Ecija	73.46	38.82	0.528	0.016	0.000	0.004	0.000	60	0.023	0.004	0.115	0.026	0.832
Zaragosa	Nueva Ecija	71.98	71.98	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Angeles City	Pampanga	62.80	62.80	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Apalit	Pampanga	60.10	60.10	1.000	0.005	0.000	0.001	0.000		0.000	0.001	0.033	0.001	0.033
Arayat	Pampanga	176.68	176.68	1.000	0.029	0.000	0.006	0.000		0.000	0.006	0.205	0.006	0.205
Bacolor	Pampanga	74.24	74.24	1.000	0.038	0.000	0.009	0.000		0.000	0.009	0.269	0.009	0.269
Candaba	Pampanga	208.20	208.20	1.000	0.038	0.000	0.009	0.000		0.000	0.009	0.274	0.009	0.274
Floridablanca	Pampanga	120.94	83.39	0.690	0.038	0.000	0.009	0.000		0.000	0.009	0.273	0.009	0.273
Guagua	Pampanga	48.93	48.93	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Lubao	Pampanga	155.02	148.79	0.960	0.038	0.000	0.009	0.000	251	0.095	0.009	0.269	0.104	3.269
Mabalacat	Pampanga	145.73	140.22	0.962	0.041	0.000	0.009	0.000	281	0.106	0.009	0.290	0.116	3.649
Macabebe	Pampanga	102.36	102.36	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Magalang	Pampanga	104.53	104.53	1.000	0.019	0.000	0.004	0.000	200	0.076	0.004	0.133	0.080	2.523
Masantol	Pampanga	45.94	45.94	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Mexico	Pampanga	122.01	122.01	1.000	0.026	0.000	0.006	0.000		0.000	0.006	0.188	0.006	0.188
Minalin	Pampanga	45.45	45.45	1.000	0.005	0.000	0.001	0.000		0.000	0.001	0.035	0.001	0.035
Porac	Pampanga	293.31	291.96	0.995	0.006	0.000	0.001	0.000	40	0.015	0.001	0.045	0.017	0.523
City Of San Fernando	Pampanga	68.57	68.57	1.000	0.050	0.000	0.011	0.000		0.000	0.011	0.355	0.011	0.355
San Luis	Pampanga	55.25	55.25	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
San Simon	Pampanga	59.93	59.93	1.000	0.003	0.000	0.001	0.000		0.000	0.001	0.018	0.001	0.018
Santa Ana	Pampanga	40.44	40.44	1.000	0.146	0.000	0.033	0.000	40	0.015	0.033	1.045	0.048	1.523
Santa Rita	Pampanga	23.19	23.19	1.000	0.012	0.000	0.003	0.000	160	0.061	0.003	0.087	0.063	1.999
Santo Tomas	Pampanga	14.46	14.46	1.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Sasmuan	Pampanga	44.80	44.76	0.999	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Bamban	Tarlac	250.57	146.51	0.585	0.000	0.000	0.000	0.000	150	0.057	0.000	0.000	0.057	1.793
Capas	Tarlac	422.30	133.94	0.317	0.011	0.299	0.002	0.068	470	0.178	0.070	2.216	0.248	7.834
Concepcion	Tarlac	221.46	221.46	1.000	0.170	0.187	0.039	0.042	630	0.239	0.081	2.556	0.320	10.085
La Paz	Tarlac	116.65	116.65	1.000	0.147	0.246	0.033	0.056	90	0.034	0.089	2.812	0.123	3.888
Tarlac City	Tarlac	261.08	132.07	0.506	0.016	0.594	0.004	0.135		0.000	0.138	4.367	0.138	4.367
Victoria	Tarlac	112.08	83.35	0.744	0.011	0.100	0.003	0.023		0.000	0.025	0.797	0.025	0.797
Total					1.122	1.426	0.255	0.324	4,390	1.664	**0.578**	18.238	**2.242**	70.708

Source: JICA Study Team

Annex-T H.3.2.7 Estimated Fisheries Water Demand by Water Balance Catchment

Water Balance Catchment	Present Net Fish Pond Area (km^2)	Future Net Fish Pond Area (km^2)	Percentage of Freshwater Fishpond (%)	Present Total Water Demand		Present Fresh Water Demand		Future Total Water Demand		Future Fresh Water Demand	
				(m^3/s)	(MCM/y)	(m^3/s)	(MCM/y)	(m^3/s)	(MCM/y)	(m^3/s)	(MCM/y)
ANG01	50.4	50.4	1.5	4.7	147.2	0.1	2.1	4.7	147.2	0.1	2.1
ANG0201	0.4	0.4	100.0	0.0	1.2	0.0	1.2	0.0	1.2	0.0	1.2
ANG0202	0.5	0.5	100.0	0.0	1.6	0.0	1.6	0.0	1.6	0.0	1.6
ANG0203	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ANG0204	0.0	0.0	100.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
ANG03	0.0	0.0	100.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
PAM01	40.0	40.0	4.9	3.7	116.8	0.2	5.7	3.7	116.8	0.2	5.7
PAM0201	18.3	18.3	99.8	1.7	53.3	1.7	53.2	1.7	53.3	1.7	53.2
PAM0202	0.0	0.0	100.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
PAM0203	0.1	0.1	100.0	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2
PAM03	0.4	0.4	100.0	0.0	1.3	0.0	1.3	0.0	1.3	0.0	1.3
PAM0401	3.8	3.8	100.0	0.4	11.2	0.4	11.2	0.4	11.2	0.4	11.2
PAM0402	0.1	0.1	100.0	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2
PAM0501	0.3	0.3	100.0	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8
PAM0502	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PAM0503	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PAN01	0.1	0.1	100.0	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3
RCH0101	8.5	8.5	100.0	0.8	24.8	0.8	24.8	0.8	24.8	0.8	24.8
RCH0102	1.6	1.6	100.0	0.2	4.8	0.2	4.8	0.2	4.8	0.2	4.8
RCH0103	1.7	1.7	100.0	0.2	4.9	0.2	4.9	0.2	4.9	0.2	4.9
RCH0104	0.0	0.0	100.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
PEN0101	0.2	0.2	100.0	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5
PEN0102	0.3	0.3	100.0	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8
PEN0103	0.0	0.0	100.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
COR01	0.4	0.4	100.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
PAS0101	33.1	33.1	5.6	3.1	96.6	0.2	5.4	3.1	96.6	0.2	5.4
PAS0102	36.6	36.6	21.3	3.4	106.9	0.7	22.7	3.4	106.9	0.7	22.7
PAS0103	8.6	8.6	100.0	0.8	25.0	0.8	25.0	0.8	25.0	0.8	25.0
PAS0104	54.4	54.4	17.6	5.0	158.8	0.9	28.0	5.0	158.8	0.9	28.0
PAS0105	0.8	0.8	66.9	0.1	2.5	0.1	1.7	0.1	2.5	0.1	1.7
PAS0106	0.9	0.9	54.4	0.1	2.7	0.0	1.5	0.1	2.7	0.0	1.5
PAS0107	0.2	0.2	100.0	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5
PAS0108	0.3	0.3	100.0	0.0	0.7	0.0	0.7	0.0	0.7	0.0	0.7
Total	262.0	262.0		24.3	765.0	**6.4**	**200.6**	24.3	765.0	**6.4**	**200.6**

Source: JICA Study Team

Annex-T H.3.2.8 Estimated Livestock Water Demand by City/Municipality

CityMun	Province	Total Area (km^2)	Area inside the study area (km^2)	Ratio	Ratio of Commer. _Cattle / Carabao	Ratio of Commer. _Others	Ratio of Commer. _Poultry	Cattle / Carabao (2008) (head)	Others (2008) (head)	Poultry (2008) (head)	Cattle / Carabao (2025) (head)	Others (2025) (head)	Poultry (2025) (head)	Water Demand (2008) (m^3/s)	Water Demand (2008) (MCM/y)	Water Demand (2025) (m^3/s)	Water Demand (2025) (MCM/y)
Angat	Bulacan	58.56	52.59	0.898	0.000	0.909	0.948	3,280	64,339	165,141	4,828	94,703	202,267	0.016	0.519	0.024	0.763
Baliuag	Bulacan	43.63	43.63	1.000	0.000	0.949	0.000	1,105	37,112	26,350	1,627	54,626	32,274	0.009	0.290	0.014	0.427
Bulacan	Bulacan	69.38	11.19	0.161	0.000	0.787	0.053	34	594	1,510	50	875	1,849	0.000	0.005	0.000	0.007
Bustos	Bulacan	40.48	17.74	0.438	0.000	0.872	0.977	522	13,148	110,328	768	19,352	135,131	0.003	0.109	0.005	0.159
Calumpit	Bulacan	46.52	46.52	1.000	0.000	0.000	0.651	766	1,277	128,143	1,128	1,880	156,951	0.001	0.021	0.001	0.030
Dona Remedios Trinidad	Bulacan	878.91	854.25	0.972	0.000	0.000	0.000	1,286	2,481	28,276	1,892	3,652	34,632	0.001	0.030	0.001	0.044
Guiguinto	Bulacan	24.80	1.64	0.066	0.000	0.875	0.329	33	292	1,815	49	430	2,223	0.000	0.003	0.000	0.004
Hagonoy	Bulacan	94.58	94.55	1.000	0.000	0.000	0.789	429	3,174	33,473	631	4,672	40,998	0.001	0.029	0.001	0.042
Malolos City	Bulacan	72.58	72.58	1.000	0.000	0.604	0.690	791	828	130,993	1,165	1,219	160,442	0.001	0.018	0.001	0.025
Norzagaray	Bulacan	246.57	206.82	0.839	0.000	0.716	0.792	2,225	19,407	242,424	3,276	28,566	296,924	0.006	0.175	0.008	0.255
Pandi	Bulacan	50.39	1.39	0.028	0.000	0.909	0.960	82	2,830	18,406	121	4,165	22,543	0.001	0.023	0.001	0.033
Paombong	Bulacan	45.83	45.83	1.000	0.000	0.590	0.000	197	3,392	18,215	290	4,993	22,310	0.001	0.028	0.001	0.041
Plaridel	Bulacan	35.44	20.04	0.565	0.000	0.834	0.731	1,253	7,024	57,580	1,844	10,338	70,525	0.002	0.065	0.003	0.095
Pulilan	Bulacan	43.62	43.62	1.000	0.000	0.857	0.833	758	15,238	132,204	1,115	22,429	161,925	0.004	0.127	0.006	0.186
San Ildefonso	Bulacan	166.53	166.53	1.000	0.000	0.852	0.944	7,833	86,865	1,073,211	11,530	127,859	1,314,480	0.024	0.766	0.035	1.116
San Miguel	Bulacan	235.92	235.92	1.000	0.000	0.864	0.910	9,781	152,570	688,983	14,397	224,572	843,873	0.040	1.260	0.059	1.848
San Rafael	Bulacan	104.95	104.95	1.000	0.000	0.731	0.931	7,549	37,657	688,870	11,111	55,428	843,735	0.012	0.374	0.017	0.542
Santa Maria	Bulacan	78.65	0.75	0.010	0.000	0.941	0.982	62	1,702	14,657	91	2,505	17,952	0.000	0.014	0.001	0.020
Aliaga	Nueva Ecija	92.17	92.17	1.000	0.000	0.000	0.662	2,194	3,460	213,695	3,229	5,093	261,735	0.002	0.053	0.002	0.075
Bongabon	Nueva Ecija	229.40	224.53	0.979	0.000	0.506	0.000	1,634	8,328	38,397	2,405	12,258	47,030	0.002	0.077	0.004	0.113
Cabanatuan City	Nueva Ecija	198.18	198.18	1.000	0.299	0.267	0.883	3,846	13,430	832,451	5,660	19,768	1,019,594	0.005	0.169	0.008	0.239
Cabiao	Nueva Ecija	113.48	113.48	1.000	0.000	0.167	0.934	842	3,262	839,366	1,239	4,801	1,028,063	0.002	0.070	0.003	0.093
Carranglan	Nueva Ecija	739.39	692.95	0.937	0.000	0.041	0.218	4,206	4,207	94,247	6,191	6,192	115,434	0.002	0.068	0.003	0.099
Gabaldon	Nueva Ecija	252.52	252.22	0.999	0.000	0.015	0.041	2,492	5,183	48,813	3,667	7,630	59,787	0.002	0.060	0.003	0.088
Gapan	Nueva Ecija	164.50	164.50	1.000	0.181	0.421	0.903	2,368	11,996	652,026	3,485	17,657	798,608	0.004	0.139	0.006	0.197
Gen Mamerto Natividad	Nueva Ecija	98.01	98.01	1.000	0.067	0.790	0.130	1,143	9,449	64,011	1,682	13,908	78,401	0.003	0.083	0.004	0.122
General Tinio	Nueva Ecija	580.85	580.04	0.999	0.375	0.540	0.917	5,819	6,704	548,290	8,565	9,868	671,551	0.004	0.120	0.005	0.170
Guimba	Nueva Ecija	219.23	137.29	0.626	0.086	0.114	0.617	3,184	6,902	97,582	4,686	10,160	119,520	0.003	0.081	0.004	0.118
Jaen	Nueva Ecija	90.45	90.45	1.000	0.000	0.226	0.765	1,258	8,919	285,475	1,852	13,128	349,653	0.003	0.090	0.004	0.129
Laur	Nueva Ecija	221.35	221.35	1.000	0.118	0.104	0.112	1,633	2,143	51,949	2,404	3,154	63,627	0.001	0.031	0.001	0.045
Licab	Nueva Ecija	60.42	60.42	1.000	0.000	0.000	0.759	1,768	2,792	249,881	2,603	4,109	306,057	0.001	0.046	0.002	0.065
Llanera	Nueva Ecija	114.25	114.25	1.000	0.000	0.009	0.452	2,037	5,302	162,124	2,999	7,804	198,571	0.002	0.063	0.003	0.091
Lupao	Nueva Ecija	142.66	129.69	0.909	0.000	0.055	0.000	2,733	5,750	62,656	4,022	8,464	76,742	0.002	0.067	0.003	0.098
Science City Of Munoz	Nueva Ecija	142.44	142.44	1.000	0.023	0.150	0.675	2,465	7,943	176,216	3,629	11,692	215,832	0.003	0.087	0.004	0.126
Palayan City	Nueva Ecija	136.11	136.11	1.000	0.000	0.532	0.815	1,012	4,327	297,368	1,489	6,370	364,219	0.002	0.054	0.002	0.076
Pantabangan	Nueva Ecija	421.05	421.05	1.000	0.222	0.002	0.000	3,296	2,875	67,883	4,852	4,232	83,144	0.002	0.050	0.002	0.073
Penaranda	Nueva Ecija	78.53	78.53	1.000	0.325	0.325	0.857	2,120	5,524	331,726	3,121	8,131	406,302	0.002	0.073	0.003	0.104
Quezon	Nueva Ecija	68.33	68.33	1.000	0.114	0.193	0.782	1,600	4,253	227,729	2,355	6,260	278,925	0.002	0.055	0.002	0.078
Rizal	Nueva Ecija	123.88	123.88	1.000	0.183	0.191	0.582	2,726	5,532	163,330	4,013	8,142	200,048	0.002	0.070	0.003	0.101
San Antonio	Nueva Ecija	156.90	156.90	1.000	0.000	0.146	0.415	1,652	6,871	111,919	2,432	10,114	137,079	0.002	0.070	0.003	0.101
San Isidro	Nueva Ecija	58.07	58.07	1.000	0.000	0.219	0.803	1,081	2,947	207,472	1,591	4,338	254,114	0.001	0.040	0.002	0.057
San Jose City	Nueva Ecija	161.75	161.75	1.000	0.113	0.108	0.734	7,755	9,887	358,280	11,414	14,552	438,824	0.005	0.150	0.007	0.217
San Leonardo	Nueva Ecija	51.69	51.69	1.000	0.000	0.256	0.913	1,138	7,441	526,102	1,675	10,952	644,375	0.003	0.089	0.004	0.125
Santa Rosa	Nueva Ecija	116.52	116.52	1.000	0.733	0.216	0.875	4,377	6,804	353,486	6,443	10,016	432,953	0.003	0.101	0.005	0.145
Santo Domingo	Nueva Ecija	82.69	82.69	1.000	0.000	0.257	0.562	1,365	4,393	217,542	2,009	6,466	266,447	0.002	0.054	0.002	0.076
Talavera	Nueva Ecija	135.06	135.06	1.000	0.000	0.287	0.795	3,582	9,957	416,738	5,272	14,656	510,425	0.004	0.122	0.006	0.174
Talugtug	Nueva Ecija	73.46	38.82	0.528	0.223	0.005	0.656	1,332	2,276	85,920	1,961	3,350	105,235	0.001	0.031	0.001	0.045
Zaragosa	Nueva Ecija	71.98	71.98	1.000	0.216	0.011	0.000	1,877	5,839	72,894	2,763	8,594	89,282	0.002	0.062	0.003	0.090
Angeles City	Pampanga	62.80	62.80	1.000	0.000	0.000	0.000	0	0	0	0	0	0	0.000	0.000	0.000	0.000
Apalit	Pampanga	60.10	60.10	1.000	0.000	0.000	0.927	533	1,121	243,587	784	1,650	298,348	0.001	0.024	0.001	0.032
Arayat	Pampanga	176.68	176.68	1.000	0.000	0.325	0.734	1,447	3,786	268,013	2,129	5,573	328,265	0.002	0.052	0.002	0.073
Bacolor	Pampanga	74.24	74.24	1.000	0.000	0.000	0.801	489	1,458	232,118	719	2,147	284,300	0.001	0.025	0.001	0.035
Candaba	Pampanga	208.20	208.20	1.000	0.000	0.438	0.795	709	9,387	536,741	1,043	13,817	657,406	0.003	0.101	0.005	0.143
Floridablanca	Pampanga	120.94	83.39	0.690	0.000	0.681	0.903	1,508	5,295	138,197	2,219	7,794	169,265	0.002	0.058	0.003	0.084
Guagua	Pampanga	48.93	48.93	1.000	0.000	0.732	0.773	889	10,047	120,602	1,308	14,788	147,714	0.003	0.088	0.004	0.129
Lubao	Pampanga	155.02	148.79	0.960	0.000	0.625	0.929	1,710	8,509	906,408	2,518	12,524	1,110,177	0.004	0.119	0.005	0.165
Mabalacat	Pampanga	145.73	140.22	0.962	0.000	0.492	0.957	1,550	2,676	366,368	2,281	3,939	448,731	0.002	0.049	0.002	0.068
Macabebe	Pampanga	102.36	102.36	1.000	0.000	0.000	0.858	16	2,345	39,198	23	3,452	48,010	0.001	0.020	0.001	0.029
Magalang	Pampanga	104.53	104.53	1.000	0.000	0.843	0.975	1,452	12,319	1,452,004	2,137	18,132	1,778,429	0.005	0.171	0.007	0.235
Masantol	Pampanga	45.94	45.94	1.000	0.000	0.000	0.426	5	1,906	28,347	7	2,806	34,719	0.001	0.016	0.001	0.023
Mexico	Pampanga	122.01	122.01	1.000	0.000	0.079	0.940	1,899	7,426	793,203	2,796	10,931	971,522	0.003	0.107	0.005	0.149
Minalin	Pampanga	45.45	45.45	1.000	0.000	0.193	0.988	97	4,932	1,790,391	142	7,259	2,192,889	0.004	0.120	0.005	0.157
Porac	Pampanga	293.31	291.96	0.995	0.000	0.864	0.989	1,462	32,415	721,829	2,153	47,713	884,103	0.009	0.290	0.013	0.418
City Of San Fernando	Pampanga	68.57	68.57	1.000	0.000	0.944	0.922	598	38,881	968,485	881	57,230	1,186,210	0.011	0.343	0.016	0.494
San Luis	Pampanga	55.25	55.25	1.000	0.000	0.140	0.842	214	5,112	104,330	315	7,525	127,784	0.001	0.045	0.002	0.065
San Simon	Pampanga	59.93	59.93	1.000	0.000	0.031	0.868	442	3,843	117,492	650	5,656	143,905	0.001	0.038	0.002	0.054
Santa Ana	Pampanga	40.44	40.44	1.000	0.000	0.047	0.956	1,067	2,713	408,778	1,571	3,993	500,675	0.002	0.047	0.002	0.065
Santa Rita	Pampanga	23.19	23.19	1.000	0.000	0.472	0.921	504	4,397	208,679	742	6,472	255,592	0.001	0.047	0.002	0.066
Santo Tomas	Pampanga	14.46	14.46	1.000	0.000	0.000	0.970	24	3,839	297,021	36	5,650	363,794	0.001	0.043	0.002	0.060
Sasmuan	Pampanga	44.80	44.76	0.999	0.000	0.000	0.890	10	731	5,770	14	1,077	7,068	0.000	0.006	0.000	0.009
Bamban	Tarlac	250.57	146.51	0.585	0.000	0.837	0.870	0	0	0	0	0	0	0.000	0.000	0.000	0.000
Capas	Tarlac	422.30	133.94	0.317	0.000	0.627	0.870	2,368	19,776	71,743	3,486	29,109	87,872	0.005	0.171	0.008	0.251
Concepcion	Tarlac	221.46	221.46	1.000	0.000	0.449	0.870	4,629	21,750	457,380	6,813	32,014	560,204	0.007	0.221	0.010	0.320
La Paz	Tarlac	116.65	116.65	1.000	0.000	0.000	0.870	3,109	10,943	254,301	4,577	16,108	311,470	0.004	0.118	0.005	0.171
Tarlac City	Tarlac	261.08	132.07	0.506	0.000	0.803	0.870	2,076	55,713	106,554	3,056	82,005	130,508	0.014	0.442	0.021	0.650
Victoria	Tarlac	112.08	83.35	0.744	0.000	0.866	0.870	3,224	24,750	113,294	4,745	36,431	138,764	0.007	0.217	0.010	0.318
Total								144,549	930,696	22,166,976	212,765	1,369,915	27,150,334	0.290	9.159	0.419	13.229

Source: JICA Study Team

Annex-T H.3.2.9 Estimated Minimum Stream Flow Requirement at Control Points

Control Point	Drainage Area (km^2)	Minimum Stream Flow Requirement (m^3/s)
P0	159.2	0.02
P1	7818.7	3.96
P2	6308.1	3.55
P3	3406.2	2.50
P4	2796.7	1.90
P5	2025.6	1.67
P6	1286.0	0.73
P7	901.3	0.52
P8	869.8	0.51
P9	849.4	0.50
P10	52.6	0.01
P11	2895.3	0.85
P12	709.4	0.43
P13	301.1	0.35
P14	696.4	0.13
P15	569.7	0.53
P16	518.5	0.53
P17	248.8	0.46
P18	712.0	0.92
A0	193.5	0.01
A1	891.7	1.93
A2	845.7	1.90
A3	617.6	1.74
A4	545.9	1.70
A5	52.1	0.02
S0	137.7	0.13
S1	1233.6	1.99
S2	398.4	0.53
S3	637.0	1.22
S4	295.1	0.63
S5	115.6	0.24
S6	132.3	0.31
S7	117.9	0.29
R1	67.9	0.15
T1	287.6	0.13
T2	524.3	0.24
T3	288.7	0.14

Source: JICA Study Team

Annex-T H.3.3.1 Evaluation of Water Usage Condition for Groundwater Source

CityMun	Province	Total Area (km^2)	Area inside the Study Area (km^2)	Ratio	GWP_H	GWP_L	SWE_H	SWE_L	Demand for other uses in 2008	GWP_H for Level 2&3 and Industrial use in 2008	GWP_L for Level 2&3 and Industrial use in 2008	Demand for Level 2&3 and Industrial use in 2008	Demand for other uses in 2025	GWP_H for Level 2&3 and Industrial use in 2025	GWP_L for Level 2&3 and Industrial use in 2025	Demand for Level 2&3 and Industrial use in 2025	Evalu-ation in 2008	Evalu-ation in 2025
					(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)		
Angat	Bulacan	59	53	0.898	10.4	4.3	0.0	0.0	1.0	9.4	3.4	1.6	1.5	8.9	2.8	2.4		
Baliuag	Bulacan	44	44	1.000	8.7	3.6	0.0	0.0	1.7	7.0	1.9	5.4	1.8	6.9	1.8	10.9	R	HR
Bulacan	Bulacan	69	11	0.161	2.6	1.1	2.6	1.1	0.1	0.0	0.0	0.5	0.1	0.0	0.0	0.7	HR	HR
Bustos	Bulacan	40	18	0.438	3.7	1.5	0.0	0.0	0.3	3.4	1.3	1.1	0.5	3.2	1.1	1.6		R
Calumpit	Bulacan	47	47	1.000	9.6	4.0	9.1	3.8	0.1	0.6	0.2	6.7	0.0	0.6	0.2	10.5	HR	HR
Dona Remedios Trinidad	Bulacan	879	854	0.972	44.8	18.7	0.0	0.0	0.0	44.8	18.6	1.0	0.1	44.8	18.6	1.5		
Guiguinto	Bulacan	25	2	0.066	0.4	0.2	0.3	0.1	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.4	HR	HR
Hagonoy	Bulacan	95	95	1.000	20.0	8.3	20.0	8.3	0.3	0.0	0.0	8.0	0.0	0.0	0.0	13.5	HR	HR
Malolos City	Bulacan	73	73	1.000	16.0	6.7	14.4	6.0	2.7	1.5	0.6	7.7	2.6	1.5	0.6	17.1	HR	HR
Norzagaray	Bulacan	247	207	0.839	14.5	6.0	0.0	0.0	0.7	13.8	5.4	3.9	1.2	13.3	4.9	5.9		R
Pandi	Bulacan	50	1	0.028	0.3	0.1	0.0	0.0	0.0	0.3	0.1	0.1	0.0	0.3	0.1	0.2	R	R
Paombong	Bulacan	46	46	1.000	9.8	4.1	9.8	4.1	0.1	0.0	0.0	2.9	0.2	0.0	0.0	4.4	HR	HR
Plaridel	Bulacan	35	20	0.565	4.4	1.8	0.0	0.0	0.4	4.0	1.4	2.8	0.4	4.0	1.5	5.3	R	HR
Pulilan	Bulacan	44	44	1.000	9.1	3.8	0.0	0.0	2.0	7.2	1.8	0.7	1.9	7.3	1.9	4.9		R
San Ildefonso	Bulacan	167	167	1.000	31.1	13.0	0.0	0.0	2.0	29.1	11.0	1.9	3.2	27.9	9.7	2.8		
San Miguel	Bulacan	236	236	1.000	40.2	16.7	0.0	0.0	2.7	37.5	14.1	4.1	4.3	35.9	12.5	6.2		
San Rafael	Bulacan	105	105	1.000	20.9	8.7	0.0	0.0	1.6	19.3	7.1	1.4	2.6	18.3	6.1	2.2		
Santa Maria	Bulacan	79	1	0.010	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.2	R	HR
Aliaga	Nueva Ecija	92	92	1.000	18.5	7.7	0.0	0.0	1.0	17.5	6.7	1.0	1.1	17.4	6.6	2.4		
Bongabon	Nueva Ecija	229	225	0.979	25.3	10.5	0.0	0.0	1.0	24.3	9.5	1.0	1.5	23.8	9.0	1.3		
Cabanatuan City	Nueva Ecija	198	198	1.000	39.9	16.6	0.0	0.0	1.7	38.2	14.9	13.3	1.2	38.8	15.5	21.0		R
Cabiao	Nueva Ecija	113	113	1.000	20.5	8.5	0.0	0.0	1.2	19.2	7.3	1.0	1.1	19.4	7.4	3.3		
Carranglan	Nueva Ecija	739	693	0.937	42.4	17.7	0.0	0.0	0.7	41.7	17.0	0.0	0.8	41.6	16.9	0.6		
Gabaldon	Nueva Ecija	253	252	0.999	17.9	7.4	0.0	0.0	0.4	17.5	7.1	0.6	0.5	17.4	7.0	1.0		
Gapan	Nueva Ecija	165	165	1.000	29.2	12.2	0.0	0.0	1.5	27.7	10.6	1.8	1.8	27.4	10.4	4.0		
Gen Mamerto Natividad	Nueva Ecija	98	98	1.000	19.3	8.0	0.0	0.0	0.6	18.7	7.5	0.5	0.8	18.5	7.2	0.7		
General Tinio	Nueva Ecija	581	580	0.999	85.1	35.5	0.0	0.0	0.6	84.5	34.9	1.0	2.1	83.0	33.4	1.6		
Guimba	Nueva Ecija	219	137	0.626	28.0	11.7	0.0	0.0	1.3	26.7	10.3	0.8	1.8	26.2	9.9	1.1		
Jaen	Nueva Ecija	90	90	1.000	16.5	6.9	0.0	0.0	1.0	15.5	5.9	0.9	1.4	15.1	5.4	1.5		
Laur	Nueva Ecija	221	221	1.000	33.1	13.8	0.0	0.0	0.4	32.7	13.4	0.6	0.6	32.6	13.2	0.9		
Licab	Nueva Ecija	60	60	1.000	11.1	4.6	0.0	0.0	0.4	10.7	4.3	0.5	0.5	10.5	4.1	0.6		
Llanera	Nueva Ecija	114	114	1.000	23.7	9.9	0.0	0.0	0.6	23.1	9.2	0.1	3.5	20.2	6.3	0.3		
Lupao	Nueva Ecija	143	130	0.909	28.1	11.7	0.0	0.0	1.1	27.0	10.6	0.0	5.0	23.1	6.7	0.1		
Science City Of Munoz	Nueva Ecija	142	142	1.000	32.7	13.6	0.0	0.0	0.9	31.8	12.8	2.5	1.2	31.5	12.4	3.3		
Palayan City	Nueva Ecija	136	136	1.000	20.7	8.6	0.0	0.0	0.5	20.2	8.1	0.9	0.7	20.0	7.9	1.1		
Pantabangan	Nueva Ecija	421	421	1.000	21.9	9.1	0.0	0.0	0.1	21.8	9.0	0.6	14.6	7.3	0.0	0.7		R
Penaranda	Nueva Ecija	79	79	1.000	13.9	5.8	0.0	0.0	0.2	13.7	5.6	1.1	0.3	13.6	5.5	1.5		
Quezon	Nueva Ecija	68	68	1.000	13.6	5.7	0.0	0.0	0.7	12.9	4.9	0.0	3.1	10.5	2.6	0.4		
Rizal	Nueva Ecija	124	124	1.000	17.2	7.2	0.0	0.0	1.2	16.0	6.0	0.0	1.6	15.6	5.5	0.3		
San Antonio	Nueva Ecija	157	157	1.000	29.6	12.3	0.0	0.0	1.1	28.5	11.2	1.0	1.5	28.1	10.8	1.6		
San Isidro	Nueva Ecija	58	58	1.000	10.4	4.3	0.0	0.0	0.6	9.8	3.7	1.3	0.5	9.9	3.8	2.7		
San Jose City	Nueva Ecija	162	162	1.000	33.4	13.9	0.0	0.0	0.3	33.1	13.6	7.7	0.4	33.1	13.6	10.0		
San Leonardo	Nueva Ecija	52	52	1.000	10.0	4.1	0.0	0.0	0.7	9.3	3.5	1.7	0.9	9.1	3.3	2.7		
Santa Rosa	Nueva Ecija	117	117	1.000	21.5	8.9	0.0	0.0	0.7	20.8	8.3	1.6	1.0	20.5	7.9	2.1		
Santo Domingo	Nueva Ecija	83	83	1.000	17.8	7.4	0.0	0.0	1.0	16.8	6.4	0.3	1.0	16.8	6.4	1.8		
Talavera	Nueva Ecija	135	135	1.000	30.0	12.5	0.0	0.0	1.5	28.4	11.0	3.0	1.5	28.5	11.0	6.0		
Talugtug	Nueva Ecija	73	39	0.528	8.8	3.7	0.0	0.0	0.3	8.5	3.4	0.1	1.1	7.7	2.5	0.2		
Zaragosa	Nueva Ecija	72	72	1.000	12.7	5.3	0.0	0.0	0.7	12.0	4.6	0.4	0.9	11.8	4.4	1.0		
Angeles City	Pampanga	63	63	1.000	13.3	5.5	0.0	0.0	1.1	12.1	4.4	18.4	0.0	13.3	5.5	29.2	HR	HR
Apalit	Pampanga	60	60	1.000	12.0	5.0	4.4	1.8	0.8	7.7	3.2	5.8	0.7	7.7	3.2	9.1	R	HR
Arayat	Pampanga	177	177	1.000	26.1	10.9	0.0	0.0	2.5	23.5	8.3	0.0	3.4	22.6	7.4	0.9		
Bacolor	Pampanga	74	74	1.000	17.0	7.1	0.0	0.0	0.6	16.4	6.5	0.5	0.7	16.2	6.3	0.8		
Candaba	Pampanga	208	208	1.000	35.6	14.8	0.0	0.0	1.8	33.7	13.0	1.2	2.7	32.9	12.2	1.5		
Floridablanca	Pampanga	121	83	0.690	14.9	6.2	0.0	0.0	0.6	14.3	5.6	3.5	0.8	14.1	5.4	4.7		
Guagua	Pampanga	49	49	1.000	10.4	4.3	1.7	0.7	1.0	8.7	3.3	4.3	1.0	8.7	3.3	7.4	R	R
Lubao	Pampanga	155	149	0.960	31.4	13.1	16.7	6.9	2.5	14.8	6.2	2.1	6.3	14.8	6.2	3.7		
Mabalacat	Pampanga	146	140	0.962	21.3	8.9	0.0	0.0	1.2	20.1	7.7	17.7	3.9	17.4	5.0	25.9	R	HR
Macabebe	Pampanga	102	102	1.000	20.8	8.7	20.8	8.7	0.4	0.0	0.0	3.1	0.6	0.0	0.0	4.1	HR	HR
Magalang	Pampanga	105	105	1.000	25.5	10.6	0.0	0.0	2.4	23.1	8.2	0.0	4.9	20.6	5.7	3.0		
Masantol	Pampanga	46	46	1.000	9.4	3.9	9.4	3.9	1.0	0.0	0.0	0.0	1.3	0.0	0.0	0.7		HR
Mexico	Pampanga	122	122	1.000	27.7	11.5	0.0	0.0	2.5	25.2	9.1	2.1	3.3	24.4	8.3	4.0		
Minalin	Pampanga	45	45	1.000	9.2	3.8	7.4	3.1	0.5	1.8	0.7	1.2	0.8	1.8	0.7	1.6	R	R
Porac	Pampanga	293	292	0.995	27.2	11.3	0.0	0.0	1.8	25.3	9.5	1.9	2.8	24.3	8.5	3.9		
City Of San Fernando	Pampanga	69	69	1.000	15.9	6.6	0.0	0.0	2.8	13.1	3.8	34.9	3.5	12.4	3.1	47.5	HR	HR
San Luis	Pampanga	55	55	1.000	10.0	4.2	0.0	0.0	1.0	9.0	3.1	0.0	1.2	8.8	3.0	1.1		
San Simon	Pampanga	60	60	1.000	11.6	4.8	0.0	0.0	0.5	11.1	4.4	1.7	0.7	10.9	4.1	2.2		
Santa Ana	Pampanga	40	40	1.000	7.7	3.2	0.0	0.0	1.6	6.1	1.6	1.0	2.4	5.4	0.8	2.4		R
Santa Rita	Pampanga	23	23	1.000	5.2	2.2	0.0	0.0	0.8	4.4	1.3	0.4	2.6	2.5	0.0	1.9		R
Santo Tomas	Pampanga	14	14	1.000	3.0	1.3	1.1	0.4	0.3	2.0	0.8	1.8	0.3	2.0	0.8	2.9	R	HR
Sasmuan	Pampanga	45	45	0.999	8.9	3.7	8.9	3.7	0.5	0.1	0.0	0.0	0.7	0.1	0.0	0.3		HR
Bamban	Tarlac	251	147	0.585	2.2	0.9	0.0	0.0	0.7	1.5	0.2	0.5	2.5	0.0	0.0	1.5	R	HR
Capas	Tarlac	422	134	0.317	13.0	5.4	0.0	0.0	2.7	10.3	2.7	0.9	8.6	4.4	0.0	1.2		R
Concepcion	Tarlac	221	221	1.000	49.9	20.8	0.0	0.0	4.4	45.5	16.4	3.0	12.8	37.1	8.0	4.1		
La Paz	Tarlac	117	117	1.000	21.8	9.1	0.0	0.0	3.9	17.9	5.2	0.6	5.5	16.3	3.6	1.0		
Tarlac City	Tarlac	261	132	0.506	28.6	11.9	0.0	0.0	6.4	22.2	5.5	6.6	6.9	21.7	5.0	10.0	R	R
Victoria	Tarlac	112	83	0.744	16.9	7.0	0.0	0.0	1.5	15.3	5.5	0.4	1.9	15.0	5.1	0.5		
Total		10,990	9,890		1,476.3	615.1	126.5	52.7	88.2	1,272.2	484.5	209.2	157.7	1,207.3	430.0	344.1		

R=At Risk, HR=At high risk

Source: JICA Study Team

Annex-T H.3.3.2 Deficit of Sustainable Local Groundwater Source by Municipality/City

CityMun	Province	Total Area (km^2)	Area inside the Study Area (km^2)	Ratio	GWP_H for Level 2&3 and Industrial use in 2008	GWP_L for Level 2&3 and Industrial use in 2008	Demand for Level 2&3 and Industrial use in 2008	Deficit in 2008	GWP_H for Level 2&3 and Industrial use in 2025	GWP_L for Level 2&3 and Industrial use in 2025	Demand for Level 2&3 and Industrial use in 2025	Deficit in 2025
					(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)	(MCM/y)
Angat	Bulacan	59	53	0.898	9.4	3.4	1.6	0.0	8.9	2.8	2.4	0.0
Baliuag	**Bulacan**	**44**	**44**	**1.000**	**7.0**	**1.9**	**5.4**	**0.0**	**6.9**	**1.8**	**10.9**	**4.0**
Bulacan	**Bulacan**	**69**	**11**	**0.161**	**0.0**	**0.0**	**0.5**	**0.5**	**0.0**	**0.0**	**0.7**	**0.7**
Bustos	Bulacan	40	18	0.438	3.4	1.3	1.1	0.0	3.2	1.1	1.6	0.0
Calumpit	**Bulacan**	**47**	**47**	**1.000**	**0.6**	**0.2**	**6.7**	**6.2**	**0.6**	**0.2**	**10.5**	**9.9**
Dona Remedios Trinidad	Bulacan	879	854	0.972	44.8	18.6	1.0	0.0	44.8	18.6	1.5	0.0
Guiguinto	**Bulacan**	**25**	**2**	**0.066**	**0.0**	**0.0**	**0.2**	**0.1**	**0.0**	**0.0**	**0.4**	**0.4**
Hagonoy	**Bulacan**	**95**	**95**	**1.000**	**0.0**	**0.0**	**8.0**	**8.0**	**0.0**	**0.0**	**13.5**	**13.5**
Malolos City	**Bulacan**	**73**	**73**	**1.000**	**1.5**	**0.6**	**7.7**	**6.2**	**1.5**	**0.6**	**17.1**	**15.6**
Norzagaray	Bulacan	247	207	0.839	13.8	5.4	3.9	0.0	13.3	4.9	5.9	0.0
Pandi	Bulacan	50	1	0.028	0.3	0.1	0.1	0.0	0.3	0.1	0.2	0.0
Paombong	**Bulacan**	**46**	**46**	**1.000**	**0.0**	**0.0**	**2.9**	**2.9**	**0.0**	**0.0**	**4.4**	**4.4**
Plaridel	**Bulacan**	**35**	**20**	**0.565**	**4.0**	**1.4**	**2.8**	**0.0**	**4.0**	**1.5**	**5.3**	**1.2**
Pulilan	Bulacan	44	44	1.000	7.2	1.8	0.7	0.0	7.3	1.9	4.9	0.0
San Ildefonso	Bulacan	167	167	1.000	29.1	11.0	1.9	0.0	27.9	9.7	2.8	0.0
San Miguel	Bulacan	236	236	1.000	37.5	14.1	4.1	0.0	35.9	12.5	6.2	0.0
San Rafael	Bulacan	105	105	1.000	19.3	7.1	1.4	0.0	18.3	6.1	2.2	0.0
Santa Maria	**Bulacan**	**79**	**1**	**0.010**	**0.1**	**0.0**	**0.1**	**0.0**	**0.1**	**0.0**	**0.2**	**0.0**
Aliaga	Nueva Ecija	92	92	1.000	17.5	6.7	1.0	0.0	17.4	6.6	2.4	0.0
Bongabon	Nueva Ecija	229	225	0.979	24.3	9.5	1.0	0.0	23.8	9.0	1.3	0.0
Cabanatuan City	Nueva Ecija	198	198	1.000	38.2	14.9	13.3	0.0	38.8	15.5	21.0	0.0
Cabiao	Nueva Ecija	113	113	1.000	19.2	7.3	1.0	0.0	19.4	7.4	3.3	0.0
Carranglan	Nueva Ecija	739	693	0.937	41.7	17.0	0.0	0.0	41.6	16.9	0.6	0.0
Gabaldon	Nueva Ecija	253	252	0.999	17.5	7.1	0.6	0.0	17.4	7.0	1.0	0.0
Gapan	Nueva Ecija	165	165	1.000	27.7	10.6	1.8	0.0	27.4	10.4	4.0	0.0
Gen Mamerto Natividad	Nueva Ecija	98	98	1.000	18.7	7.5	0.5	0.0	18.5	7.2	0.7	0.0
General Tinio	Nueva Ecija	581	580	0.999	84.5	34.9	1.0	0.0	83.0	33.4	1.6	0.0
Guimba	Nueva Ecija	219	137	0.626	26.7	10.3	0.8	0.0	26.2	9.9	1.1	0.0
Jaen	Nueva Ecija	90	90	1.000	15.5	5.9	0.9	0.0	15.1	5.4	1.5	0.0
Laur	Nueva Ecija	221	221	1.000	32.7	13.4	0.6	0.0	32.6	13.2	0.9	0.0
Licab	Nueva Ecija	60	60	1.000	10.7	4.3	0.5	0.0	10.5	4.1	0.6	0.0
Llanera	Nueva Ecija	114	114	1.000	23.1	9.2	0.1	0.0	20.2	6.3	0.3	0.0
Lupao	Nueva Ecija	143	130	0.909	27.0	10.6	0.0	0.0	23.1	6.7	0.1	0.0
Science City Of Munoz	Nueva Ecija	142	142	1.000	31.8	12.8	2.5	0.0	31.5	12.4	3.3	0.0
Palayan City	Nueva Ecija	136	136	1.000	20.2	8.1	0.9	0.0	20.0	7.9	1.1	0.0
Pantabangan	Nueva Ecija	421	421	1.000	21.8	9.0	0.6	0.0	7.3	0.0	0.7	0.0
Penaranda	Nueva Ecija	79	79	1.000	13.7	5.6	1.1	0.0	13.6	5.5	1.5	0.0
Quezon	Nueva Ecija	68	68	1.000	12.9	4.9	0.0	0.0	10.5	2.6	0.4	0.0
Rizal	Nueva Ecija	124	124	1.000	16.0	6.0	0.0	0.0	15.6	5.5	0.3	0.0
San Antonio	Nueva Ecija	157	157	1.000	28.5	11.2	1.0	0.0	28.1	10.8	1.6	0.0
San Isidro	Nueva Ecija	58	58	1.000	9.8	3.7	1.3	0.0	9.9	3.8	2.7	0.0
San Jose City	Nueva Ecija	162	162	1.000	33.1	13.6	7.7	0.0	33.1	13.6	10.0	0.0
San Leonardo	Nueva Ecija	52	52	1.000	9.3	3.5	1.7	0.0	9.1	3.3	2.7	0.0
Santa Rosa	Nueva Ecija	117	117	1.000	20.8	8.3	1.6	0.0	20.5	7.9	2.1	0.0
Santo Domingo	Nueva Ecija	83	83	1.000	16.8	6.4	0.3	0.0	16.8	6.4	1.8	0.0
Talavera	Nueva Ecija	135	135	1.000	28.4	11.0	3.0	0.0	28.5	11.0	6.0	0.0
Talugtug	Nueva Ecija	73	39	0.528	8.5	3.4	0.1	0.0	7.7	2.5	0.2	0.0
Zaragosa	Nueva Ecija	72	72	1.000	12.0	4.6	0.4	0.0	11.8	4.4	1.0	0.0
Angeles City	**Pampanga**	**63**	**63**	**1.000**	**12.1**	**4.4**	**18.4**	**6.3**	**13.3**	**5.5**	**29.2**	**15.9**
Apalit	**Pampanga**	**60**	**60**	**1.000**	**7.7**	**3.2**	**5.8**	**0.0**	**7.7**	**3.2**	**9.1**	**1.4**
Arayat	Pampanga	177	177	1.000	23.5	8.3	0.0	0.0	22.6	7.4	0.9	0.0
Bacolor	Pampanga	74	74	1.000	16.4	6.5	0.5	0.0	16.2	6.3	0.8	0.0
Candaba	Pampanga	208	208	1.000	33.7	13.0	1.2	0.0	32.9	12.2	1.5	0.0
Floridablanca	Pampanga	121	83	0.690	14.3	5.6	3.5	0.0	14.1	5.4	4.7	0.0
Guagua	Pampanga	49	49	1.000	8.7	3.3	4.3	0.0	8.7	3.3	7.4	0.0
Lubao	Pampanga	155	149	0.960	14.8	6.2	2.1	0.0	14.8	6.2	3.7	0.0
Mabalacat	**Pampanga**	**146**	**140**	**0.962**	**20.1**	**7.7**	**17.7**	**0.0**	**17.4**	**5.0**	**25.9**	**8.5**
Macabebe	**Pampanga**	**102**	**102**	**1.000**	**0.0**	**0.0**	**3.1**	**3.1**	**0.0**	**0.0**	**4.1**	**4.1**
Magalang	Pampanga	105	105	1.000	23.1	8.2	0.0	0.0	20.6	5.7	3.0	0.0
Masantol	**Pampanga**	**46**	**46**	**1.000**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.7**	**0.7**
Mexico	Pampanga	122	122	1.000	25.2	9.1	2.1	0.0	24.4	8.3	4.0	0.0
Minalin	Pampanga	45	45	1.000	1.8	0.7	1.2	0.0	1.8	0.7	1.6	0.0
Porac	Pampanga	293	292	0.995	25.3	9.5	1.9	0.0	24.3	8.5	3.9	0.0
City Of San Fernando	**Pampanga**	**69**	**69**	**1.000**	**13.1**	**3.8**	**34.9**	**21.8**	**12.4**	**3.1**	**47.5**	**35.2**
San Luis	Pampanga	55	55	1.000	9.0	3.1	0.0	0.0	8.8	3.0	1.1	0.0
San Simon	Pampanga	60	60	1.000	11.1	4.4	1.7	0.0	10.9	4.1	2.2	0.0
Santa Ana	Pampanga	40	40	1.000	6.1	1.6	1.0	0.0	5.4	0.8	2.4	0.0
Santa Rita	Pampanga	23	23	1.000	4.4	1.3	0.4	0.0	2.5	0.0	1.9	0.0
Santo Tomas	**Pampanga**	**14**	**14**	**1.000**	**2.0**	**0.8**	**1.8**	**0.0**	**2.0**	**0.8**	**2.9**	**1.0**
Sasmuan	**Pampanga**	**45**	**45**	**0.999**	**0.1**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.3**	**0.2**
Bamban	**Tarlac**	**251**	**147**	**0.585**	**1.5**	**0.2**	**0.5**	**0.0**	**0.0**	**0.0**	**1.5**	**1.5**
Capas	Tarlac	422	134	0.317	10.3	2.7	0.9	0.0	4.4	0.0	1.2	0.0
Concepcion	Tarlac	221	221	1.000	45.5	16.4	3.0	0.0	37.1	8.0	4.1	0.0
La Paz	Tarlac	117	117	1.000	17.9	5.2	0.6	0.0	16.3	3.6	1.0	0.0
Tarlac City	Tarlac	261	132	0.506	22.2	5.5	6.6	0.0	21.7	5.0	10.0	0.0
Victoria	Tarlac	112	83	0.744	15.3	5.5	0.4	0.0	15.0	5.1	0.5	0.0
Total		10,990	9,890		1272.2	484.5	209.2	55.1	1207.3	430.0	344.1	118.3

Source: JICA Study Team

Annex-T H.3.3.3 List of Consummative, Flow through and Reservoir Nodes in MODSIM Modeling

Consumative/ Flow through/ Reservoir Nodes	Descripition	Type	Location of return flow	Priority Present condition	Priority Future Condition
A_ANG03	Total demand for CISs and aquaculture in ANG03	C	U_Ang	10	10
A_ANG0204	Total demand for CISs and aquaculture in ANG0204	C	Ipo	20	20
A_ANG0203	Total demand for CISs and aquaculture in ANG0203	C	U_Bay	30	30
A_ANG0202	Total demand for CISs and aquaculture in ANG0202	C	Bustos	40	40
A_ANG0201	Total demand for CISs and aquaculture in ANG0201	C	A1	50	50
E_Ang	Minimum stream flow requirement at release point of main pipe from Angat dam	F		105	105
Municipal	Demand for Municipal water use through Ipo dam (basically for MWSS. for future condition, demand for municipal use for the province of Bulacan is included.)	C	(No return)	110	110
I_ANG0202R	Total demand for industrial water use by abstraction from Angat river in ANG0202	C	Bustos	130	130
A_ANG0202R	Total demand for CISs and aquaculture by abstraction from Angat river in ANG0202	C	Bustos	140	140
E_Bay	Minimum stream flow requirement at control point A5	F		205	205
Bay_C	Total demand for new irrigation area along Bayabas river	C	A-B	N/A	210
E_Bus	Minimum stream flow requirement at control point A2 (Bustos dam)	F		215	215
NIS_AMRIS	Demand for AMRIC	C	P1	250	250
A_ANG0201R	Total demand for CISs and aquaculture by abstraction from Angat river in ANG0201	C	A1	260	260
Bayabas Dam	Proposed Bayabas storage dam	R		400	400
Angat Dam	Angat storage dam	R		500 (WL>180m) 200 (WL<180m)	500 (WL>180m) 200 (WL<180m) with Bayabas Dam 300 (WL<184m)
A_ANG01R	Total demand for CISs and aquaculture by abstraction from Angat river in ANG01	C	(No return)	610	610
A_PAN01	Total demand for CISs and aquaculture in PAN01	C	U_Pan	1010	1010
A_PAM0502	Total demand for CISs and aquaculture in PAM0502	C	Rizal	1020	1020
A_PAM0501	Total demand for CISs and aquaculture in PAM0501	C	P-C	1030	1030
A_COR01	Total demand for CISs and aquaculture in COR01	C	P-C	1040	1040
A_PEN0102	Total demand for CISs and aquaculture in PEN0102	C	Penaranda	1050	1050
A_PAM0401	Total demand for CISs and aquaculture in PAM0401	C	P-P	1060	1060
A_PAM0201	Total demand for CISs and aquaculture in PAM0201	C	P1	1070	1070
A_RCH0104	Total demand for CISs and aquaculture in RCH0104	C	Talavera	1110	1110
A_RCH0103	Total demand for CISs and aquaculture in RCH0103	C	T-B	1120	1120
A_RCH0102	Total demand for CISs and aquaculture in RCH0102	C	T-B	1130	1130
A_RCH0101	Total demand for CISs and aquaculture in RCH0101	C	P-R	1140	1140
E_Tal	Minimum stream flow requirement at control point P13 (Talavera dam)	F		1205	1205
NIS_Talavera	Demand for UPRIIS (net DWR at Talavera dam)	C	T-B	1210	1210
A_RCH0103R	Total demand for CISs and aquaculture by abstraction from RioChico river in RCH0103	C	T-B	1220	1220
A_RCH0101R	Total demand for CISs and aquaculture by abstraction from RioChico river in RCH0101	C	P-R	1230	1230
E_Riz	Minimum stream flow requirement at control point P7 (Rizal dam)	F		1305	1305
NIS_Rizal	Demand for UPRIIS (net DWR at Rizal dam)	C	P-P (48.9%), T-B(42.0%), P-R(9.1%) for existing P-P (36.7%), T-B(31.5%), P-R(6.8%) for future	1310	1310
A_PAM0501R	Total demand for CISs and aquaculture by abstraction from Pampanga river in PAM0501	C	P-C	1320	1320
A_PAM0402R	Total demand for CISs and aquaculture by abstraction from Pampanga river in PAM0402	C	P-P	1330	1330
E_Bon	Minimum stream flow requirement at control point P5 (Bongabon dam)	F		1405	1405
NIS_Bongabon	Demand for UPRIIS (net DWR at Bongabon dam)	C	P1 (36.6%), P-R(63.4%)	1410	1410
A_PAM0401R	Total demand for CISs and aquaculture by abstraction from Pampanga river in PAM0401	C	P-P	1420	1420
E_Pen	Minimum stream flow requirement at control point P16 (Peneranda dam)	F		1505	1505
NIS_Penaranda	Demand for UPRIIS (net DWR at Penaranda dam)	C	P1	1510	1510
A_PAEN0101R	Total demand for CISs and aquaculture by abstraction from Penaranda river in PEN0101	C	P-P	1520	1520
A_PAM03R	Total demand for CISs and aquaculture by abstraction from Pampanga river in PAM03	C	P-R	1530	1530
A_PAM0203R	Total demand for CISs and aquaculture by abstraction from Pampanga river in PAM0203	C	CongDadong	1540	1540
Pantabangan Dam	Pantabangan storage dam	R		1600	1600
E_Maa	Minimum stream flow requirement at control point P10	F		1615	1615
Maasim Dam	Proposed Maasim storage dam	R		1620	1620
E_Bal	Minimum stream flow requirement at control point P17	F		1655	1655
NIS_Balintingon	Demand for New Balintingon Irrigation Syatem	C	P1	N/A	1660
Balintingon Dam	Proposed Balintinogon dam	R		1670	1670
E_Con	Minimum stream flow requirement at control point P2 (Cong Dadong dam)	F		1705	1705
A_PAM0201R	Total demand for CISs and aquaculture by abstraction from Pampanga river in PAM0202	C	P1	1710	1710
I_PAM0201R	Total demand for industrial water use by abstraction from Pampanga river in PAM0202	C	P1	1720	1720
NIS_PDRIS	Demand for PDRIS	C	S2	1730	1730
A_PAM01R	Total demand for CISs and aquaculture by abstraction from Pampanga river in PAM01	C	(No return)	1740	1740
A_PAS0102R	Total demand for CISs and aquaculture by abstraction from Pampanga river in PAS0102	C	S1	1750	1750
E_Smo	Minimum stream flow requirement at control point T1 (Smoris dam)	F		2005	2005
E_Bul	Minimum stream flow requirement at control point T2 (Bulsa dam)	F		2007	2007
NIS_TASMORIS	Demand for TASMORIS	C	P-R (56.4%), T-B (23.4%)	2010	2010
Balog-Balog Dam	Proposed Balog-Balog storage dam	R		2150	2150
A_PAS0108	Total demand for CISs and aquaculture in PAS0108	C	U_Gum	3010	3010
A_PAS0106	Total demand for CISs and aquaculture in PAS0106	C	Porac	3020	3020
A_PAS0104	Total demand for CISs and aquaculture in PAS0104	C	S3	3030	3030
A_PAS0103	Total demand for CISs and aquaculture in PAS0103	C	S2	3040	3040
A_PAS0102	Total demand for CISs and aquaculture in PAS0102	C	S1	3050	3050
E_Por	Minimum stream flow requirement at control point S5 (Porac dam)	F		3105	3105
NIS_Porac	Demand for Porac Iriigation Syastem	C	G-G (90.8%), P-G (9.2%)	3110	N/A
E_Gum	Minimum stream flow requirement at control point S6 (Gumain dam)	F		3115	3115
NIS_Gumain	Demand for Gumain Iriigation Syastem	C	(No return)	3120	3120
A_PAS0107R	Total demand for CISs and aquaculture by abstraction from Gumain river in PAS0107	C	(No return)	3130	3130
A_PAS0105R	Total demand for CISs and aquaculture by abstraction from Gumain river in PAS0105	C	(No return)	3140	3140
A_PAS0101R	Total demand for CISs and aquaculture by abstraction from Pasac river in PAS0101	C	(No return)	3150	3150
Gumain Dam	Proposed Gumain storgae dam	R		3200	3200
Masiway Dam	Masiway dam	R		4000	4000
HPP_Cas	Hydropower plant for inflow from Casecnan	R		4000	4000

Note: Smaller number in the column to show priority has higher priority.

Source: JICA Study Team

Annex-T H.4.2.1 (1/4) Project Profile for Inter-Sector for Water Resources Management

Project Code	IS-C-01	
Project Title	Establishment of Comprehensive Groundwater Monitoring in Pampanga River Basin	
Status of Project	Conceptual	
Objective Area	Entire Pampanga river basin	
Implementing Agency	NWRB / Others	
Objectives	Establishment of groundwater monitoring system to address sustainable water source for municipal water supply	
Project Cost (Million Pesos)	Estimated by Project Proponent	Estimated by Study Team for 2011-2025
	(N/A)	297 as of 2009
EIRR	(N/A)	
Expected Source of Fund	(N/A)	
Expected Implementation Schedule	(N/A)	

Project Description

- It is recommended that periodical intensive groundwater monitoring for the municipalities and cities whose groundwater usage is at risk. There is also inferred land subsidence in the lower reach of the study area based on some previous studies, which should be verified in detail. Considering these, the conceptual projects for Establishment of Comprehensive Groundwater Resources Monitoring in Pampanga River Basin is proposed in the present study.
- The projects should include the following activities.
  1) Establishment of monitoring wells and observation
     - Proper locations and density of monitoring wells to capture the lowering of groundwater level and salt-water intrusion in a basin scale, especially for lower reach of Pampanga river basin, should be selected.
     - Monitoring wells for sole use should be installed (1 monitoring well/30km^2 in average).
     - Monitoring network for land subsidence in lower reach of the study area should be installed, utilizing the installed monitoring wells.
     - Database and their management system should be established.
     - Water level and water quality in the monitoring wells should be periodically monitored by WDs, LGUs etc.
     - The monitoring results should be stored in one database and shared by stakeholders.
  2) Groundwater resource management
     - Groundwater resource management by NWRB and/or river basin organization based on the periodically monitored data, which may include the policy establishment for groundwater regulation and so on, should be implemented.
- It is proposed that the installation of monitoring wells would be gradually expanded during 15years. The lower Pampanga area should be firstly covered by the monitoring wells.

Remarks

- The monitoring wells would be installed in strategic location based on geology within the river basin (totally about 5,400km^2 mainly in plain are), which requires about 180 monitoring wells.
- It is assumed that the cost for developing a monitoring well is 1.5 mil pesos/well, which results in 270 mil pesos for installing the monitoring wells. It is further assumed that 10% of the cost for installation of monitoring wells is required for establishing the data management system as well as monitoring network for land subsidence.
- The estimated initial investment cost is 297 mil. pesos.
- Annual maintenance cost for the installed monitoring wells and data management system is assumed to be 0.5% of the initial investment cost.
- The cost for observation by observer is assumed to be 12,000pesos/well/year, which requires 2.2mil. pesos/year for operation of the monitoring.
- The estimated annual O&M cost is 3.7 mil. pesos/year.

Required Action to Upgrade to a Proposed Project for Implementation

- Basic project components should be studied.

Source of Information

Annex-T H.4.2.1 (2/4) Project Profile for Inter-Sector for Water Resources Management

Project Code	IS-C-02	
Project Title	Project for Recovery of Reliability of Water Supply in Angat-Umiray System	
Status of Project	Conceptual	
Objective Area	Bulacan Province and Metro Manila	
Implementing Agency	NWRB / NIA/ MWSS/ NPC / Bulacan Government	
Objectives	Recovery of reliability of water supply in Angat-Umiray system	
Project Cost (Million Pesos)	Estimated by Project Proponent	Estimated by Study Team for 2011-2025
	(N/A)	7,966 as of 2009
EIRR	(N/A)	
Expected Source of Fund	(N/A)	
Expected Implementation Schedule	(N/A)	

Project Description

- It is evaluated that the present reliability of water supply in Angat-Umiray system is not enough for both Municipal water supply for MWSS and irrigation water supply for AMRIS. To address this problem, the conceptual project for Recovery of Reliability of Water Supply in Angat-Umiray System is proposed. The project would include both new water resources development and reduction of water demand.
- The preliminary study to discuss the future direction of the project has identified the following alternatives.
  Alternative-1: Upgrading AMRIS + Bayabas dam
  Alternative-2: Upgrading AMRIS + Balintingon dam ($2.9m^3/s$) + Laiban dam ($0.5m^3/s$)
  Alternative-3: Upgrading AMRIS + Laiban dam ($3.1m^3/s$)
  Alternative-4: Laiban dam ($4.0m^3/s$) only
- The study team conditionally recommends Alternative-1, based on the overall evaluation. The technical variability of Alterenative-1 will have to be clarified by further study and proper institutional arrangement should be considered for implementation of this alternative.
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Remarks

Required Action to Upgrade to a Proposed Project for Implementation

- F/S level study would be required.

Source of Information

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Annex-T H.4.2.1 (3/4) Project Profile for Inter-Sector for Water Resources Management

Project Code	IS-C-03	
Project Title	Enhancement of Monitoring System for Surface Water in Pampanga River Basin	
Status of Project	Conceptual	
Objective Area	Entire Pampanga river basin	
Implementing Agency	NWRB / Others	
Objectives	Establishment of Inter-sector surface water monitoring system to prepare for future expected increase of conflict among water users, especially between municipal and irrigation water users	
Project Cost (Million Pesos)	Estimated by Project Proponent	Estimated by Study Team for 2011-2025
	(N/A)	10 as of 2009
EIRR	(N/A)	
Expected Source of Fund	(N/A)	
Expected Implementation Schedule	(N/A)	

Project Description

- The usage of surface water will increase and become more complicated, because of very complicated water movement by abstraction for irrigation and municipal use and their return flow. To utilize the limited water resources more efficiently and effectively, it is vital to monitor the actual condition of water movement by natural and artificial drainage system. The conceptual project for Enhancement Monitoring System for Surface Water in Pampanga River Basin is proposed to realize the inter-sector surface monitoring system by enhancing the existing monitoring system by each sector and agency.
- The projects should include the following activities.
  1) Establishment of monitoring networks
     - Proper and important monitoring locations for capturing the actual movement of surface water in the basin should be selected. The monitoring points may include the existing hydrometric stations, large storage dams and major intakes.
     - At the selected monitoring stations, the strengthening of monitoring method such as automatic observation and transfer of data should be introduced.
     - Database and their management system should be established.
     - Monitoring results should be stored in one database and shared by stakeholders.
  2) Surface water resource management by NWRB and/or river basin organization based on the monitored data should be conducted. The monitored data may be utilized for controlling water use permit. The accumulated monitoring data will benefit significantly for the preparation of the next river basin management planning so as to grade-up the spiral of IWRM process.
- Recommended measures
  - Establishing main database and data transfer system: 1
  - Establishing local database and data transfer system for storage dams: 2
  - Establishing local database and data transfer system for dam-intake: 6
  - Installation of automatic gauge(water level and rainfall), cable facilities for discharge measurement and establishing data transfer system at HMS: 1
  - Establishing data transfer system with PAGASA flood warning system (optional): 1
  - Software and system development: 1
- It is proposed that the project be implemented firstly in Umiray-Angat system as a pilot project. Then, the remaining area in Pampanga river basin should be covered by the project after getting the lesson and learned from the pilot project.

Remarks

- Unit cost for installation of automatic gauge station and cable facilities for discharge measurement with data transfer facilities = 5.0mil.pesos/st.
- Unit cost for installation of local database and data transfer facilities = 0.25mil.pesos/st.
- Unit cost for installation of main database and data transfer facilities = 0.50mil.pesos/st.
- The cost for software and system development is assumed to be 25% of the installation cost for the facilities.
- The estimated initial investment cost is 10mil. pesos.

- Annual maintenance cost for the installed facilities is assumed to be 0.5% of the initial investment cost.
- Unit cost for data transfer = 0.075mil.pesos/st./year
- Unit cost for observer for HMS = 0.012mil.pesos/st./year
- Unit cost for operator for data input and transfer = 0.12mil.pesos/st./year
- Unit cost for discharge measurement = 0.05mil.pesos/st./year
- The estimated annual O&M cost is 2.0mil. pesos/year.

Required Action to Upgrade to a Proposed Project for Implementation

- Basic project components should be determined.

Source of Information

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Annex-T H.4.2.1 (4/4) Project Profile for Inter-Sector for Water Resources Management

Project Code	IS-C-04	
Project Title	Capacity Development of NWRB and Relevant Agencies on Water Allocation and Distribution	
Status of Project	Conceptual	
Objective Area	Angat-Umiray system (1st phase) Entire Pampanga river basin or Nation-wide (2nd phase)	
Implementing Agency	NWRB / Others	
Objectives	Capacity development for water allocation and distribution to prepare for future expected increase of conflict among water users, especially between municipal and irrigation water users	
Project Cost (Million Pesos)	Estimated by Project Proponent	Estimated by Study Team for 2011-2025
	(N/A)	300 as of 2009
EIRR	(N/A)	
Expected Source of Fund	(N/A)	
Expected Implementation Schedule	(N/A)	

Project Description

- To recover the inadequate reliability of water supply in Angat-Umiray system, it is indispensible to improve water allocation including refinement of water use permit. The capacity development of NWRB and Relevant Agencies on Water Allocation and Distribution is proposed as one of conceptual projects, in order to improve the water governance by NWRB.
- The operation of hydropower plant should be well balanced for other functions of the storage dam such as flood control, water use for irrigation and municipal water supply. The proper regulation of operation of hydropower plant is also one of the topics to be dealt with in the project.
- The project is also to prepare for the expected increase of conflict among water users in the entire Pampanga river basin and even in the entire country in long-term on the basis of the experience in Angat-Umiray system.
- The expected outputs of the project are as follows.
    1) Improvement of water permitting system, especially for irrigation water use, in Angat-Umiray system,
    2) Enhanced Capacity of NWRB and relevant agencies on operation of water allocation and its monitoring in Angat-Umiray system,
    3) Identification of critical area for water conflict in the nationwide considering possible future climate change,
    4) Preparation of framework for application of the refined methodology for water allocation and water permitting system to the identified critical areas, and
    5) Recommendation on improvement of institution and legislation, through the activities on the project.

Remarks

- Two phases are considered for implementation for total 5years. In the 1st phase, Angat-Umiray system will be mainly dealt with as a pilot area. Based on the experience in 1st phase, 2nd phase will be implemented for the entire Pampanga river basin or nation-wide activity.
- For the project cost, input on technical assistance by foreign expert team (60 mil.pesos/year) for 5years is considered.

Required Action to Upgrade to a Proposed Project for Implementation

- TOR for the T.A. should be determined.

Source of Information

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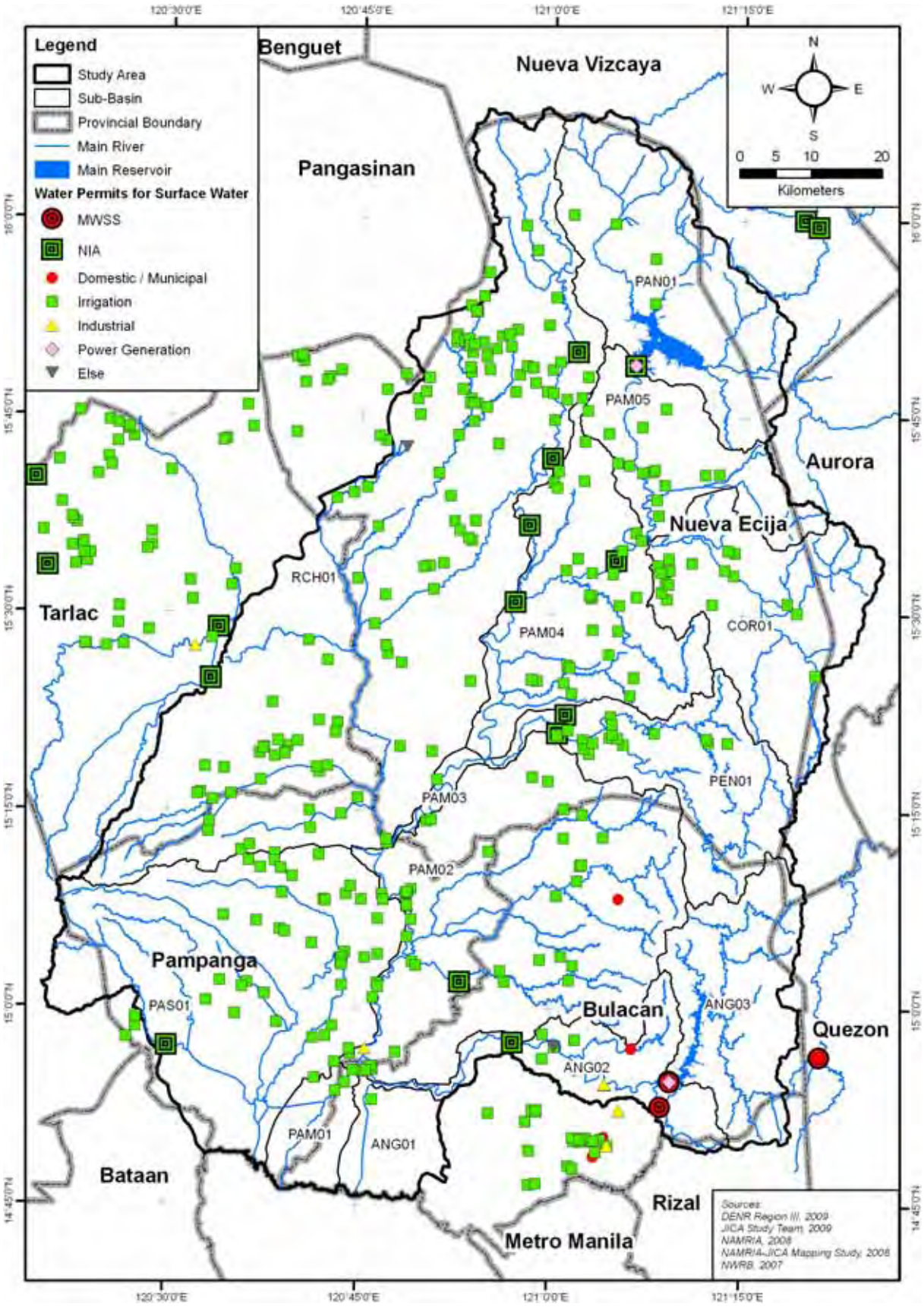
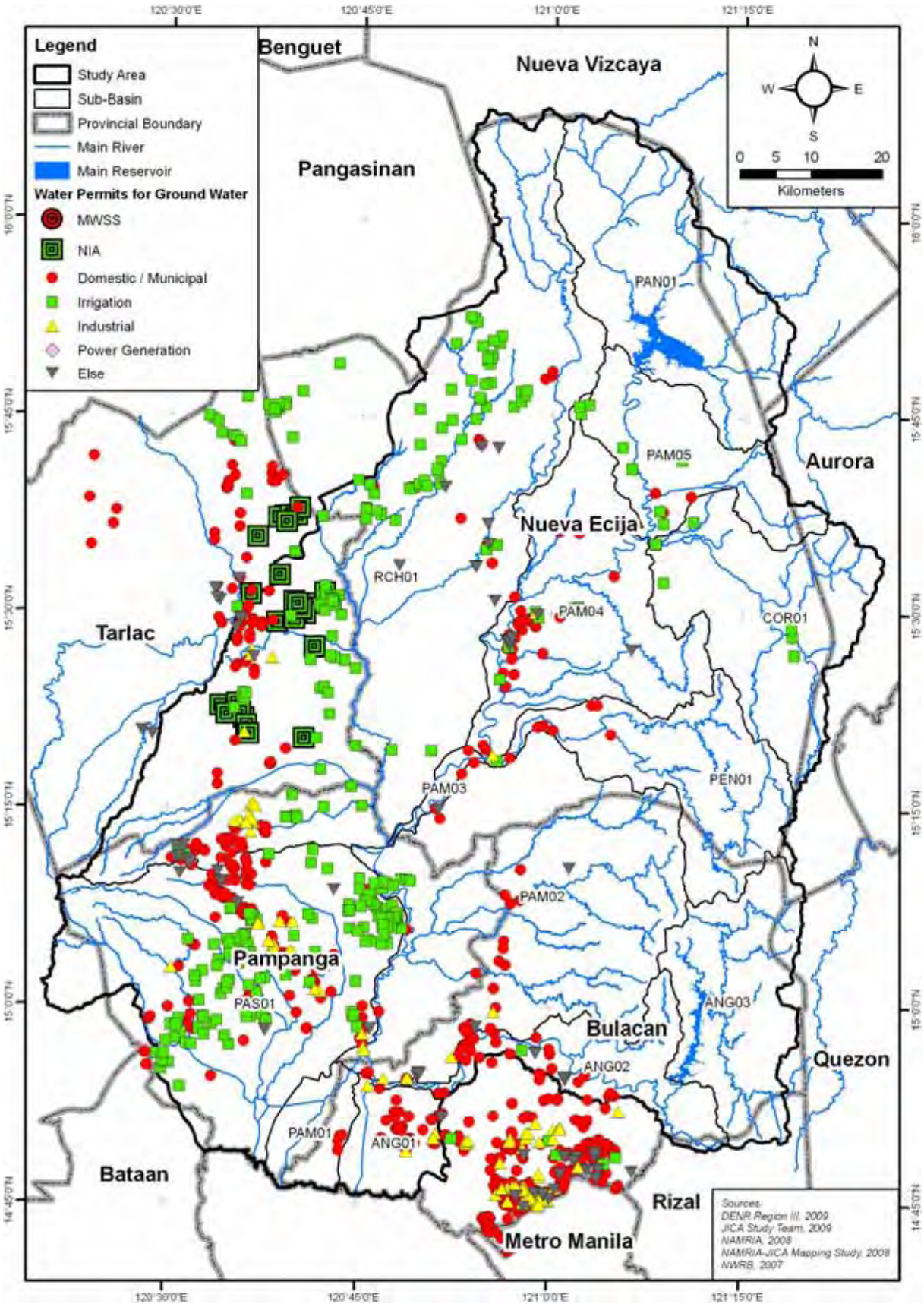
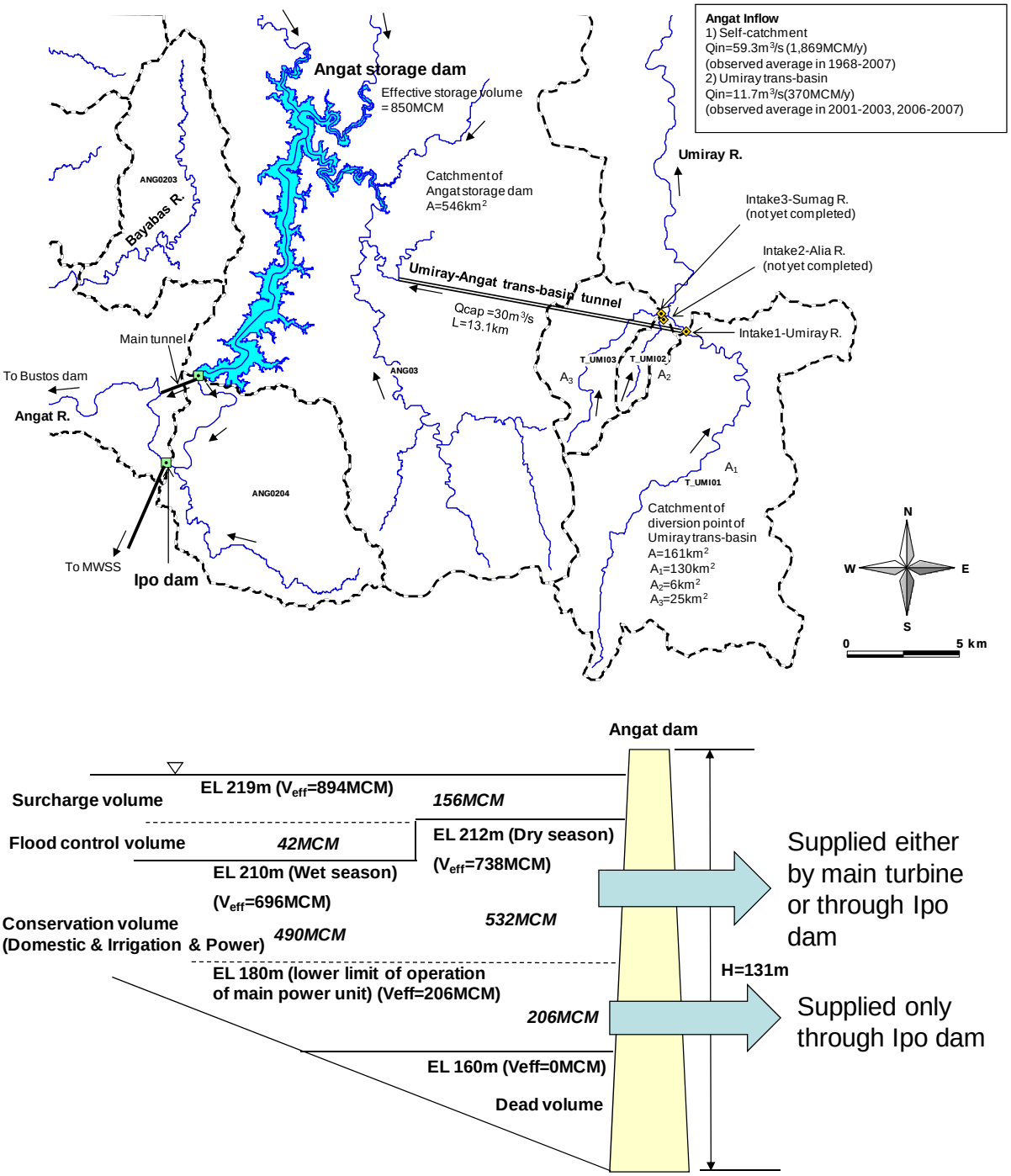
Annex-Figures



Annex-F H.2.2.1 Location of Water Permits for Surface Water

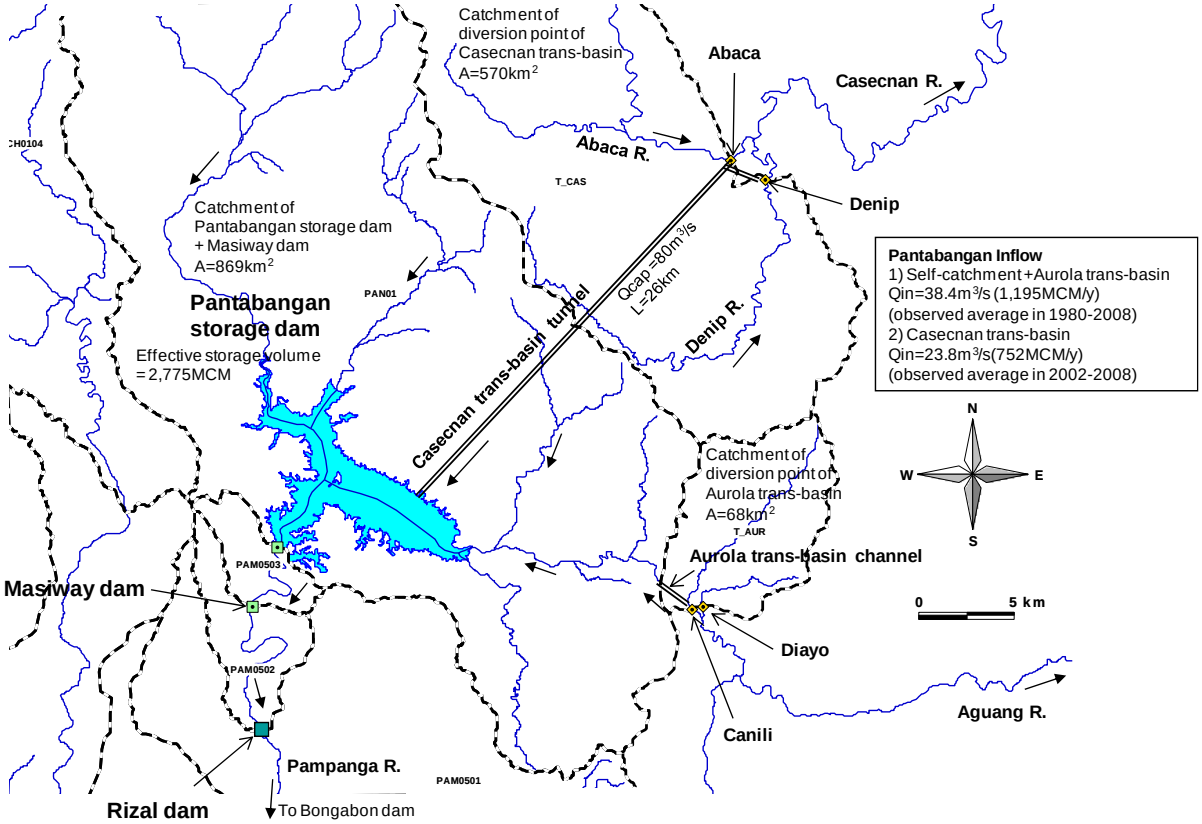


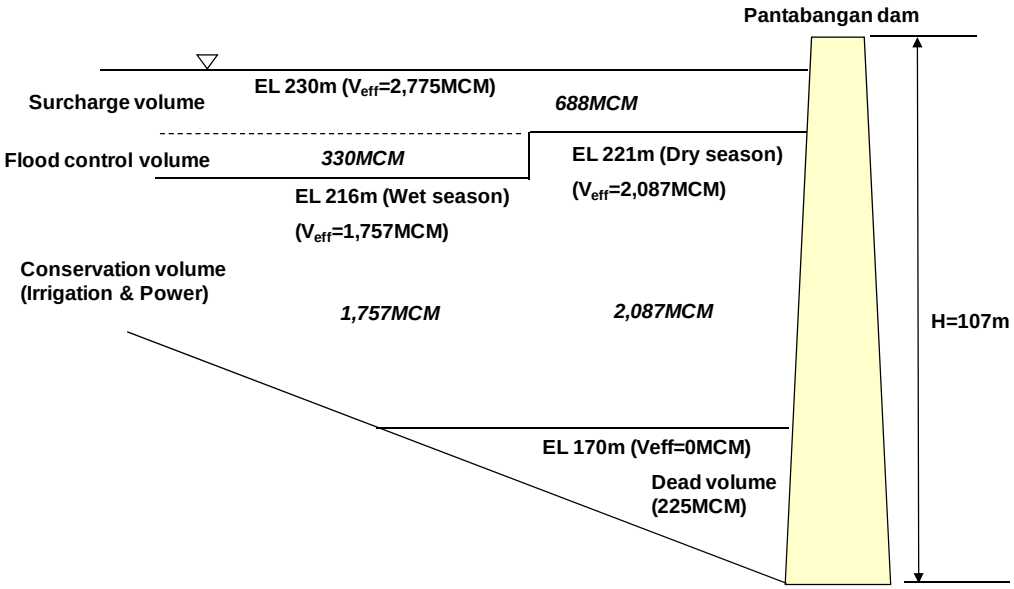
Annex-F H.2.2.2 Location of Water Permits for Groundwater



Source: JICA Study Team

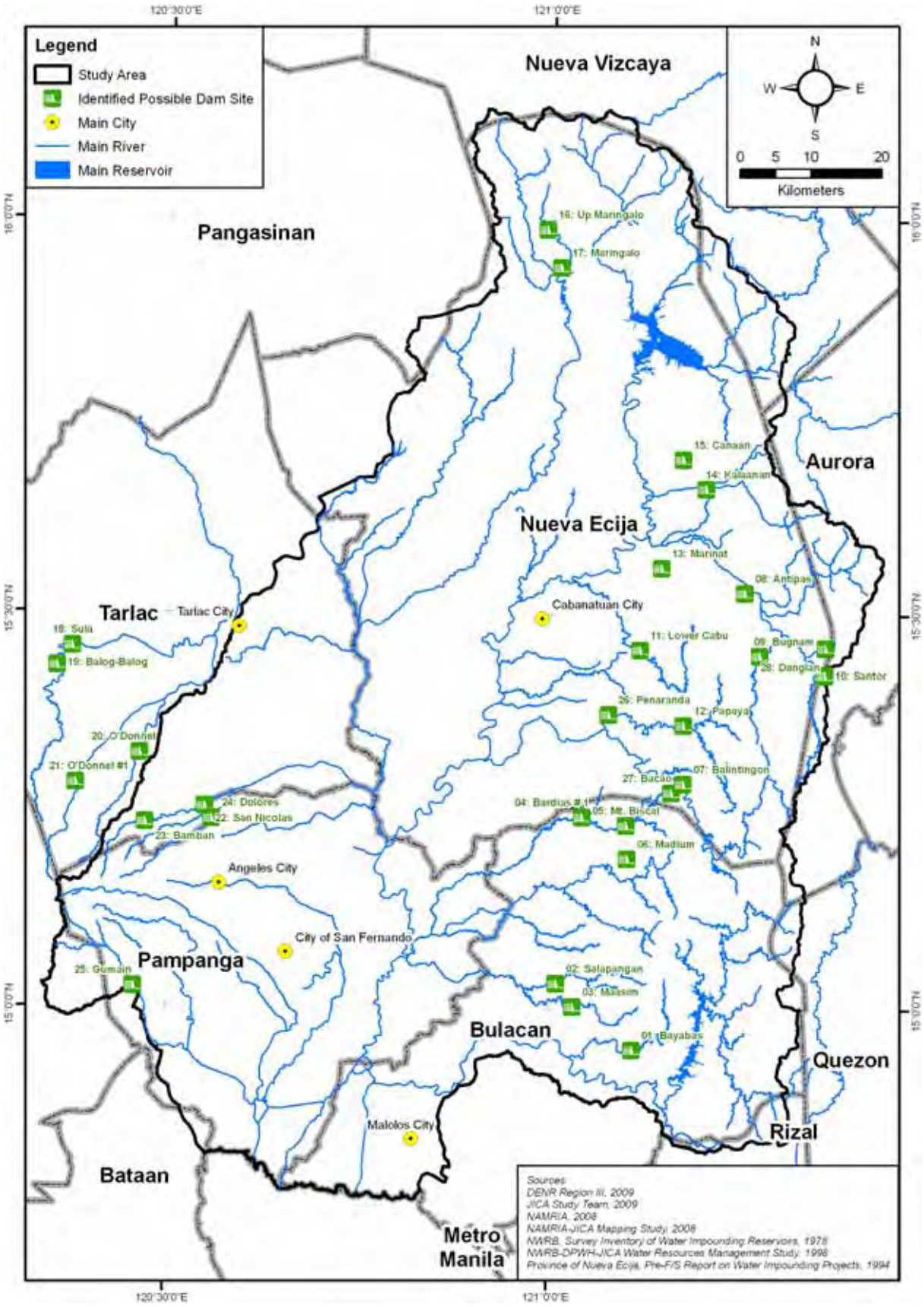
Annex-F H.2.3.1 Location and Dimension of Angat Storage Dam



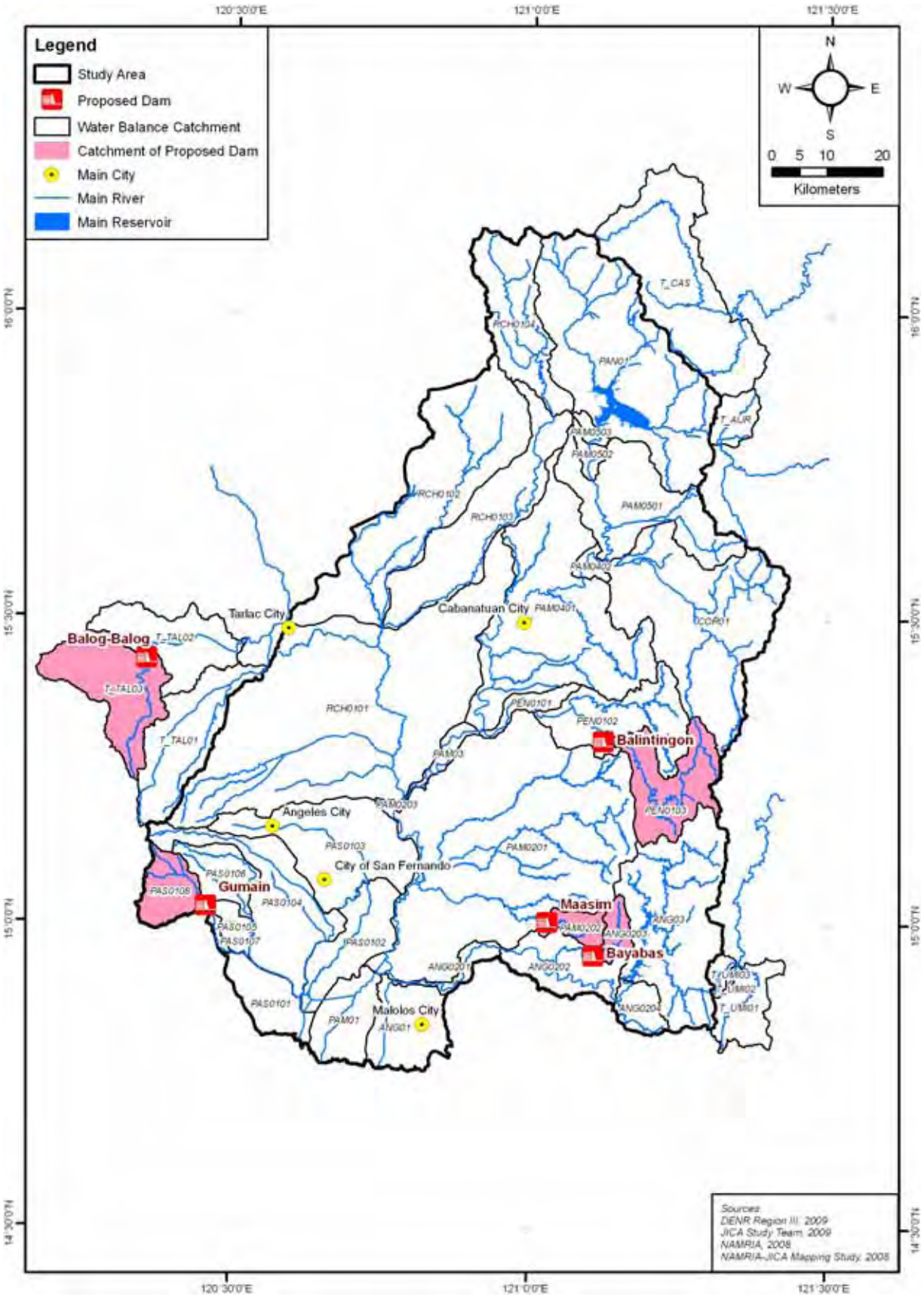


Source: JICA Study Team

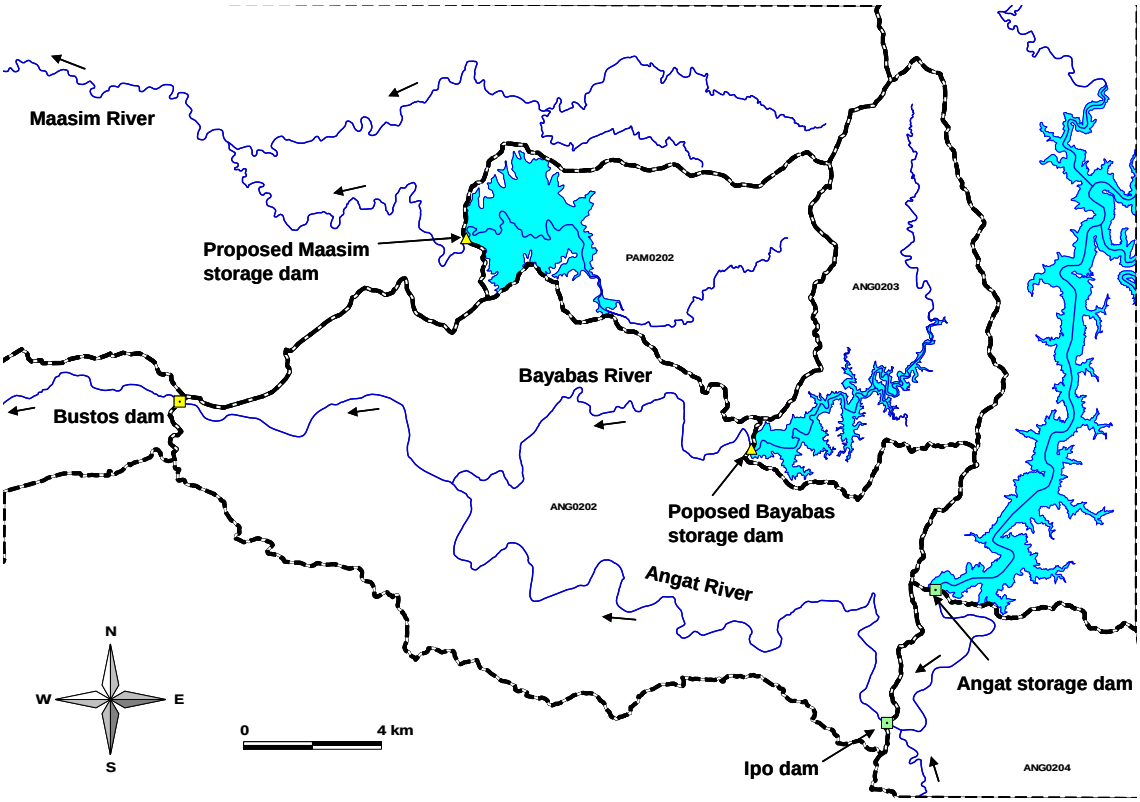
Annex-F H.2.3.2 Location and Dimension of Pantabangan Storage Dam



Annex-F H.2.3.3 Location of Identified Possible Large Storage Dam Sites

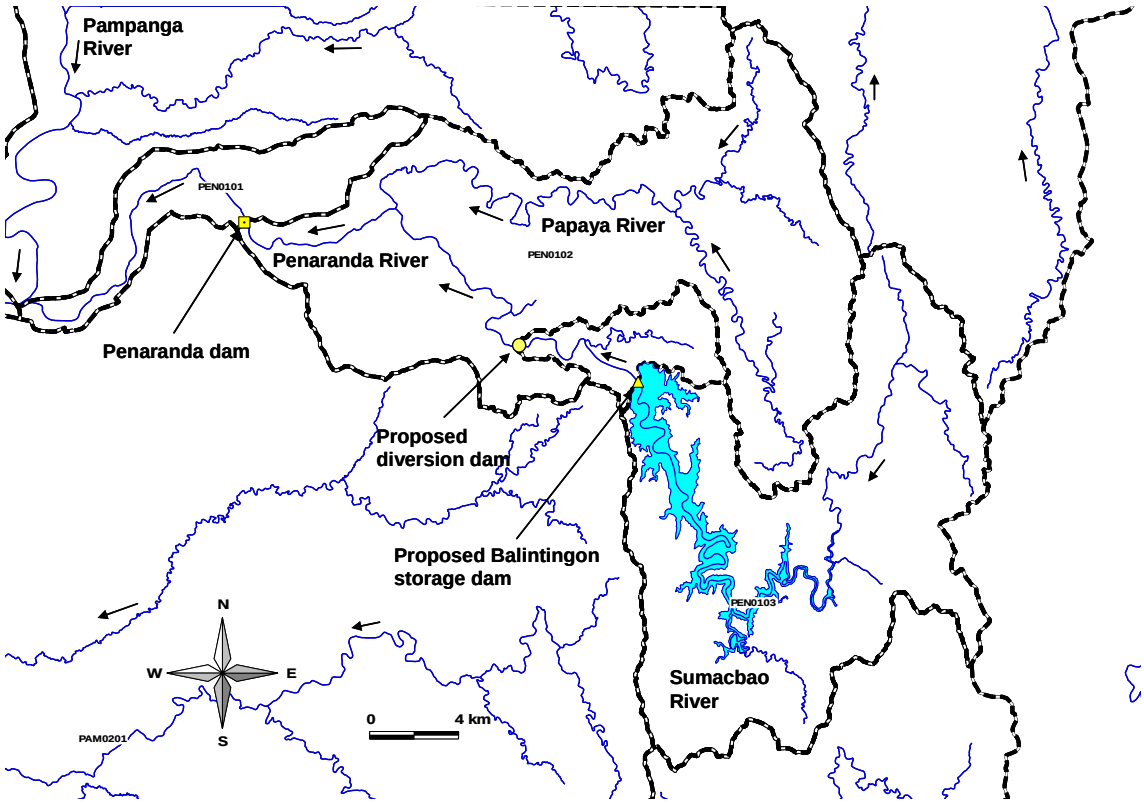


Annex-F H.2.3.4 Location of Proposed Large Storage Dam Sites



Source: JICA Study Team

Annex-F H.2.3.5 Location of Proposed Bayabas and Maasim Storage Dams



Source: JICA Study Team

Annex-F H.2.3.6 Location of Proposed Balintingon Storage Dam