Part 3 Rehabilitation and Expansion Plan, Approximate Implementation Cost, and Economic and Financial Analysis

CHAPTER 8 REHABILITATION AND EXPANSION PLAN OF THE VAKHSH CONDUITS

8.1 REHABILITATION PLAN FOR THE VAKHSH CONDUITS

8.1.1 TARGET FACILITIES OF THE PLAN

The Scope of the Study on the Plan is limited in the Rayons of Vakhsh, Dzhilikul and Kumsangir except Rayon Centers. The Study Team accordingly established the rehabilitation plan for the following systems:

- The Vakhsh Conduits from the Sarband Intake to Vakhsh, and Dzhilikul, Dusti, and Kolkhozobod via Uzun. (refer to the *Figure 8.1.2*) and the sub-mains which connect the main and the WSSs
- The WSSs located in the area in Bokhtar Rayon shall be excluded
- The WSSs owned by the Vodokanal
- The WSSs located in the area where the main conveyance pipe is owned by the Vodokanal of Kolkhozobod (downstream area from the valve which locates around 2.2km before Kolkhozobod) shall be excluded
- The area where CIP is installed in Vakhsh Rayon shall be excluded except section between the connection point of the CIP with the Steel Pipe of Vakhsh Conduits and the Mehnatobod village WSS[1]. Because, the brittle CIP of which the age is reportedly over 30 is to be replaced and no WSS connects with the Conduits in this area. Furthermore, the Conduits in this area have not reached the Vakhsh Rayon center yet. A WSS in the Vakhsh Rayon center pumps up water from the Stalin canal. The intake locates at the downstream point of the Sarband SB (Intake).

After all, the number of WSSs to be studied for rehabilitation is 53 and is shown in the unshaded cells of *Table 3.3.1 (Chapter 3)*.

Regarding the WSSs of which water source is a well or an irrigation canal, it is recommended establishing independent WSS with a treatment plant considering the cost efficiency.

8.1.2 PROPOSED PROJECT TIMELINE

Table 8.1.1 presents the proposed Project Timeline which is the base of the financial analysis including population projection and water demand prediction. As shown in the table, the Project duration of the Project's financial situation is considered 20 years starting from 2009 until 2028. If the Project duration is long, there will be the risk that the capacity of facilities will be excessive due to the uncertainty of the prediction and if the Project period is short, the next phase rehabilitation will not be able to be planned and designed based on the actual water supply data, and, moreover, if the actual water demand exceeds the projected one, there will not be sufficient time and maybe budget to prepare further expansion work.

[1] A drain facilities should be installed just after the connection point of Mehnatobod village WSS to evacuate water of the Vakhsh Conduits into nearby canal.

Table 8.1.1 Proposed Project Timeline

year	event
2007	Starting the JICA Study
2008	Rehabilitation Planning
2009	Completion of the JICA Study, Starting the detailed survey and planning, Financing
2010	Detailed planning and design, Financing
2011	Detailed design and construction works
2012	Detailed design and construction works
2013	Partial Inauguration of the Systems, Detailed design and construction works
....	OM&M, Detailed survey and design, and construction works
2028	Final year of the Project duration of the Rehabilitation Project of the Vakhsh Conduits System

Source: own study

8.1.3 WATER DEMAND PREDICTION

(1) Factors to be Applied to the Water Demand Prediction

The following factors are necessary for the water demand projection:

1) Per capita consumption per day

Considering the existence of a developed irrigation canal system, the rural water supply system should be more convenient in terms of fetching water. The Study Team accordingly recommends designing the WSS based on a yard connection in order to assure the sustainability of the water supply. If a consumer wants to have a yard connection, it should be installed at a cost of service facilities such as service pipe (from just after a stop valve to a yard tap via a water meter), water meter and other fixtures should be borne by it.

It will make the service facilities consumer's property and consumers should consequently maintain it, the consumer shall bear the cost of maintenance. Furthermore, a metered rate system can be applied and it will reduce the UFW i.e. foster the sense of water saving. A progressive rate system can be developed which can consider people who are in a financially difficult condition and to recover the renewal cost of the WSS.

The rehabilitation project should be based on collective water supply including yard connections on a request basis and the project should aim to achieve the rate of yard connection at nearly 100% by the end of the Project duration, 2028.

Considering the above, the Study Team proposes that the per capita consumption per day in the final year of the project duration as 50 liters referring to the literature of WHO, and other organizations. That of 2013, which is the first year of starting the operation of the WSSs and Vakhsh Conduits after the rehabilitation and communal taps seems to prevail, and is set as 20 liters due to the relatively short distance between a house and a communal tap, i.e. the time for fetching water is not long.

As for the Rayon Centers, considering the water supply of Vodokanal for the several stories apartment house which has two (2) or three (3) taps and rather rapid urban development, 100 liters/capita/day in the final year of the project duration and 50 liters/capita/day in 2013 have been projected.

2) Coverage

Though the definition of "the water supply coverage" in Tajikistan is not clear, the National Development Strategy (NDS) of the Tajikistan Government approved in 2007 sets the targets of the water supply coverage as shown in *Table 8.1.2*. The national water supply program promulgated in 2006 reportedly shows the urban water supply coverage in 2006 as 87% and targets the rural water supply coverage in 2020 for 90%.

Table 8.1.2　Targeted Water Supply Coverage in NDS

	2004	2010	2015
Rural Water Supply	47	64	74
Urban Water Supply	93	96	97

Source: own study

As mentioned above, the Study Team assumed the water supply coverage to be applied to the water demand prediction from 2004 to 2028 in the following *Table 8.1.3.*

Table 8.1.3　Water Supply Coverage applied to the Study

	2004	2006	2010	2015	2020	2028
Rural Water Supply	47	52	64	74	90	90
Urban Water Supply		87	96	97	97	97

Source: own study

The water supply coverage in the years shown in the Table, assume an increase incrementally in equal intervals up to 90% in case of the rural water supply and 97% in case of the urban water supply in 2020 and both rural and urban coverage will not change from 2020 to 2028 considering the difficulty to achieve 100% water supply coverage in a number of countries.

3) Rate of unaccounted-for water (UFW)

According to the NDS, the loss in drinking water supply system is 50 to 60% on average.　50% is accordingly applied to the rate of UFW in 2013 and UFW of 30% in the final year considering the contribution of the rehabilitation during the project duration.　The rate from 2014 to 2027 is assumed to decrease incrementally by equal intervals up to 30% in 2028.

4) Water demands of factories, businesses, public institutions and WSS's use as percentage of a domestic water demand

Since, data and literature concerning the water demand of factories, businesses and public institutions for water supply systems in rural towns and villages is scarce, the Study Team referred to the Second Water Utilities Book (Asian Development Bank, 1996) which shows such data of relatively large urban water supply systems.　According to this literature, the lowest industrial, commercial, and public institutional water use among 23 WSSs as a percentage of the domestic water demand is 4% respectively.　Considering that data is rather old, 5% of domestic use is assumed as water demands of factories, businesses, and public institutions to the water supply in the Rayon Center and 2% for the rural water supply, taking into account micro-businesses will be set up according to the development of rural areas.

(2) Population Projection

The population projection of six (6) Rayons and Kurgan Tyube is made using statistics shown in *Table 3.2.1* and *Table 3.2.2* in order to estimate the water demand for the Vakhsh Conduits system.

1) Methodology for Population Projection

In case the data of several years are available as shown in *Table 3.2.1*, the following three methods are used to estimate the future population, and one method which gives the result between the largest and the smallest ones.　Because socio-economic factors such as investment plans, development trends of industries, etc. which influence population growth are not available.

If only a datum is given as shown in *Table 3.2.2*, the projection by geometric series is applied referring to the estimation result of the related Rayon shown in the *Table 3.2.1*.

Concerning the population in the service area of WSSs connected to the Vakhsh Conduits, it is assumed that the ratio between the populations in the service area to that of Rayon is constant during the project duration.

i) projection by arithmetic series

$$P=P_0(1+a\cdot n)$$

where P : Population

P_0 : Population in reference year

a : Coefficient relative to population growth

n : Number of years from the reference year

ii) projection by geometric series

$P=P_0(1+r)^n$

where P : Population

P_0 : Population in reference year

r : Population growth rate

n : Number of years from the reference year

iii) projection by power function

$P=P_0+An^a$

where P : Population

P_0 : Population in reference year

A, a : Constants

n : Number of years from the reference year

2) Population Projection of six (6) Rayons and Kurgan Tyube

The method of projection by arithmetic series is applied to Sarband Rayon and Kurgan Tyube, and the population project of other Rayons are made by the method of projection by power function. The results are shown in *Attached Tables 8.1-8.7 (Supporting Report)* and the following *Table 8.1.4* presents the projected population in 2013 and 2028 of six (6) Rayons and Kurgan Tyube.

Table 8.1.4 Projected Population of Rayons and Kurgan Tyube in 2013 and 2028

	Population in 2013	Population in 2028
Sarband	29,100	41,100
Bokhtar	243,500	337,300
Vakhsh	166,400	217,600
Kolkhozobod	175,800	237,800
Dzhilikul	103,100	139,000
Kumsangir	117,100	157,400
Kurgan Tyube	79,800	100,800
Total	914,800	1,231,000

Source: own study

3) Projection of Rayon Centers Population and Rural Population

Since the population in 2007 is the only available data of each Rayon Center, the population projection is made in the following manner:

i) Population growth rate is computed based on the result of each Rayon mentioned above.

ii) Add 0.5% to the population growth rate considering more rapid population growth than that of the rural area due to expected socio-economic growth. This assumption means some population will flow into the Rayon Centers from the rural areas.

iii) The population of each year in the project duration is made applying the method of projecting by geometric series.

The rural population is calculated by subtracting the population of Rayon Center from that of the whole Rayon.

The results of the projection are shown in *Attached Tables 8.1 – 8.7 (Supporting Report)* and the following *Table 8.1.5* shows the Population of Rayon Centers and Rural Population in 2013 and 2028.

Table 8.1.5 Projected Population of Rayon Centers and Rural Areas in 2013 and 2028

	Population in 2013		Population in 2028	
	Rayon Center	Rural Area	Rayon Center	Rural Area
Sarband	16,700	12,400	27,000	14,100
Bokhtar	8,800	234,700	13,400	323,900
Vakhsh	14,300	152,100	20,500	197,100
Kolkhozobod	15,300	160,500	22,800	215,000
Dzhilikul	16,200	86,900	24,200	114,800
Kumsangir	15,300	101,800	22,700	134,700
Total	86,600	748,400	130,600	999,600

Source: own study

(3) Water Demand Prediction

1) Average Daily Water Demand

The Study Team made the water demand prediction based on the Population Projection applying the factors described in Section 8.1.3 (1) for all the Vakhsh Conduits System as well as the target part of Conduits, i.e. from the Sarband SB to Vakhsh, and Dzhilikul , Kolkhozobod and Dusti via Uzun.

Following *Table 8.1.6* shows the water demand prediction of the rural area in six (6) Rayons for reference in the final year of the project duration.

Table 8.1.6 Water Demand Projection in Rural Area of six (6) Rayons

			year	2028
(1)	rural water supply coverage	%		90
(2)	assumed rate of UFW	%		30
(3)	rural population			999,600
(4)	rural population will be served		(3)x(1)/100	899,600
(5)	liter per capita per day	liter		50
(6)	domestic use	m^3/day	(4)x(5)/1000	44,980
(7)	industrial use (2% of domestic use)	m^3/day	(6)x0.02	900
(8)	commercial use (2% of domestic use)	m^3/day	(6)x0.02	900
(9)	Institutional use (2% of domestic use)	m^3/day	(6)x0.02	900
(10)	sub-total	m^3/day	(6)+(7)+(8)+(9)	47,680
(11)	UFW	m^3/day	(10)x((2)/(1-(2)/100)/100	20,434
(12)	sub-total	m^3/day	(10)+(11)	68,114
(13)	water use of WSS (5% of above)	m^3/day	(12)x0.05	3,406
(14)	average daily water demand in rural	m^3/day	(12)+(13)	71,520

Projected Water Demand of Sarband, Bokhtar, Vakhsh, Kolkhozobod, Dzhilikul and Kumsangir Rayons and Kurgan Tyube

Projected water demand in 2013 and 2028 of the Sarband, Bokhtar, Vakhsh, Kolkhozobod, Dzhilikul and Kumsangir Rayons and Kurgan Tyube are 595,00 m^3/day and 123,900 m^3/day respectively. Details are shown in the *Attached Table 8.8* (Supporting Report).

Projected Water Demand on the Vakhsh Conduits from Sarband Settling Basin to Vakhsh, and Dzhilikul , Kolkhozobod, and Dusti via Uzun

As aforementioned, the Study covers captioned Vakhsh Conduits. The projection of water demand on the Conduits is necessary to prepare their rehabilitation plans. Having the water demand, following water demand is to be subtracted from the total projected water demand mentioned in Section 8.1.3 (1).

- Water demand of Kurgan Tyube and Sarband Rayon because they are out of the study scope
- Water demand of the Vakhsh Rayon Center. The WSS in this area reportedly takes water from a downstream point of the Stalin canal. Considering the necessity of water treatment, it is recommended constructing independent WSS by selecting an appropriate place for gravity intake in the Starling canal. Extension of 3.5km around the 600mm diameter conduit does not seem to be economical because the diameter of the conveyance pipe for Vakhsh Rayon Center will be apparently smaller than 600mm.
- 60% of the projected water demand of the rural area of Vakhsh Rayon is to be subtracted from the total projected water demand. Other rural WSSs in the Vakhsh rayon of which the water source is a canal are also recommended constructing an independent WSS though some of them can be constructed by a centralized water treatment plant. According to the result of the inventory survey implemented by the JICA Study Team, Nine (9) WSSs out of 15 (60%) have an intake at the irrigation canal. It is assumed that this rate will not change until the final year of the project duration.
- Projected water demand of following WSSs

Table 8.1.7 WSSs and their service population excluded from the Water Demand Projection on the target Conduits

WSS	Jamoat	Rayon	Water Source	Population
Kirov village from the bore hole 5 to Main pipe line	Tugalang	Kolkhozobod	well	5,000
Yosh-Lrninchi (From bore hole 4 to main pipe-line)	Tugalang	Kolkhozobod	well	5,000
Water constructions Uzun 1	Uzun	Kolkhozobod	well	3,986
Pyatiletka of Jamoat Tugalang	Tugalang	Kolkhozobod	irrigation canal	2,791
5-th village	Pyanj	Kumsangir	irrigation canal	6,600
total				23,377

Since these WSSs might have their water source nearby and the conveyance, it seems to be economical to operate as independent system rather than the WSS having water from the Vakhsh Conduits.

Following *Table 8.1.8* shows the projected water demand in 2028 on the Vakhsh Conduits covered by the JICA Study. *Attached Tables 8.8 - 8.12* (Supporting Report) presents the detail of water demand projection for the *Table 8.1.8*.

Table 8.1.8 Water Demand on the Vakhsh Conduits covered by the JICA Study

	Area		Water demand (m^3/day)
(1)	Total		123,892
(2)	Kurgan Tyube		30,514
(3)	Sarband		5,530
(4)	Vakhsh Rayon Center		3,435
(5)	60% of Vakhsh Rural		8,461
(6)	four (4) WSSs in Kolkhozobod and one (1) WSS in Kumsangir		2,489
	Average Daily Water Demand on the Vakhsh Conduits	(1)-(2)-(3)-(4)-(5)-(6)	73,463

Table 8.1.9 shows the yearly projected water demand from 2013 to 2028 on the Vakhsh Conduits covered by the JICA Study.

Table 8.1.9 Projected Water Demand on the Vakhsh Conduit

		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
rural water supply coverage	%	70	72	74	77	80	83	86	90	90	90	90	90	90	90	90	90
urban water supply coverage	%	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97
assumed rate of UFW	%	50	49	47	46	45	43	42	41	39	38	37	35	34	33	31	30
Total Water Demand of Six (6) Rayons and Kurgan Tyube	m^3/day	**59,476**	**63,378**	**67,456**	**72,037**	**76,784**	**81,822**	**86,981**	**92,875**	**96,758**	**100,575**	**104,433**	**108,302**	**112,174**	**116,077**	**119,970**	**123,892**
Kurgan Tyube	m^3/day	26,006	26,326	26,555	26,878	27,164	27,441	27,767	28,064	28,352	28,651	28,982	29,239	29,576	29,915	30,175	30,514
Sarband Rayon	m^3/day	2,343	2,532	2,741	2,927	3,129	3,373	3,587	3,808	4,042	4,225	4,425	4,673	4,880	5,070	5,317	5,530
Vakhsh Rayon Center	m^3/day	1,680	1,785	1,909	2,001	2,104	2,224	2,332	2,438	2,576	2,694	2,800	2,921	3,045	3,169	3,307	3,435
Vakhsh Rural	m^3/day	4,744	5,321	5,920	6,637	7,380	8,155	8,974	9,930	10,450	10,975	11,513	12,024	12,548	13,069	13,587	14,102
60% of Vakhsh Rural	m^3/day	2,846	3,193	3,552	3,982	4,428	4,893	5,385	5,958	6,270	6,585	6,908	7,214	7,529	7,841	8,152	8,461
four (4) WSSs in Kolkhozabad and one (1) WSS in Kumsangir	m^3/day	806	911	1,013	1,147	1,274	1,407	1,554	1,723	1,815	1,924	2,012	2,117	2,211	2,297	2,403	2,489
Average Daily Water Demand on the Vakhsh Conduits	m^3/day	**25,795**	**28,631**	**31,686**	**35,102**	**38,686**	**42,483**	**46,357**	**50,884**	**53,703**	**56,496**	**59,307**	**62,138**	**64,933**	**67,785**	**70,616**	**73,463**
Vakhsh Conduits to be loaded (based on the maximum daily water supply)	m^3/day	35,596	39,511	43,727	48,441	53,386	58,627	63,973	70,220	74,110	77,964	81,843	85,751	89,607	93,544	97,450	101,378
Population corresponded to		423,621	446,388	469,948	500,526	532,448	565,185	598,609	640,377	653,938	667,723	681,607	695,428	709,363	723,592	737,499	751,908
Maximum daily water demand by 83 WSSs	m^3/day	21,427	23,297	24,915	26,803	28,736	30,295	32,236	34,153	35,735	37,706	39,726	41,232	43,264	45,347	46,869	48,959
Population corresponded to		256,050	261,961	268,034	274,049	280,272	286,456	292,695	298,820	305,106	311,633	318,169	324,508	331,064	337,810	344,256	348,790
Assumed maximun daily water demand on the Conduits	**m^3/day**	**21,427**	**26,757**	**32,087**	**37,417**	**42,747**	**48,077**	**53,408**	**58,738**	**64,068**	**69,398**	**74,728**	**80,058**	**85,388**	**90,718**	**96,048**	**101,378**

2) Maximum Daily Water Demand

The water demand varies seasonally, it is big in summer and small in winter. The peak factor for daily water demand acquired by following formula shown in "3.4 (2) Establishment of Quantitative Service Level Indicator" represents the scale of this variation. (Though water supply and water demand is different, if "water demand" replaces "water supply" in the formula, it can be considered that the return will be same.)

$$\text{the peak factor for daily water demand} = \frac{\text{the maximum daily water supply (usually in summer)}}{\text{the average daily water supply (yearly water supply/365)}}$$

The capacity of the Vakhsh Conduits should be sufficient to deliver the MDWD.

Namely, the Vakhsh Conduits shall have the capacity over the total of MDWD of the WSSs covered by the Conduits.

The Study Team established the rehabilitation plan through the hydraulic model applying the MDWD to the Vakhsh Conduits acquired by following manner:

- summing up the average daily water demand of the 83WSSs covered by the Vakhsh Conduits
- summing up the MDWD of said 83WSSs
- calculation of the peak factor to be applied to the Conduits
- having the MDWD on the Vakhsh Conduits

Concerning the MDWD and the peak factor of the WSSs, the value of them depend on the scale of service area, climate, etc. Usually, the data of actual water demand in the past several years or the values applied to the WSS under the similar conditions, however, no data is available for the WSSs covered by the Conduits.

The Study Team consequently borrows the data on the peak factor from the following *Figure 8.1.1*.

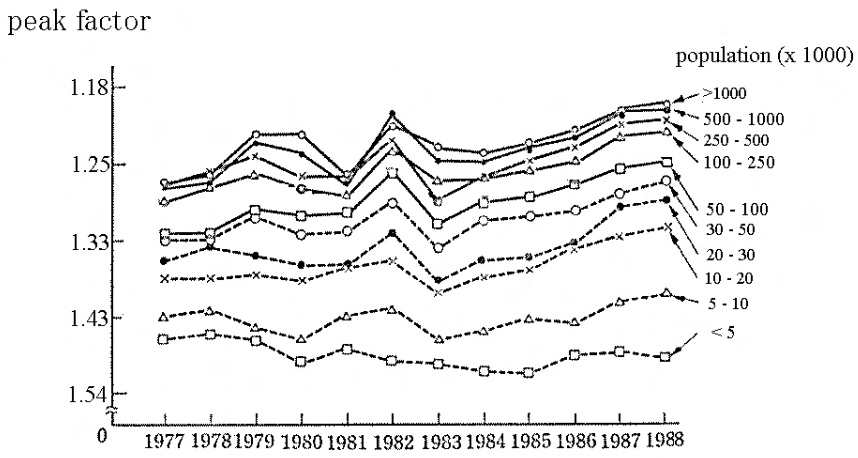

Figure 8.1.1 Peak Factor for Daily Water Demand

Source: Japan Water Works Association, 1990, Design Criteria for Waterworks Facilities

Following table shows the peak factor for daily water demand applied to the WSSs:

Table 8.1.10 Peak Factor for Daily Water Demand Applied

Service Population	Peak Factor
1 – 5,000	1.45
5,001 – 10,000	1.34
10,001 – 20,000	1.27

Source: own study

The peak factor to be applied to the Vakhsh Conduits is got as following:

- total of the average daily water demand of the 83 WSSs: 35,400 m3/day
- total of the MDWD of the 83 WSSs: 48,960m3/day
- the peak factor for the daily water demand = 48,960/35,400 = 1.38

The MDWD on the Vakhsh Conduits by applying this peak factor is:

73,463m^3/day (predicted average daily water demand in 2028, refer to *Table 8.1.9*) x 1.38 = 101,378 m^3/day

3) The Maximum Daily Water Demand of each year in the Project duration

As mentioned above, there are 83 WSSs connect with the Vakhsh Conduits among which 27 is under shutdown and 15 can not distribute water to meet the demand. The repair and restoration of these WSSs are urgent matters and it should be kept abreast with the Plan.

On the other hand, there is the difference between the average daily water demand on the Vakhsh Conduits; 73,500m3/day and that of 83 WSSs; 35400m3/day. The difference; 38,100m3/day is the water demand of the areas where WSSs do not exist. It is assumed that the WSSs will be constructed keeping pace with the progress of the Plan.

Considering above mentioned fact, the Study Team applied the following assumption to the plan:

- The MDWD on the Vakhsh Conduits in 2013, the first year of project duration: the MDWD of 83 WSSs; 21,400m3/day.
- The MDWD on the Vakhsh Conduits in 2028, the final year of project duration: the MDWD on the Vakhsh Conduits based on the projected service population; 101,400m3/day.

Table 8.1.9 shows the projected MDWD on the Vakhsh Conduits of each year in the project period.

8.1.4 REHABILITATION PLAN

Figure 8.1.2 shows the rough outline of hydraulic model of the Vakhsh Conduits. The name of each zone is frequently referred in the following text and attached tables.

(1) Projected Intake

As explained in “3.3 Current Conditions of the Vakhsh Conduits”, there are two pipeline routs in the Vakhsh Conduits, one is for Kurgan Tyube with double pipelines and another is single but dendritic pipeline for Bokhtar, Vakhsh, and Dzhilikul, Kolkhozobod, Kumsangir via Uzun.

The water supply to the areas mentioned above complying with the national plan will necessitate around 140,200m^3/day. The breakdown of it is as follow:

- for Kurgun Tyube: 38,800m^3/day
  - the average daily water demand in 2028: 30,514m^3/day
  - the peak factor for the daily demand: 1.27 (shown in *Table 8.1.10*)
  - the MDWD in 2028: 30,514 x 1.27 = 38,800 m^3/day
- for five (5) Rayons: 101,400m^3/day

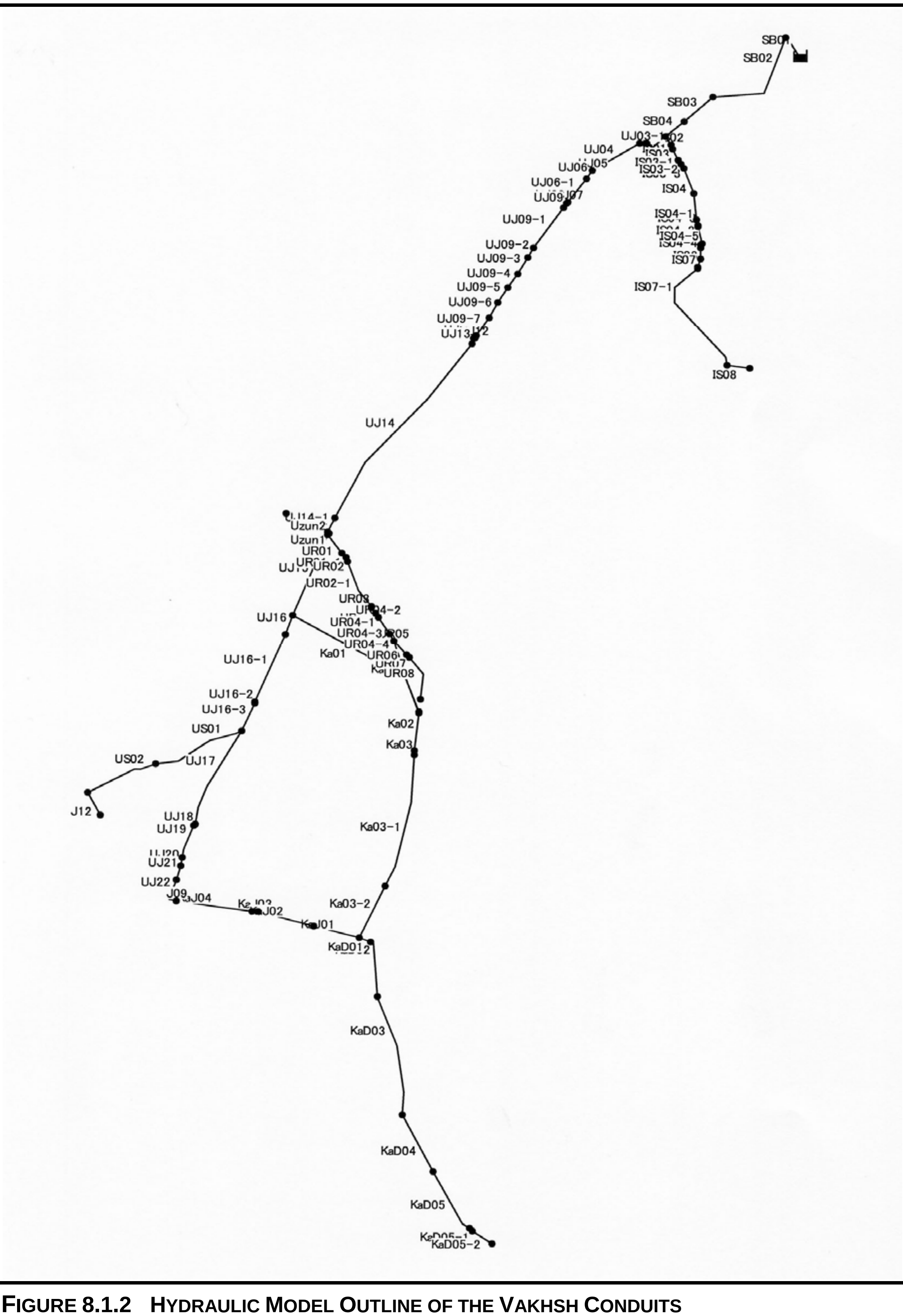

FIGURE 8.1.2 HYDRAULIC MODEL OUTLINE OF THE VAKHSH CONDUITS

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Project intake should have 10% allowance and accordingly it should be 155,000m^3/day at the intake in the Sarband SB facilities.

Regarding the capacity of intake, it seems to be possible to take 155,000m^3/day because the cross section area of intake channel is 2.6m^2 makes the velocity of flow only a little less than 0.7m/s.

(2) Hydraulic Analysis of the Vakhsh Conduits Based on Water Demand Prediction

1) Hydraulic Analysis

The Study Team made the hydraulic analysis making use of the hydraulic model of the Vakhsh Conduits explained in “3.3.9 Capacity of the Vakhsh Conduits under the Current Situation”. The objective of the analysis is to establish appropriate model of Plan in order to introduce the sufficient capacity into the Conduits to meet the water demand in 2028.

2) Water Demand Loaded to the Conduits in the Analysis

As aforementioned, there are a number of areas where the WSS does not exisit in target five (5) Rayons.

Following table shows the Rayon-wise comparison of the total water demands of the WSSs in 2028 based on the assumption described in “8.1.3 (2) Population Projection and (3) Water Demand Prediction” and that of the rayon. In this comparison, it is assumed that the number of WSSs will not change.

Table 8.1.11 Total Water Demand of WSSs and Rayon in 2028

Rayon	WSS (m^3/day)	Rayon (m^3/day)	Ratio
Bokhtar	4,255	23,177	5.45
Vakhsh	2,196	5,641	2.57
Dzhilikul	3,323	8,211	2.47
Kolkhozobod	8,575	13,541	1.58
Kumsangir	3,323	8,211	2.47

Note）The water demand for WSSs which take water from the canal is excluded in the Vakhsh Rayon

Source: own study

Followings are assumptions to introduce above mentioned “non-water supply” into the hydraulic analysis:

- The Vakhsh Conduits will deliver water to the areas where WSS does not exist
- Each WSS is the point to load the water demand on the Vakhsh Conduits (outflow of water takes place at the point of WSS)
- The water demand at the above-mentioned point is the MDWD of the WSS times ratio shown in the *Table 8.1.11*.
- Inflow to WSSs is regulated with a valve and accordingly discharge will never exceed the water demand mentioned above.
- The water demand of Rayon Centers is the predicted one in 2028
- Discharge is constant during 24 hours

Attached Table 8.13 (Supporting Report) shows the MDWD represented by liter/second unit in 2028 of each WSSs and the water demand (total is equivalent to the total of the MDWD on the Vakhsh Conduits in 2028) applied to the hydraulic analysis.

3) Lessons Learned from the Hydraulic Analysis

Hydraulic analysis gave several points to consider in the Plan:

Insufficient Capacity of Pipeline between the Sarband Settling Basin and Uzun Pumping Station

Negative pressure takes place in the vicinity of Uzun PS by loading of MDWD of the WSSs only. It is consequently impossible for the Conduits to deliver total water demand in 2028 without expansion of this section in the Conduits.

Critical Point regarding Flow Rate of the Vakhsh Conduits

As shown in *Figure 8.1.2*, the single pipeline comes to Uzun PS and then it starts the ramification and finally four (4) pipelines appear representing by zone D, E, F, G, H, I. There are Rayon Centers, etc. which have big water demand at the end points of the zone D, E, G, H. Unless there is sufficient dynamic pressure at Uzun PS (it represent the position of the Conduits and hereinafter there are similar descriptions), necessary water accordingly will not come to the end of each pipeline. Hydraulic Analysis shows that existing 700mm in inside diamter (hereinafter referred to as ID700) can not maintain the sufficient dynamic pressure to deliver water to all the WSSs in the downstream area of Uzun. It is necessary to expand the conduit between Sarand Settling Basin and Uzun PS.

Conveyance to G Area is Difficult from the Viewpoint of the Costs

The conduit to Dusti (The Kumsangir Rayon Center) starts the connection point where around 4.2km to the south-west of Uzun in D area and go through nearby point of the south of Kolkhozobod Rayon Center and then go southward until Dusti via Kalinin PS. It extends up to Kolkhoz Lenin WSS (Q-04). Most of the conduit has ID514mm and the total length is around 40km. The elevation of Q-04 is 390m and that of Uzun is 364, Q-04 is 26m higher than Uzun in elevation.

Total water demand of G in 2028 is 206 liter/second (17,900 m^3/day) and it necessitates around 126m water head energy to deliver this flow rate to Q-04 from Uzun. However, the elevation difference between the Sarband SB and Uzun PS is only 80m, it is impossible to deliver the said discharge from Uzun to Q-04 through existing conduit even if there is not any friction loss head between SB and Uzun PS.

Decreasing the friction loss head between Sarband SB and Uzun PS by the expansion of the conduit and expansion of around 40km of conduit between Uzun PS and Q-04 will make it possible to deliver necessary water to G area. However, the cost of expansion seems to be very expensive for the conveyance of only 17,900m^3/day.

Kalinin PS makes currently convey water to Dusti by pumping up from the Kumsangir canal. Kumsangir canal flows nearby area of the WSSs in Kumsangir Rayons. It seems to be more economical if respective WSSs or group of WSSs construct a water treatment plant by pumping up water from the canal than having water from the Vakhsh Conduits by expansion.

Furthermore, the exclusion of G area from the service area of the Vakhsh Conduits will bring following merits:

- To decrease the load on the conduit between the Sarband SB and Uzun
- To restrain the project cost
- To make it possible to convey water from Sarband SB to other areas by gravity

Regarding the water right to take water from the Kumsangir canal, it does not seem to be problem because the Kumsangir canal connects with the Stalin canal, if only RWSA will be able to set the water right for the necessary volume of water mentioned earlier.

Expansion of Conduits to and in H area

Around 9.6km of ID313mm steel pipe in H area connects with the Vakhsh Conduits in D area at around 10km to the south-west of Uzun. The maximum flow rate in 2028 of the conduit for Dzhilikul at just after Uzun is 458 liter/second and that of just after the connection point with the conduit for F area which locates around 4.2km to the south of Uzun is 246 liter/second. These flow rates consume around 77m water head energy between Uzun and the connection point with the conduit of H area.

Followings are rough calculation of the total water head at the said connection point in 2028.

- Elevation difference between Uzun and the connection point is only 8m
- Available dynamic pressure at Uzun in 2028 is around 55m water head after the expansion of conduit between Sarband SB and Uzun
- Total water head at Uzun = 364m (elevation of Uzun) + 55m = 419m
- Total water head at the connection point = 419m – 77m + (364m – 356m (elevation of the connection point)) = 350m < 356m (elevation of the connection point)

It shows that there is a negative pressure at the connection point in 2028. Namely, the current Vakhsh Conduits in D area can not convey necessary water to H area in 2028.

Moreover, the connection points of the WSSs in the downstream area of the connection point in D area will have the negative pressure because there is not enough elevation difference between such WSSs, of which elevation is 350m to 355m, and the connection point.

It is consequently necessary to lay the new conduit from Uzun to the connecting point to connect with the conduit in H.

Insufficient Diameter of Several Connecting Pipelines between the Vakhsh Conduits and WSS

The Diameter of Several connecting pipelines between the Vakhsh Conduits and the WSS will become insufficient with increasing the water demand. These pipeline should be renewed appropriately.

Pumping Stations

The hydraulic analysis result shows that energy increase of flow by the operation of the Bokhtar Head PS will cause higher friction loss head between Bokhtar Head PS and Uzun PS and most of increase energy is consumed by the Uzun PS. Considering this inefficiency, the Study Team did not include the operation of the Bokhtar Head PS in the Plan.

The Study Team discussed about making use of Uzun PS as the booster PS for the conduit with ID514mm in D area which has insufficient capacity as mentioned above. However, the flow rate of the conduit in 2028 is 252 liter/second after deduction of the flow rate to G area and the velocity is 1.2m/second. It exceeds the efficient velocity of pump operation, 1.0m/second and therefore, the position of Uzun PS is not appropriate as the booster PS. The Study Team consequently did not consider the Uzun PS in the Plan.

The Kalinin PS currently pump up water from the Kumsangir canal and make pump pressurized conveyance to the Dusti and Dzhilikul WSSs. When the Plan is realized, the water conveyance to Dzhilikul is made by gravity from the Sarband SB. As for the Dusti WSS, as mentioned already, the Team recommended constructing independent WSS. After all, the Kalinin PS will stop its work after the construction of the WSSs in G area which take water from the Kumsangir canal.

(3) Alternative Plans

1) Location of Water Treatment Plant

There are two (2) ways to locate the water treatment plant; one is centralized and the other is decentralized. Specifically, the former is to locate the plant near the Sarband SB or Bokhtar Head PS and the latter is to locate near respective WSSs or groups of WSSs.

In case of a centralized water treatment, the WSS has to distribute the treated water to WSSs through the existing Vakhsh Conduits. However, considering the pipe material of Conduits, which does not have an internal protective lining though the outside is coated with asphalt, and its age, the condition of the conduits might have deteriorated to some extent. Internal corrosion of iron pipes decreases their structural durability and may create leaks and at worst may cause a rupture, and also consumes disinfectant residual, accumulates deposits, creates encrustations and biofilms and consequently decreasing the pipe cross section, i.e. decrease the capacity of the Conduits.

As discussed earlier, one of the factors which influence the sustainability of the Plan is “the differentiation between the waters of irrigation canal and pipe supply”. If the water quality of the piped supply is poorer than that of the water of irrigation canal, the consumers will not use the piped water supply so much. For example, the scales, sediments, biofilms, etc. in the conduits detaches from the inner surface might put color and odor to the supplied water and it has the population who shall be the consumer of the WSS return to the conventional water sources such as irrigation canals, shallow wells, etc.

Considering the potential of the Vakhsh Conduits to deteriorate the water in terms of aesthetic and microbial quality, it should be avoided to utilize the Vakhsh Conduits to distribute the treated water.

There is an option to adopt the centralized treatment method by applying in-situ pipe cleaning and lining, however, it is extremely expensive. Even if the decentralized water treatment plant is constructed, it necessitates the construction cost, i.e. the cost of cleaning and lining is net increase of the project cost. Hence, the Study Team can not recommend adopting this option from the viewpoint of the cost efficiency.

In Japan, uncoated steel pipe and galvanized steel pipe are not considered as service and distribution pipe.

The Study Team consequently recommends establishing decentralized water treatment system.

2) Water Supply to Kolkhozobod Rayon Center

As mentioned in “8.1.4 (2) Hydraulic Analysis of the Vakhsh Conduits Based on Water Demand Prediction”, the dynamic pressure at Uzun affects the conveyance of water to the downstream area of Uzun. The decrease of water demand in the downstream area accordingly makes the Conduits hydraulically stable and it contributes the decrease of the cost of rehabilitation.

Though, the WSS of Kolkhozobod Rayon Center currently have water from the Conduits, it pumped up water from the Kumsangir canal which runs just aside the WSS.

Therefore, if the cost of water from the Vakhsh Conduits is higher than that of pumping up from the canal, the Vodokanal of Kolkhozobod probably will change the water source from the Conduits to the Kumsangir canal. In fact, in case that the cost recovery of the Plan targets the Vodokanal, such change will take place easily.

Consequently, the Plan considers the alternative of supplying or not supplying water to the WSS of Kolkhozobod Rayon Center. In case no supplying water, the target WSSs are those connects with the conduits between Kolkhozobod Rayon Center and the valve located 3.3km before the Center. Because this section is the property of the Vodokanal. Total number of WSSs will be excluded from the Plan is seven (7); R-05, R-04, R-32, R-37, R-38, R-06, R-30 including that of the Rayon center (R-05) and the total water demand including the water demand of non-water supply area is 102 liter/second (8,800m3/day)

Among seven (7) WSSs, the elevation of R-05 is the highest and the distance between the farthest WSS and R-05 is around 2.4km. Hence, the distribution by gravity from the R-05 is better than having water from the Vakhsh Conduits which makes a long distance conveyance.

(4) Rehabilitation Plan

1) Vakhsh Main Conduits

The Plan intends to limit the repair and rehabilitation of existing conduits to repair the parts where the parties concerned has already recognize the leakage, etc. The Study Team recommends making out the drawings which shows the conduit routes with elevation, length, thickness of soil cover, etc, social and natural settings along the Conduits, etc. through the detailed survey to be implemented at the initial stage of the Plan. Then RWSA will be able to maintain and/or improve the performance of the Conduits as current OM/M. The Plan consequently does not have the rehabilitation plan of the existing conduits. However, the renewal of existing gray cast iron pipe is projected to renew due to following reasons:

- Low performance against shock power
- Socket joint necessitates thrust concrete blocks, restrained couplings, etc. to the uneven force caused by the pipe inner flow is necessary
- Low performance of earthquake protection (Khatlon Oblast exists in the seismic zone)
- Degradation of hydraulic performance and water quality caused by incrustation, etc.

Besides, if the rehabilitation work finds out leakages, corrosion, etc., they will be repaired or partially renewed.

Followings are proposed rehabilitation plan of the Vakhsh Conduits based on the water demand prediction and the hydraulic analysis:

Rehabilitation Plan of the Vakhsh Conduits

a) installing the valve, which has a good functions to control flow rate, in all the conduits which connect the Vakhsh Conduits with the WSSs and the flow-meter to manage the volume of water delivered to the WSSs.

b) disconnecting G area and the WSSs of Kolkhozobod Rayon Center and six (six) WSSs (R-04, R-32, R-37, R-38, R-06, R-30) in the vicinity of it from the service area of the Vakhsh Conduits

c) renewal of existing pipe by equivalent or more grade pipe in the following sections which the RWSA reported.
 * 350m of ID1200mm concrete pipe in the section between Sarband SB and Bokhtar Head PS
 * around 3.2km of ID700mm steel pipe in the B area

d) to replace the existing ID313mm steel pipe of 7.8m in H area by ID414mm steel pipe

e) installation of ID996mm steel pipe with around 7.7km long from the Sarband SB to juction of B and C area. This conduit should make a short cut without going through the Bokhtar Head PS. The conduit in the C area connects with this new conduit.

f) installation of new ID414mm steel pipe with around 10.2km long between Uzun and the junction of the D and H areas and connection with the existing ID700mm steel pipe at Uzun and newly installed ID414mm steel pipe in the H area. Disconnecting the conduit in the H area from the existing ID514mm steel pipe in D area.

g) installation of iD700mm steel pipe with 25.4km long in parallel with the conduit in the B area and connection with newly installed ID996mm steel pipe in the A area and the existing ID514mm conduits of D and E areas.

h) disconnecting the conduit in the F area from the conduit between Uzun and Dzhilikul and connecting the conduit in the F area with newly installed ID414mm steel pipe from Uzun to the H area.

i) to replace the existing CIP ID600mm by ID614mm steel pipe in the section between the connection point of the existing steel pipe and CIP, and WSS of B-24. Length is around 400m. This newly installed steel pipe should be stopped just after B-24 by installing a valve for a wash out. There is a irrigation canal nearby.

j) installation of ID614mm with around 500m long steel pipe between the new junction of the conduits in the A , B and C areas and the WSS of V-15 in parallel with existing ID614mm steel pipe. V-15 will have water from this new conduit.

The capacity of the Vakhsh Conduit after the above mentioned rehabilitation is around 78,200m^3/day.

Alternative Plan

a) same as a) of above-mentioned rehabilitation plan

b) disconnecting G area from the service area of the Vakhsh Conduits

c) – f) same as c) – f) of above-mentioned rehabilitation plan.

g) installation of ID800mm steel pipe with 25.4km long in parallel with the conduit in the B area and connection with newly installed ID996mm steel pipe in the A area and the existing ID514mm conduits of D and E areas.

h) – j) same as h) – j) of above-mentioned rehabilitation plan.

The capacity of the Vakhsh Conduit after the above mentioned alternative rehabilitation is around 84,100m^3/day.

2) Vakhsh sub-main Conduits (from Main Conduit to a WSS)

The diameter of the sub-main conduit to several WSSs will be insufficient with increasing water demand. Following table shows the rehabilitation plan. High density polyethylene pipe (HDPE) is applied to the sub-main conduit to the WSSs, which are projected to construct a water treatment plant, and steel pipe is applied to the WSSs which are supposed to have water from the centralized water treatment plant of several WSSs.

Table 8.1.12 Renewal Plan of Sub-main Conduits

area	WSS	existing conduit				renewed conduit			
		material	ID	C	length (m)	material	ID	C	length (m)
C	V15	SP	234.0	44	57	SP	414.0	110	57
	B08	SP	81.0	55	1,189	HDPE	110.2	110	1,189
	B09	SP	81.0	55	968	HDPE	123.4	110	968
E	R38	SP	68.0	44	223	HDPE	141.0	110	223
F	R15	SP	156.0	55	409	SP	234.0	110	409
H	J12	SP	208.0	55	1,257	SP	208	110	1,257
	J13	SP	313.0	44	1,747	SP	313.0	110	1,747

Note: SP- Steel Pipe, HDPE- High Density Polyethylene Pipe, ID- Inside Diameter C- Hydraulic factor related to the roughness of pipe inner surface; the value is as of 2028 (the “C” value of SP decreases with aging)

Table 8.1.13 shown in the following page presents the overview of the rehabilitation plan.

Table 8.1.13 The Rehabilitation Plan Overview of the Vakhsh Conduits

Pipe	N.D. (mm)	I.D. (mm)	existing (m)	to abandoned (m)	to be renewed (m)	to be installed (m)	total (m)
Main							
SP	1220	1192	5223				5223
SP	1020	996	3975			7669	11644
SP	920	900	8030				8030
SP	720	700	16330	3151	3151	25443	41773
SP	630	614	6194			885	7079
SP	530	514	54044	3000			51044
SP	426	414	3215	3215	7840	10214	18054
SP	325	313	17773	9141			8632
Concrete	1200	1200	1229	350	350		1229
CIP	600	600	7526	7526			0
CIP	500	500	8984	8984			0
sub-total			132523	35367	11341	44211	152708
Sub-main							
SP	426	414			57		57
SP	325	313	2199	1747	1747		2199
SP	273	262	50	50			0
SP	245	234	57	57	409		409
SP	219	208	6583	4979	1257		2861
SP	150	156	1745	409			1336
SP	140	132	533				533
SP	133	124	217				217
SP	114	105	7171				7171
SP	89	81	3155	2157			998
SP	76	68	737	223			514
SP	32	36.7	71				71
SP	25	27.9	192				192
SP	20	24.1	23				23
HDPE	225	198.2	287				287
HDPE	160	141			223		223
HDPE	140	123.4			968		968
HDPE	125	110.2			1189		1189
HDPE	110	96.8	383	166			217
HDPE	50	40.8	49				49
CIP	200	200	435				435
CIP	150	150	3973				3973
CIP	100	100	1723	123			1600
PVC	225	207.8	50	50			0
PVC	160	147.6	64				64
PVC	110	101.6	231	8			223
PVC	40	36.2	442				442
sub-total			30370	9969	5850	0	26251
total			162893	45336	17191	44211	178959

note：SP – Steel Pipe, HDPE – High Density Polyethylene, CIP – Gray Cast Iron Pipe, PVC – Polyvinyl Chloride,

3) Pumping Facilities

According to the rehabilitation plan of the Vakhsh Conduit, the water is drawn by gravity to Kalinin. Therefore, it is not necessary to rehabilitate pumping stations.

(i) Bokhtar Head Pumping Station

The reason mention above, this pumping station isn't necessary. So rehabilitation will not be implemented.

(ii) Uzun Pumping Station

The reason mentioned above, this pumping station isn't necessary. So rehabilitation will not be implemented.

(iii) Kalinin Pumping Station

This pumping station will continue to be used till 2012 in this rehabilitation plan of Vakhsh Conduits. Prediction of water demand in 2013 in the area is 3,177 m3/day (=132 m3/h) where this pumping station will distribute.

It is enough to cover this water demand with using one existing pump that has a specification (320 m3/h, 50m), so it is not necessary to rehabilitate. Intake pumps have enough condition to continue to work till 2012 if regularly maintenance is going well.

4) Water Treatment Plant

As mentioned in the section "8.1.4 Rehabilitation Plan, (3) Alternative Plans, 1) Location of Water Treatment Plant", though the Study Team proposed to construct a WTP in the vicinity of a WSS, the Team also planned to make the scale of WTP big by grouping existing WSSs and accordingly decreasing the number of WSSs to be constructed. Followings are the reasons:

- the bigger the capacity of WTP is, the less inexpensive the unit construction cost of water to be treated providing that the water treatment process is same.
- the more the number of WTPs increases, the more the number of staffs for the WTP increases and accordingly the fixed cost of WTP operation as well as the water rate to be applied increase.

WSSs which meet the following condition are grouped: "Around 20m or more water head of dynamic pressure should be secured at the entrance of WSSs when an elevated tank with 20m height is constructed in the vicinity of the WTP which connects with the WSSs through the appropriate diameter of conduit regarding flow rate" In practice, if a site of which elevation is 20m or more higher than that of the WTP is available, the construction of semi-buried tank should have the priority.

The Plan assumed that WSSs can distribute water by gravity providing that the dynamic pressure at the entrance of WSSs is at least around 20m water head. It consequently necessitates to study the change of inflow conduit route in order to have higher dynamic pressure then 20m water head or necessity of booster PS in the distribution system at the implementation stage.

Above mentioned plan includes the WSSs operated by the Vodokanal to avoid the construction of a number of small scale WTPs in the Study area due to the difference of operator. Institutional arrangement regarding the Rural Water Supply will be necessary at the implementation stage.

Though the Scope of Study does not cover the WSSs in Bokhtar Rayon, the Study Team incorporated them into the planning and made the hydraulic analysis to prepare the rational Plan.

Projected WTPs are shown in *Attached Table 8.14.* shows the projected WSSs with the maximum daily water demand to them and *Figure 8.1.3* presents the location of projected WTPs with the WSSs connected.

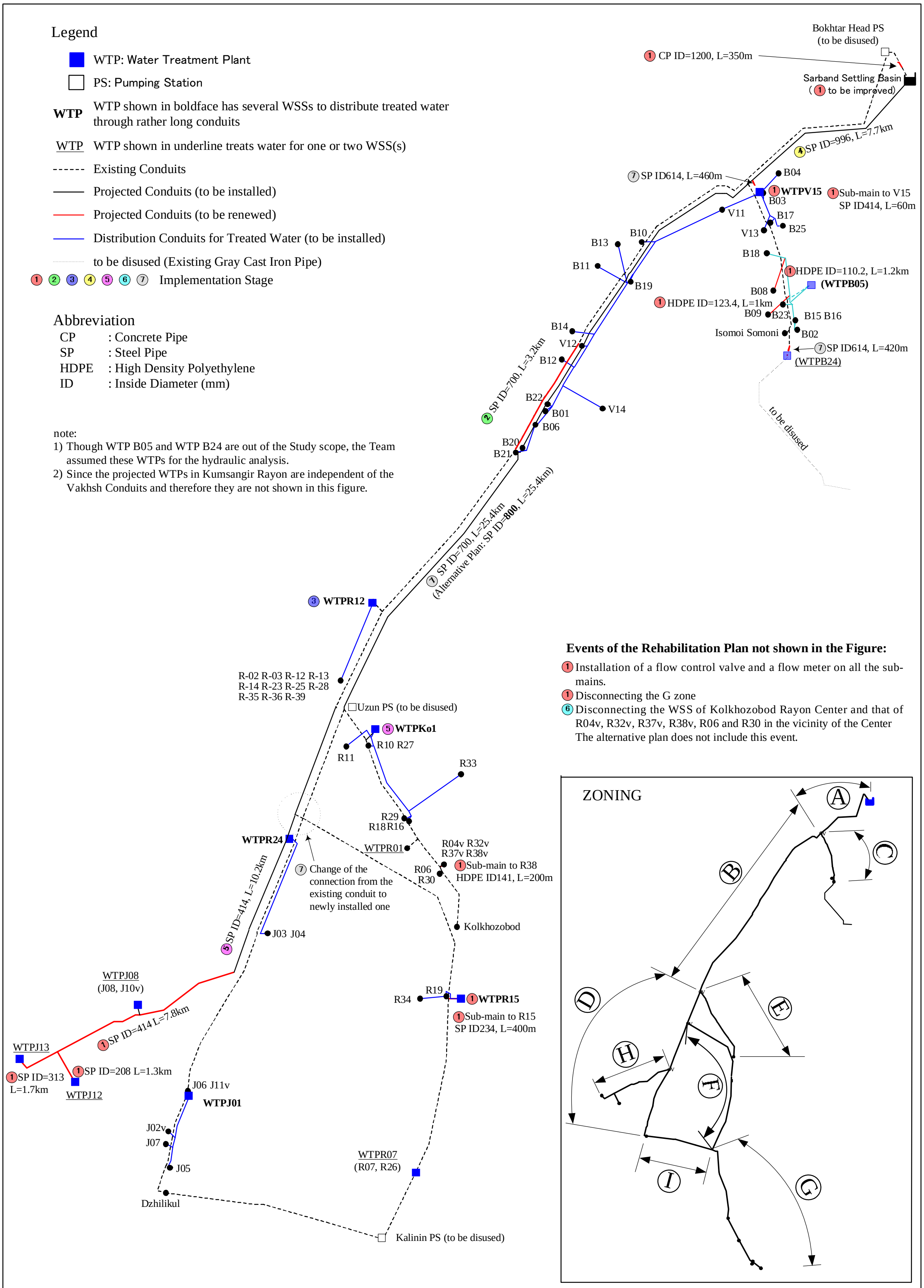

Figure 8.1.3 Outline of the Rehabilitation Plan for the Vakhsh Conduits

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

(i) Selection of water treatment method

Nature of water source is as follows.

- Type of Water Source：Irrigation canal,
- Water quality：Average conductivity in rainy season about 10-30NTU
- Temperature：5 to 25 degree Celsius

(ii) Treatment method

The rapid sand filtration method (auto filter type) is applied as the treatment method. Following facilities are included in the treatment plant.

a. Backwashing pump, b. Surface washing pump, c. Suspended solid contact clarifier

d. Sedimentation basin, d. Coagulant and e. Chlorination

(iii) Wastewater treatment facility

Wastewater and sludge are stored in the temporary sedimentation tank. Then, supernatant is discharged to channels. Since capacity of 14 treatment facilities out of 15 is less than 10,000 m3/day, volume of wastewater from the treatment facilities is not large.

(iv) Mechanic and Electric Facilities

Mechanic and electric facilities are designed by following basic concepts;

a. Pump, b. Electric Motor, c. Valves, d. High Voltage Incoming and Switching Panels,

e. Transformer, f. Generator, g. Control Panel, h. Hoist, i. Air Conditioning and Ventilation,

and j. Illumination

Basic specifications for Electric Motor, Transformer and Generator are shown in *Table 8.16, 8.17, 8.18 and 8.19*, respectively. Basic specification for illumination is presented in *Table 8.20*.

(v) Measurement, Control and Watching Facilities

Measurement, Control and Watching Facilities are composed of followings.

a. Flow Meter, b. Pressure Gauge, c. Water Level Gauge, d. Measuring Instrument of Water Quality and e. Operation and Monitoring Board

5) Distribution Facilities

This section describes the Plan on the conduits which connect the WTP and WSSs and the distribution system of respective WSSs are explained later. As aforementioned, the distribution system of WSSs will have water directly without installing a distribution tank from the WTP in the Plan. The variation of water demand on the WSSs will consequently govern the diameter of conduits between the WTP and WSSs. The maximum hourly water demand on the WSSs is the condition to determine the diameter of conduits. *Attached Table 8.15* shows the maximum hourly water demand of each WSS in 2028.

The target conduits are those connects the WSS with three or more WSSs shown in *Attached Table 8.14.*

Followings are design conditions:

- Flow rate : The maximum hourly water demand in 2028 to be loaded on the nodes, which represent the location of WSSs, in the hydraulic model comes from multiplying the average maximum daily water demand per hour by the time coefficient explained in the section "3.4 Underlying Difficulties in the Rehabilitation of the Vakhsh Conduits, (2) Establishment of Quantitative Service Level Indicator, 2)".

Since the applicable data regarding the time coefficient is not available in Tajikistan, the Study Team determined the values of time coefficient based on the following mathematical expression derived from the data in Japan. *Table 8.1.14* shows the value of time coefficient to be applied to the Study.

$$K=2.7445(Q/24)^{-0.0726}$$

where K: time coefficient

Q: maximum daily water demand

Table 8.1.14 Time Coefficient

Maximum Daily Water Demand (m^3/day)	Time Coefficient
<100	2.6
100-500	2.3
500-1000	2.1
1001-2000	2.0
>2000	1.9

- Elevation of WTP outlet : Elevation of WTP site + 20m (Construction of elevated tank or semi-buried tank on a neighboring plot where the elevation is 20m or more higher than that of the WTP site)
- Dynamic pressure at the entrance of WSSs
  : 20m water head at the minimum
- Pipe to be used and hydraulic factor related to pipe inner surface for having the friction loss head
  : High density polyethylene pipe, 110 is applied to the hydraulic factor considering the minor loss caused by valves, etc. and long term use.

Attached Table 8.22 –27 shows the outline of the projected WTPs.

6) Ancillary Facilities

Ancillary facilities includes;

a. Valves, b. Wash Outs, c. Instrumentation Equipments and d. Water Pipe Bridge.

7) WSSs connected to the Conduits

This section describes the rehabilitation planning of distribution conduits of WSSs connected to the Vakhsh Conduits. The Study Team prepared the Plan in the following manner referring the Inventory Survey result.

Inside Diameter of Conduits

* In case of the distribution by gravity, it can be considered that multiplying the number of communal taps by their design flow rate is the flow rate used to determine the ID of distribution

mains[2]. The Study Team determined the ID of projected diameter when the friction loss head of projected distribution mains caused by the maximum hourly water demand in 2028 or the flow rate mentioned above whichever is bigger matched approximately the friction loss head of existing distribution mains by the flow rate mentioned above.

The IDs of projected distribution sub-mains were computed applying the ratio of IDs of the existing distribution mains and sub-mains.

Followings are the assumptions applied to the above-mentioned calculation.

- The design flow rate of communal tap is assumed as 0.1 liter/second based on the information of UNDP.
- The number of communal tap will not change.

* In case of the distribution by gravity with little information on existing facilities, the following conditions considering the assumption applied to the Plan that the minimum dynamic pressure at the entrance of WSSs is around 20 meters and the Inventory Survey result determined the ID of the conduits:

- the minimum dynamic pressure at the communal taps is 5 meters
- the maximum total loss head of the distribution conduits from the entrance of WSS to the furthest communal tap is 15 meters
- the friction loss head of projected distribution mains is 5 meters at the maximum

Above-mentioned method is applied to have the IDs of projected distribution sub-mains.

* In case of pump pressurized distribution, the relationship between pipe ID and flow rate for economical pump operation was applied to determine the ID of distribution mains. The flow rate to determine the ID of distribution main comes from the maximum hourly water demand in 2028. The same manner applied to the case of distribution by gravity determined the IDs of sub-mains.

* The WSS of R36 will not utilize the dynamic pressure given by the Vakhsh Conduit due to the realization of Plan. It was considered that this case is same as that of the distribution by gravity with little information on existing facilities.

Length of Distribution Conduits

* The calculation of projected length of distribution mains and sum-mains was made based on the assumption that the length increases in proportion as the population growth. However, the point to compute the length is the implementation year of the Plan explained later. Since the prediction of the service area expansion is quite difficult, it was assumed that the detailed design would be made based on the service area in the implementation year of rehabilitation work.

* In case that the WSS of which information on distribution conduits are not available, the ratio of distribution mains to sub-mains was assumed as 1 to 2.

Minimum Diameter of Distribution Sub-mains

* Since the Plan targets on the realization of yard connection, the Study Team proposed to apply 75mm of ID as the minimum diameter of distribution sub-main in order to secure sufficient

[2] The definition of the distribution main in the planning is as follows: The conduit which has the biggest inside diameter among the distribution conduits is the distribution main and the conduits which have smaller inside diameter up to two sizes than that of the distribution main are the distribution sub-main.

dynamic pressure in the service pipe.

Material of Conduits

* The HDPE pipe was considered because the pipe can be procured in Tajikistan.

Utilization of Existing Conduits

* The HDPE pipe will replace the SP without inside coating and CIP which are not suitable to deliver treated water due to recontamination.

* PVC and HDPE pipes will not be replaced.

Attached Table 8.33 – 36 shows the quantity of projected distribution mains and sub-mains of targeted WSSs.

8.1.5 FACILITY DESIGN AND COST ESTIMATION（CIVIL WORK）

(1) Newly planned Water Supply Facilities in the Water Supply Area of Vakhsh Conduit

1) General Facility Design

This plan schedules to rehabilitate Vakhsh Transmission Pipeline, and constructs thirteen water treatment plants with intake facilities at vicinity irrigation canal and transmission/distribution pipe to supply water from new water treatment plant to existing water supply area along the Vakhsh Pipeline.

The composition of the main facilities of the new WTP is shown as following.

- Intake facilities

Intake Weir, Intake Grid, Sand Settlement Basin, Intake Pump Station, Raw Water Main

- Water Treatment Plant (WTP)

Receiving Well, Coagulation and Sedimentation Basin, Rapid Sand Filtration Basin, Distribution Reservoir, Distribution Pump Station, Sludge Lagoon, Transmission Main/Distribution Main

If necessary, elevated tank should be installed. Adopted design standard is shown in *Table 8.1.15*.

Table 8.1.15 Adopted Design Standard (Excluding Mechanical Equipment)

Kind of facilities	Design Standard	Standard Value	No. of Basin/ Component	Remarks
Intake weir, intake grid	-	-	-	According to intake amount, water level and surrounding ground level.
Sand Settlement Basin	Retention Time	About 15minute	2basins	
Receiving well	Retention Time	About 1.5minute	2basins	
Chemical Sedimentation Basin	Baffling Type			
-Coagulation Basin	Retention Time	About 45minute	2basins	（Baffling Basin）
-Sedimentation Basin	Surface Load	15－30 mm/min	2basins	Area of Basin÷Volume
	Velocity	>0.4 m/min		Sectional area of flow direction of Basin÷Volume
Rapid Filtration Basin	Filtration Speed	120-150 m/day	About 8-12basin Including 1standby Basin Totally 20% standby capacity	Small *WTP: Less than 8basin Refer to Patterned Drawing: A,B,C,D
Reservoir	Retention Time	6 hours	1Basin 2Tanks	
Transmission /Distribution Main	Velocity	Less than 3m/s		

Note, *WTP：Water Treatment Plant

2) Patterned Design of Water Treatment Plant

As a lot of WTPs is planed in the study, some standard type of designs (patterned design) of the facilities is made according to the structural condition, and the construction cost is estimated according to the patterned design. Developed patterns of proposed WTP and their designs are shown in *Table 8.1.16*. Required area of the proposed WTPs is shown in *Attached Table 8.37*.

Table 8.1.16 Proposed Water Treatment Plant

NO	Name of Proposed WTP	Estimated Demand (m^3/day)	Total Necessary Filtration Basin Area (m^2)	Type of WTP	WTP Pattern Code	Patterned Nominal Capacity	Filtration Max. Speed	Number of Basin
						(m^3/day)	(m/day)	Including 1Stanby Basin
1	TR-01	900	6.7	Type A	A-1200	1,200	150	4
2	TJ01	3,600	26.7	Type A	A-4400	4,400	150	12
3	TK01	5,100	40.0	Type B	B-6400	6,400	150	8
4	TR24	1,200	13.3	Type A	A-1200	1,200	150	6
5	TV15	38,400	266.7	Type C	C-40000	40,000	150	10
6	TR12	7,800	53.3	Type B	B-8200	8,200	150	12
7	TR15	2,700	20.0	Type A	A-3500	3,500	150	10
8	TR07	2,400	20.0	Type A	A-2800	2,800	150	8
9	TQ04	6,600	46.7	Type B	B-8000	8,000	150	10
10	TQ05	4,800	33.3	Type B	B-6400	6,400	150	8
11	TQ06	2,100	20.0	Type A	A-2800	2,800	150	8
12	TQ02	1,800	13.3	Type A	A-2000	2,000	150	6
13	TJ-12	1,800	13.3	Type A	A-2000	2,000	150	6
14	TJ-13	1500	13.3	Type A	A-2000	2,000	150	6
15	TJO8	4,500	30.0	Type B	B-6400	6,400	150	8
	TOTAL	77,400				93,300		

The following patterns of facilities are collectively described in each figure.

- *Figure 8.1.8* Site Facility Arrange Plan
  - Type A in capacity of 1,000-4,500m^3/day
  - Type B in capacity of 6,400-8,200m^3/day
- *Figure 8.1.9* Site Facility Arrange Plan
  - Type C in capacity of 40,000m^3/day
  - Type D in capacity of 80,000m^3/day
- *Figure 8.1.10* Structural Drawing of Coagulation ands Sedimentation Basin
  - Type A in capacity of 1,000-4,500m^3/day
  - Type B in capacity of 6,400-8,200m^3/day
  - Type C in capacity of 40,000m^3/day
- *Figure 8.1.11* Structural Drawing of Rapid Filtration Basin
  - Type A in capacity of 1,000-4,500m^3/day
  - Type B in capacity of 6,400-8,200m^3/day
- *Figure 8.1.12* Structural Drawing of Rapid Filtration Basin
  - Type C in capacity of 40,000m^3/day
- *Figure 8.1.13* Structural Drawing of Rapid Filtration Basin
  - Type D in capacity of 80,000m^3/day
- *Figure 8.1.14* Distribution Reservoir
  - TYPE A /B and C

3) Vakhsh Pipeline facilities

Renewal/Rehabilitation plan of a partial Vakhsh Conduits are shown in *Table 8.1.17*.

Table 8.1.17 Renewal Pipeline List

Pipe ID	Diameter (mm)	Length(m)	Total Renewal Length of Each Diameter (m)	Pipe Materials standard adopted for cost estimation
SBO1	1,200	1,229	1,229	Steel Pipe for Water Supply
V1+16++	900	25,769	25,769	Steel Pipe for Water Supply
16++V2	800	3,886	3,886	Steel Pipe for Water Supply
UJO9-5	700	852		
UJO9-6	700	825		
UJO9-7	700	1,030		
UJ10	700	156		
UJ11	700	36		
UJ12	700	22	2,921	Steel Pipe for Water Supply
V1+Va1+	614	440		
Va1+Va2+	614	21	461	Steel Pipe for Water Supply
US01	414	4,348		
US02	414	3,492		
V15	414	57		
V218	414	10,214	18,111	Steel Pipe for Water Supply
R15	234	409	409	Polyethylene Pipe for Water Supply
JO1	148	51		
R10	148	13		
R38	141	223	287	Polyethylene Pipe for Water Supply
R32	100	223		
R23	97	217	440	Polyethylene Pipe for Water Supply
V13	36	442	442	Polyethylene for Water Supply
Total			53,955	

Note: Steel Pipe for Water Supply: with coating and lining

(2) Approximate Implementation Cost

1) Procurement of main materials and equipment

The manufacturing products are imported from nearby countries of the Soviet years and other vicinal countries. The main importing countries of construction materials are shown as follows. However, days might be required to clear the customs, it is necessary to note it.

Table 8.1.18 Procurement of Main Materials and Equipment

Items	Contents
Tajikistan Domestic products	Reinforcing bar
The third country products	1. Steel Pipe and vinyl chloride pipe etc for Water Supply. Russia and other r vicinity countries. 2. Cement: Pakistan
Import route	The main import route to transport Japanese product is through China or through Russian Siberia railway. Transportation from third countries by road and railway can be available.

2) Design criteria

Tajikistan Government adopts Design Criteria and Industrial Standard that Established in Soviet years presently. Therefore Tajikistan Government is programming to establish own Design Criteria and Industry Standard within this year (2008).

It might be noticed that though a lot of imported materials and equipment is distributed in the market, defective imported products are often seen in this country. To adopt adequate Design Criteria and industry standard is essential for this project.

Vakhsh Transmission main is passing through long distance in cotton field. As plastic pipe such as Polyethylene Pipe is seen getting damage while calibration by tractor and other works, pipe laying work shall be taken notice of protection of the pipeline such as pipe depth etc. even if the material of transmission main is steel.

3) Estimation of approximate implementation cost

In the rehabilitation and expansion plan for the Vakhsh Conduits, it is required to construct 15 water treatment facilities (capacity: 1,200～40,000 m3/day, total capacity: 93,000 m3/day), and partial replacement of existing pipe and installation of new pipelines (diameter: 125～1,200 mm, length: 61 km).

Required implementation cost is approximately 441 Million Somoni (130 Million US$, 13,900 Million Yen) as shown in *Table 8.1.19*.

Table 8.1.19 Approximate Implementation Cost

Item	Approximate Construction Cost		
	(Million Somoni)	(Million US$)	(Million Yen)
Construction of Water Treatment Facilities (15 sites) (Capacity: 93,000m3/day including 20% of Standby capacity)	222	65.4	7,000
Construction of Pipelines (diameter: 125～1,200mm, length: 61km)	127	37.4	4,000
Construction of Intake and Pumping Station(15 sites) (including electromechanic facilities)	63	18.7	2,000
Other Ancillary Facilities	29	8.4	900
Total	441	129.9	13,900

Note: 1Somoni=0.294 US$, 1US$=107Yen、1 Somoni=31.5Yen (July 2008)

8.1.6 PHASED IMPLEMENTATION PROGRAM

The Study Team proposed following implementation program on the Plan based on “8.1.4 Rehabilitation Plan, (2) Hydraulic Analysis of the Vakhsh Conduits Based on Water Demand Prediction and (4) Rehabilitation Plan”

However, it is necessary to conduct the water analysis of samples taken from several points on the Vakhsh Conduits. Sampling should be made at least one in a month throughout one year and all the samples should be analyzed on all the parameters stipulated in the Guidelines for Drinking-water Quality as much as possible and to study the necessity of the WTP. If the result of water analysis will show the necessity of WTP, the water treatment process should be determined and the effect of it should be confirmed through the operation of rather small scale pilot WTP. It is preferable to train the OM/M staffs of WTP in the pilot one.

Phase 1

1. Appropriate valves are installed to control the flow rate, which meets the maximum daily water demand of WSS, of the Vakhsh sub-mains which connect the Vakhsh main with the installation of WSS.
2. Area G is disconnected.
3. Improving the Sarband SB
4. Concrete pipe in the section between SB and HPS in the area A is renewed, D1200mm, L350m
5. WTP is constructed in the site of V15 of C area for 20 WSSs (B-04, B-01, B-06, B-10, B-11, B-12, B-13, B-14, B-19, B-20, B-21, B-22, V-11, V-12, V-14, B-03, B-17, B-25, V-13, V-15) and the neighboring areas without water supply service of them.
6. Conduits in the area H is replaced with SP-D426mm, L7.8km and the sub-mains to J12 and J13 are renewed with SP-D219mm, L1.3km and SP-D325mm, L1.7km respectively
7. WTP is constructed in the site of R15 of F area for three WSSs (R15, R19, R34) and the neighboring areas without water supply service of them.
8. Pipe R38 is replaced with HDPE-D160mm, L200m
9. Pipe V15 is replaced with SP-D426mm, L60m
10. Pipe B08 is replaced with HDPE-D125mm, L1.2km
11. Pipe B09 is replace with HDPE-D140mm, L1.0km
12. Pipe R15 is replaced with SP-D245mm, L400m

Phase 2

1. SP-D720mm, L3.2km is renewed in the B area from around 11km down from V1 (junction of the conduits in the A, B and C areas).

Phase 3

1. WTP is constructed in the vicinity of around 1km north to the Uzun PS in the B area for 11WSSs (R-02, R-03, R-12, R-13, R-14, R-23, R-25, R-28, R-35, R-36, R-39) and the neighboring areas without water supply service of them.
2. WTP is constructed in the vicinity of B05 of the C area for 8WSSs (B-02, B-05, B-08, B-09, B-18, B-23, B-15, B-16) and the neighboring areas without water supply service of them.

Phase 4

1. Conduit is doubled between SB and V1 by installing SP-D1020mm, L=7.7km.

Phase 5

1. WTP is constructed in the vicinity of Ko1 of E area for 7WSSs (R-11, R-33, R-10, R-27, R-16, R-18, R-29) and the neighboring areas without water supply service of them.
2. Conduit is doubled between V2 (junction of the conduits in the B, D and E areas) and V6 (junction of the conduits in the D and H areas) by installing SP-D426mm L=10.2km

Phase 6

1. The WSSs in the vicinity of and the WSS of Kolkhozabad; 7 WSSs in total (R-05, R-04, R-32, R-37, R-38, R-06, R-30), are disconnected

Phase 7

1. The conduit from V1 to V2 in the B area is doubled by installing SP-D720mm,

L=25.4km

2. The conduit to the F area is now connected with the conduit from V2 to Dzhilikul in the D area.　The junction is shifted from the said conduit in the D area to the newly installed conduit from V2 to V6.
3. The existing CIP-D600mm up to the WSS of B24, which is located the farthest from V1 in the C area, is replaced with SP-D630mm, L420m.
4. The conduit is doubled from V1 to the Junction to WSS of V15 in the C area by installing SP-D630mm, L460mm.　The sub-main to V15 is changed it’s connection to newly installed conduit.

Table 8.1.20 shows the yearly water demand and the capacity of Vakhsh Conduits according to the phased implementation program.

＜Alternative Plan＞

The Vakhsh Conduits will cover the seven (7) WSSs in Kolkhozobod Rayon Center and it’s vicinity.

Phase 1 to 5　Same as the Plan mentioned above

Phase 6

1. The conduit from V1 to V2 in the B area is doubled by installing SP-D820mm, L=25.4km
2. The conduit to the F area is now connected with the conduit from V2 to Dzhilikul in the D area.　The junction is shifted from the said conduit in the D area to the newly installed conduit from V2 to V6.
3. The existing CIP-D600mm up to the WSS of B24, which is located the farthest from V1 in the C area, is replaced with SP-D630mm, L420m.
4. The conduit is doubled from V1 to the Junction to WSS of V15 in the C area by installing SP-D630mm, L460mm.　The sub-main to V15 is changed it’s connection to newly installed conduit.

Table 8.1.21 shows the yearly water demand and the capacity of Vakhsh Conduits according to the phased implementation program on the alternative Plan.

Table 8.1.20 Stage Implementation Plan

year	Assumed actual maximun daily water demand on the Conduits (m^3/day)			Rehabilitation and Expansion Phase				Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7
	whole area	Area G is disconnected	Area G and WSSs in the vicinity of Kolkhozabad are disconnected	Tasks		Deadline of Construction	Capacity of the Conduits (m^3/day)	37,229	38,812	39,394	41,476	45,307	49,098	78,228
2007				Commencement of JICA Study										
2008				Rehabilitation Planning										
2009				Detailed Study and Planning										
2010				Detailed Planning and Design										
2011				Design and Construction										
2012					Design and Construction of WSSs for the areas where they do not exist	Phase 1	37,229							
2013	21,427	17,044	13,714				37,229							
2014	26,757	21,484	17,847				37,229							
2015	32,087	25,923	21,981				37,229							
2016	37,417	30,363	26,114				37,229							
2017	42,747	34,802	30,247			Phase 2 and 3	39,394							
2018	48,077	39,242	34,380			Phase 4 and 5	45,307							
2019	53,408	43,681	38,514				45,307							
2020	58,738	48,121	42,647			Phase 6	49,098							
2021	64,068	52,560	46,780			Phase 7	78,228							
2022	69,398	57,000	50,913				78,228							
2023	74,728	61,439	55,047				78,228							
2024	80,058	65,879	59,180				78,228							
2025	85,388	70,318	63,313				78,228							
2026	90,718	74,758	67,446				78,228							
2027	96,048	79,197	71,580				78,228							
2028	101,378	83,637	75,713				78,228							

Table 8.1.21 Stage Implementation Plan (Alternative)

year	Assumed actual maximun daily water demand on the Conduits (m^3/day)		Rehabilitation and Expansion Phase				Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 7
	whole area	Area G is disconnected	Tasks		Deadline of Construction	Capacity of the Conduits (m^3/day)	37,229	38,812	39,394	41,476	45,307	84,119
2007			Commencement of JICA Study									
2008			Rehabilitation Planning									
2009			Detailed Study and Planning									
2010			Detailed Planning and Design									
2011			Design and Construction									
2012				Design and Construction of WSSs for the areas where they do not exist	Phase 1	37,229						
2013	21,427	17,044				37,229						
2014	26,710	21,484				37,229						
2015	31,993	25,923				37,229						
2016	37,276	30,363				37,229						
2017	42,559	34,802			Phase 2 and 3	39,394						
2018	47,841	39,242			Phase 4 and 5	45,307						
2019	53,124	43,681			Phase 7	84,119						
2020	58,407	48,121				84,119						
2021	63,690	52,560				84,119						
2022	68,973	57,000				84,119						
2023	74,256	61,439				84,119						
2024	79,539	65,879				84,119						
2025	84,822	70,318				84,119						
2026	90,104	74,758				84,119						
2027	95,387	79,197				84,119						
2028	100,670	83,637				84,119						

8.2 REVIEW OF THE PLAN

This sub-chapter reviews the Rehabilitation Plan of Vakhsh Conduits under the Study in order to have clearer idea on detailed surveys and designs which will be implemented to materialize the Plan.

It is said that around 90% of the 800 thousand population in eight (8) Rayons of the southern region of the Khatlon Oblast where the Study covers lives and most of them are considered as poor. The water supply service, which is one of the basic utilities, is insufficient and existing water supply systems are deteriorating. The beneficiary population in Bokhtar, Vakhsh, Dzhilikul, Kolkhozobod and Kumsangir Rayons, who have the water supply service through the Vakhsh Conduits, is 298 thousand as of 2006. It is only 43.5% of the total population in the said five (5) Rayons.

Since the five (5) Rayons mentioned above have scarcely groundwater resources, most of the population in the Rayons depends on developed irrigation canals for its domestic water. This situation gives the population burdens of water fetching, limited water quantity for living, the danger of diseases related to water.

The rehabilitation plan prepared by the Study intends to renew or expand the existing Vakhsh conduits and to construct water treatment plants, if necessary in order to transmit water to existing or planned water supply systems. This scheme is supposed to enable to supply the population with drinking water which meets the forthcoming drinking water quality standards of Tajikistan through yard taps. This projected water supply facilities will be more convenient than fetching water from existing irrigation canals. Consequently, the realization of Plan will hopefully contribute to the poverty reduction, the public health, the rural development, etc.

Though, it has 30 years passed since the Vaksh conduits was constructed, the Plan will make use of the existing systems and facilities as long as possible except those which necessitates rehabilitation. Te double conduits of existing and projected pipelines will be able to meet the increased water demand in a future. It can be considered to be more economical than the change of all the conduits.

Since the steel pipe without internal coating, which, in general, generates rust-colored water due to incrustation of rust on the pipe inner wall, is used for the Vakhsh Conduits, the Plan locates projected water treatment plant in upstream area of the water supply systems and installs the high density polyethylene pipe, which does not have the danger of incrustation, for the distribution network of them.

The total construction cost of water treatment plants will be higher than that of integrated water treatment plant, however, it necessitates to replace all the existing pipes with new pipes with internal coating and hence the total project cost of the Plan will be far less than that of the rehabilitation plan to adopt the integrated water treatment plant.

The following is description of the Plan:

* Target Rayons: Bokhtar, Vakhsh, Dzhilikul, Kolkhozobod

* Target year:	2013	2028	25years
* Projected population to be served:	424,000	752,000	
* Service coverage (rural):	70% (2020: 90%)	90%	NDS, National water supply program
* Service coverage (Rayon Center):	97%	97%	ditto
* Projected rate of UFW:	50%	30%	
* Projected specific consumption:	20 lpcd	50 lpcd	
* Projected average daily conveyance of water:	25,800m^3/day	73,500m^3/day	

* Rehabilitation plan:

- Rehabilitation of existing conveyance conduits (ND20mm to 1020mm) 162.9km (to be abandoned: 45.3km, to be renewed: 17.2km, to be newly installed: 44.2km Total pipe length after rehabilitation: 179km）
- Construction of water treatment plant: 15 (1,200 – 40,000 m^3/day 93,300m^3/day in total)
- Renewal and new installation of ancillary facilities of the Conduits: valves, flow meters, water pipe bridge, etc.

The Study Team recommends reviewing the following points mentioned in "3.4 Underlying Difficulties in the Rehabilitation of the Vakhsh Conduits" in the implementation stage of the Plan and taking necessary measures to improve them.

(1) Collection of Data and Information Necessary for the OM/M
(2) Establishment of Quantitative Service Level Indicator
(3) Necessity of Water Quality Control
(4) Raising Population's Awareness of the Benefits of Water Supply and the Principle of "Beneficiary Payment"
(5) Establishment of Organization for OM/M of the WSSs
(6) Necessity of Drainage Facilities

As mentioned in "3.3.8 WSSs Connected to the Conduits", the number of existing WSSs which receive the water from the Vakhsh Conduits are 78 (the WSSs in Kumsangir Rayon are excluded) and a little less than 50% of them now stop their operation due to the deterioration or so. Even if 78 WSSs can operate, the total population served will be 349 thousand in 2028. It is accordingly necessary to construct WSSs for remaining 403 thousand population keeping pace with the progress of the Plan implementation.

The total cost to realize the Plan is estimated as about 441 million Tajikistan Somoni (US$ 130 million), the Study Team strongly recommends reviewing the construction plan of rural WSSs to be prepared in a near future as well as the rehabilitation Plan of the Vakhsh Conduits from the view points of the cost and financing.

Furthermore, it is necessary to prepare the detail layout of the Vakhsh Conduits which should have the attributed information such as repair records, specification of facilities, etc. by the implementation of detailed survey and design, to make out a topographic map of which scale is 1/5000, to analyze the raw water and to appraise the project considering the following points:

- Whether the target population wants to have water supply through the Vakhsh Conduits, or not? (Is the Vakhsh Conduits only the solution for the water supply in aforementioned four (4) Rayons?)
- Is the cost of water supply less than that from assumed alternative water sources such as groundwater, etc.?

Is it possible to include the OM/M cost of the Vakhsh Conduits into the water rate to be set for the WSSs connected/will be connected with the Vakhsh Conduits?

CHAPTER 9 REHABILITATION AND EXPANSION PLAN OF RURAL WATER SUPPLY SYSTEM

9.1 GENERAL

The target of priority water supply systems are those of which the water source is groundwater in Kabodiyon, Shakhritus, Nosiri-Khisrav and Pyandzh Rayons (Area B). A total of 25 rural water supply systems have not been working and six (6) systems are partly working in area B (Kabodiyon, Shakhritus, Nosiri-Khisrav and Pyandzh Rayons) mentioned in *Chapter 4*. Those 31 systems shall be properly rehabilitated in order to improve the water supply condition in the area. Among them, priority facilities are selected in each Rayon by following two step procedures.

- 1st step: Evaluation by killer factors
- 2nd step: Evaluation

Furthermore, one system is selected as a candidate of the pilot project.

9.2 EXISTING CONDITION OF MALFUNCTIONING WATER SUPPLY SYSTEMS

In order to evaluate the target systems, the Study Team carried their study out based on the results of the Inventory Survey submitted by the local contractor.

Most systems stopped their operation in the 1990s due mainly to the trouble of the water pump and were left without repair. Those systems were rehabilitated after the Civil War by Donors and NGOs such as UNDP, MERCI Corp, and ACTED. However, the pumps of those systems were broken in a few years, then left again without repair. In a couple of villages, minor repair was carried out by the community people.

The major reason for deterioration of systems is (1) breakdown of the water pump and (2) intrusion of fine sand in the borehole. The factor for (1) seems to be frequent change in electric voltage and over depletion of the groundwater table against the setting depth of the water pump. In order to improve this situation, the following measures are required. Otherwise, the same trouble will be caused to the pumps, even if rehabilitation is carried out.

- a circuit to stop the operation of the pump when voltage is lowered
- a circuit to stop the operation of the pump when the groundwater level goes down below the depth of the water pump.

Factor (2) above is caused by improper well structure: the size of gravel packed in the annular space between the well and screen/casing pipes. Counter measures to this phenomenon is to install the proper screen such as Jonson type screen.

It is found that some boreholes are filled with stones after removing the pump from the borehole. It is impossible to rehabilitate such a borehole.

Some systems are left many years without rehabilitation or repair. In such case, tank and/or pipes were corroded and the pipe was collapsed in the system in Pyandzh. Regarding the layout of facilities, no plan is available for most systems. Therefore, it is difficult to understand the detail and design of each facility. The results of the field survey are summarized in *Table 9.2.1*.

Table 9.2.1 Summary of Field Survey on Water Supply Systems

	Rayon	Jamoat	Village	Owner	Operator	Service Population	Operating condition	Year of Deterioration	Borehole condition	Water quality	Necessity of Rehabilitation (major items) Berehole	Pump	Tank	Transmission/ Distribution lines
K-1	Kabodiyon	Nosiri Khisrav	Lenin and others	Jamoat	Vodokanal	5,120	Partly	2001	1-pump removed 2-filled with stone	No problem	1 new well	2 pumps	No problem	No problem
K-2	Kabodiyon	Khdoikudova	Yangi Yul	Jamoat (Kolkhoz)		2,300	No	2005	pump remained	No problem	to be confirmed	1 pump	No problem	500m
K-4	Kabodiyon	S. Khdoikudov	Khaeti Nav	Jamoat (Kolkhoz)		1,860	No	2003	pump removed	No problem	to be confirmed	1 pump	No problem	360 m
K-5	Kabodiyon	Navobod	Navruz	RWSA		5,820	No	2006	pump remained	No problem	to be confirmed	2 pump	No problem	1.5 km
K-7	Kabodiyon	S. Khdoikudov	Dusharkurgan	Jamoat		3,620	No	2006	1-pump removed 2-working	No problem	to be confirmed	1 pump	No problem	3.4 km
K-9	Kabodiyon	U. Nazarov	Kabda	Jamoat		22,000	No	2000	pump remained	No problem	to be confirmed	1 pump	No problem	6 km
K-10A	Kabodiyon	Yangi Yul	Kalinin-A	Jamoat		5,649	No	1992	filled with stone	No problem	filled with stone	4 pump	Required	
K-10D	Kabodiyon	Yangi Yul	Kalinin-D	Jamoat		955	No	2004	pump remained	No problem	to be confirmed	1 pump	To be confirmed	9.5 km
K-11	Kabodiyon	S. Khdoikudov	Borshevik	Jamoat		3,220	No	1993	pump removed	No problem	to be confirmed	1 pump	No problem	280 m
K-12	Kabodiyon	Niyazov	Tsorbog y Ziraki	Jamoat		12,570	No	1999	1-pump remained	No problem	1-to be confirmed	Replace of 1 pump and reconstruction of 1 station		
K-13	Kabodiyon	S. Khdoikudov	Kalinin	Jamoat		1,640	No	1993	pump removed half buried with sand	No problem	to be confirmed	1 pump	No problem	240 m
K-14	Kabodiyon	Yangi-Yul	Qizil-Kuch	OVP "Kafolat"		1,450	No	2006	pump remained	No problem	to be confirmed	1 pump	To be confirmed	500m
N-1	Nosiri Khusrav	Istiklol	44-Chashma "Oltinsoy"	Jamoat	RWSA	8,500	Partly	2000	pump removed	No problem	1-to beconfirmed	1 pump	No problem	11.7 km
N-2	Nosiri Khusrav	Komsomol	Ala Ferma	Jamoat		520 (8,000)	No	2000	filled with stone	No problem	2 new wells	2 pump	No problem	4 km
N-3	Nosiri Khusrav	Furza Muhammadiev	Navruz Savkhoza-5	Jamoat		1,615	No	1992	pump removed, but maybe pluged by plastic bottle	1-No problem 2-salty	to be confirmed	1 pump	To be confirmed	3 km
S-2	Shakhritus	Obshoron	Rudaki	Jamoat		(250)	No	2005	pump remained	solid	to be confirmed	1 pump	No problem	640m
S-4	Shakhritus	Obshoron	Batan	Jamoat		5,300	No	2001	pump remained	No problem	to be confirmed	1 pump	No problem	3.5 km
S-5	Shakhritus	Pakhtaobod	Surtanabod	Jamoat	RWSA	6,065	No	2007	1-pump removed 2-working	No problem	to be confirmed	1 pump	No problem	3.5 km
S-9	Shakhritus	Obshoron	Binokor	Jamoat	Vodokanal	4,000	Partly	2006	1-riser pipe remained 2-pump remained 3-working	No problem	to be confirmed	2 pumps	No problem	6.2 km
P-1	Pyandzh	Tugun	Tugul	Jamoat		5,270	No	1992	filled with stone	No problem	to be confirmed	1 pump	To be confirmed	4.8 km
P-2	Pyandzh	Arab	Orjonikidze	Jamoat		4,000	No	2004		No problem	to be confirmed	1 pump	To be confirmed	3.3km
P-5	Pyandzh	Arab	Komsomol	Jamoat		5,780	No	2002	filled with stone	No problem	1 new well	1 pump	No problem	3.3 km
P-6	Pyandzh	Kuldeman	Pekhtakor	Jamoat		4,500	No	2004	1&2-pump remained	No problem	2 new well	2 pump	To be confirmed	5.9 km
P-9	Pyandzh	Namuna	Zarbdor	Jamoat		2,500	No	2005	pump remained	bitter	to be confirmed	1 pump	No problem	3.2 km
P-10	Pyandzh	Sarmantoy	Dzerjinsk-2	RWSA		4,500	Partly	2001		No problem	to be confirmed	2 pump	To be rehabilitate	7.2 km
P-11	Pyandzh	Tugun	Shakardasht(1)	Jamoat		3,756	No	1990	filled with stone	No problem	1 new well	1 pump	To be rehabilitate	6 km
P-12	Pyandzh	Tugun	Shakardasht(2)	Jamoat		2,223	No	1994	filled with stone	No problem	1 new well	1 pump	No problem	3.5 km
P-13	Pyandzh	Sarmantoy	Sarmantoy	Jamoat		5,900	No	2004	1-pump remained	No problem	to be confirmed	2 pump	No problem	6.4 km
P-14	Pyandzh	Tugun	Gorikiy	Jamoat		2,058	No	2006	pump removed	No problem	to be confirmed	1 pump	To be rehabilitate	1 km
P-15	Pyandzh	Arab	Burka	Jamoat		2,800	No	1992	3 wells, 1-handpump installed 2&3-filled with stone	No problem	2 new well	2 pump	To be rehabilitate	10 km
P-16	Pyandzh	Sarmantoy	Kuibeshev	Jamoat		3,500	No	2004		No problem	to be confirmed	1 pump	To be rehabilitate	1.4 km

9.3 SELECTION OF PRIORITY SYSTEMS

9.3.1 EVALUATION FOR PRIORITY OF WATER SUPPLY SYSTEMS

As described in *Chapter 4*, a total of 31 systems are not working or partly working due to deterioration. Therefore, those 31 systems are the priority target of evaluation. As the first sep, the systems are evaluated based on killer factors. If a system corresponds to one of the killer factors, such a system is excluded from the target. After this screening, the remain systems are given scores from the viewpoint of effectiveness of rehabilitation. Then, priority systems are selected in each Rayon. *Figure 9.3.1* shows the flow of the selection of priority water supply systems.

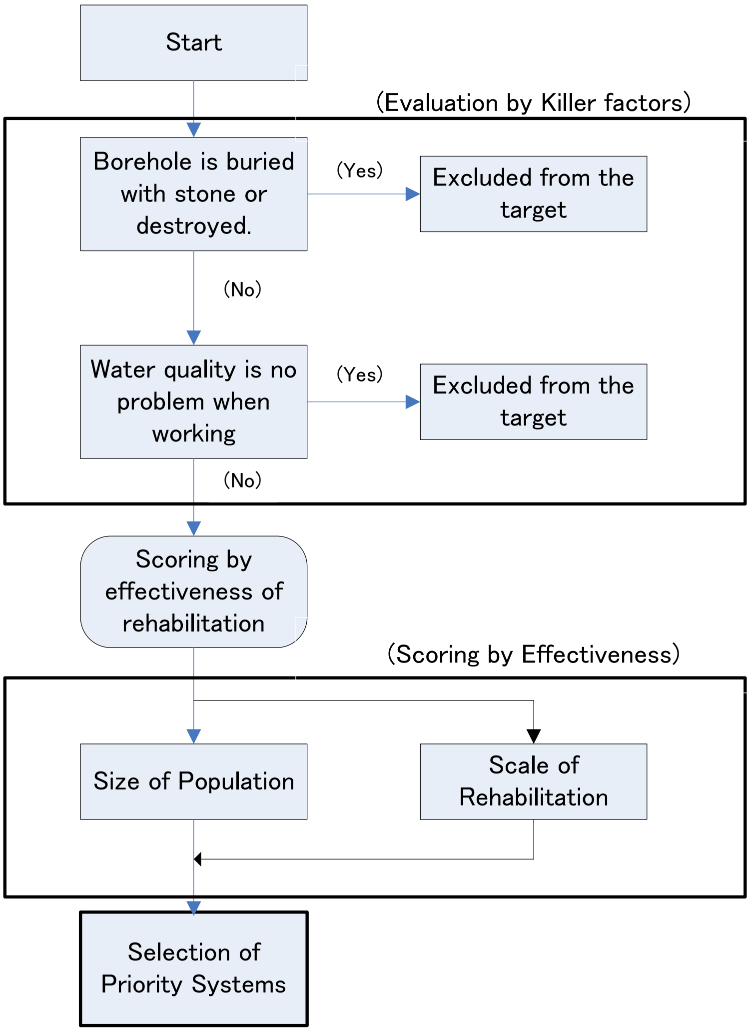

Figure 9.3.1 Flow of the Selection on Priority Water Supply Systems

(1) 1st Step: Evaluation by Killer Factors

Existence of a water source is one of the most important factors in formulating a rehabilitation plan of the system. From this point of view, the condition, "a system has a reusable borehole as water source", is set as a killer factor. If a borehole is filled with stones and it is impossible to use as the water source, such system is excluded from the target. Water quality is another important issue for the water supply. If the water quality of a system does not meet the drinking water standard, such system is excluded from the target.

Screening of systems was carried out using the results of the field survey and the inventory survey. The following systems was excluded because one (1) boreholes is filled with stones or completely destroyed and two (2) water quality problem (*Table 9.3.1*). 20 systems remained as evaluation targets for priority systems. However, it was found that four (4) systems out of 20 systems stopped working after evaluation of the priority systems was completed (after submission of Progress Report (1)). Therefore, 16 systems remained as candidates of priority systems as reported in Progress Report (1).

Table 9.3.1 Water Supply Systems Excluded from the Target

Killer Factor	Systems excluded from the target
Reusable of borehole	Kabodiyon: Lenin/Dushra Azizov Sino/Tursunzade (K-1), Kalinin (K-13), Chorbog and Ziraki (K-12) Shakhritus: Rudaki (S-2) Nosiri-Khisrav: Ala Ferma (N-2) Pyandzh: Tugul (P-1), Komsomol (P-5), Shakardasht (1) (P-11), Shakardasht (2) (P-12), Burka (P-15)l (Total: 10 systems)
Water quality	Shakhritus: Rudaki (S-2) Pyandzh: Zarbdor (P-9) (Total: 2 systems)

(2) 2nd Step: Scoring by Effectiveness

Effectiveness of rehabilitation shall be considered in formulation of the rehabilitation plan. From this viewpoint, two (2) factors were applied: Size of population and scale of rehabilitation work. If the rehabilitation cost is the same, rehabilitation will take place in the larger village. From the viewpoint of scale of rehabilitation, except for the water source, rehabilitation of water supply tank requires larger scale.

Scoring of each factor is shown in *Table 9.3.2*.

Table 9.3.2 Scoring of Evaluation Factor for Effectiveness

Evaluation Factor	0	1	2	3	4
Size of population	-	<2,500	2,500-4,999	5,000-9,999	9,999<
Scale of rehabilitation	Reconstruction of all facilities are required.	Rehabilitation of tank is required.	Rehabilitation of tank may be required.	Rehabilitation of tank is not required.	-

If a system was providing water to 5.6 thousand persons, the system is given “3” points from the size of population. If the system requires the rehabilitation of a distribution tank, the system is given “3” points. Therefore, the score of the system becomes 6 (=3+3). Following this procedure, the 16 systems were evaluated as shown in *Table 9.3.3*.

Table 9.3.3 Evaluation Result for Priority

Rayon	No.	Jamoat	Village	Owner	Operator	Service Population	Evalustion (Scoring) Population	Evalustion (Scoring) Scale of Rehabilitatio	Evaluation Result Evaluation	Evaluation Result Priority
Kabodiyon	K-2	S. Khdoikulov	Yangi Yul	Jamoat (Kolkhoz)	Jamoat (Kolkhoz)	3,618	2	2	4	2
	K-4	S. Khdoikulov	Khaeti Nav	Jamoat (Kolkhoz)	Jamoat (Kolkhoz)	1,860	1	2	3	3
	K-5	Navobod	Navruz	RWSA	RWSA	820	2	3	4	2
	K-7	S. Khdoikulov	Jarkurgan	Jamoat	Jamoat	3,917	2	2	4	2
	K-9	U. Nazarov	Kabla	Jamoat	Jamoat	17,564	4	2	6	1
	K-10	Yangi Yul	Kalinin	Jamoat	Jamoat	955	1	1	2	4
	K-11	S. Khdoikulov	Bolshevik	Jamoat	Jamoat	3,816	2	2	4	2
	K-13	S. Khdoikulov	Kalinin	Jamoat	Jamoat	1,640	1	2	3	3
Nosiri Khusrav	N-1	Istiklol	44-Chashma "Oltinsoy"	Jamoat	RWSA	7,100	3	1	4	1
	N-3	Furza Muhammadiev	Navruz Savkhoza-5	Jamoat	Jamoat	1,615	1	1	2	2
Shakhritus	S-4	Obshoron	Vatan	Jamoat (Sovkhoz)	Jamoat (Sovkhoz)	5,300	3	2	5	1
	S-5	Pakhtaobod	Surtanabod	Jamoat	RWSA	6,065	3	2	5	1
	S-9	Obshoron	Binokor	Jamoat	Vodokanal	2,642	2	2	4	2
Pyandzh	P-1	Tugul	Tugul	Jamoat	Jamoat	5,270	3	1	4	2
	P-6	Kuldeman	Pekhtakor	Jamoat	Jamoat	4,500	2	1	3	3
	P-13	Sarmantoy	Sarmantoy	Jamoat	Jamoat	5,900	3	2	5	1

Each system was given an evaluation score and priority as shown in *Table 9.3.3*. Evaluation scores distributed from 2 to 6. Among them, the systems which scored more than 4 are considered to have a high priority. Because population is not small and scale of rehabilitation is not so large. Therefore, a total of 11 systems were selected as candidates of priority systems (*Table 9.3.4*). At this stage, observation by borehole camera was not completed. It was observed in the "P-1 Tugul" system that lots of stones were piled on the submersible pump installed in the borehole and it was impossible to remove the pump from the borehole. Thus, "P-1 Tugul" was excluded from the priority systems. The total number of priority systems finally became 10.

Table 9.3.4 List of Priority Systems

No.	Rayon	Jamoat	Village
K-2	Kabodiyon	S. Khudoikulov	Yangi Yul
K-5	Kabodiyon	Navobod	Navruz
K-7	Kabodiyon	S. Khudoikulov	Jarkurgan
K-9	Kabodiyon	U. Nazarov	Kabla
K-11	Kabodiyon	S. Khudoikulov	Bolshevik
N-1	Nosiri-Khisrav	Istiklol	44 Chashma, Oltinsoy
S-4	Shakhritus	Obshoron	Vatan
S-5	Shakhritus	Pakhtaobod	Sultanabod
S-9	Shakhritus	Obshoron	Binokor
P-13	Pyandzh	Sarmantoy	Sarmantoy

9.4 GROUNDWATER RESOURCES

The water source of rural water supply systems is groundwater in the target villages. Therefore, the groundwater potential of target villages was evaluated from both yield of water and water quality. In order to clarify the possibility of re-use of malfunctioning boreholes, observation by borehole camera, pumping test , water quality analyses, measurement of Spontaneous Potential (SP) and temperature logging were carried out at the following water supply systems (*Table 9.4.1*).

Table 9.4.1 List of Water Supply Systems Surveyed

No.	Rayon	Village	Observation by Borehole Camera	SP	T logging	Pumping Test	Water Quality Analyses
K-1	Kabodiyon	Lenin and others	0-11m	X	0-11m	-	-
K-2	Kabodiyon	**Yangi Yul**	-	X	20-80m	X	X
K-4	Kabodiyon	Khayoti Nav		X	0-13m	-	-
K-5	Kabodiyon	**Navruz**		X	-	X	X
K-7	Kabodiyon	**Jarkurgan**	0-34m	X	0-34m	-	-
K-9	Kabodiyon	**Kabla**	0-26m	X	0-26m	X	X
K-10	Kabodiyon	Kalinin	0-15m	X	0-15m	-	-
K-11	Kabodiyon	**Bolshevik**	0-42m	X	0-42m	X	X
K-12	Kabodiyon	Chorbog, Ziraki		X	-	-	-
K-13	Kabodiyon	Kalinin		X	0-70m	-	-
N-1	Nosiri-Khisrav	**44 Chashma, Oltinsoy**		X	-	X	X
N-2	Nosiri-Khisrav	Ala Ferma	0-22m	X	0-22m	-	-
N-3	Nosiri-Khisrav	**Navruz**	0-70m	X	0-70m	-	-
S-2	Shakhritus	Rudaki	0-22m	X	0-70m	-	-
S-4	Shakhritus	**Vatan**		X	-	X	X
S-5	Shakhritus	**Sultanabod**	0-15m	X	0-15m	X	X
S-9	Shakhritus	**Binokor**	0-33m	X	0-33m	X	X
P-1	Pyandzh	Tugul		X		X	X
P-5	Pyandzh	Komsomol		X		-	-
P-6	Pyandzh	Pakhtakor		X	0-11m	-	-
P-9	Pyandzh	Zarbdor		X	0-21m	-	-
P-11	Pyandzh	Guliston		X	-	-	-
P-12	Pyandzh	Shakardasht		X	-	-	-
P-13	Pyandzh	**Sarmantoy**		X	-	X	X
P-14	Pyandzh	M. Gorky	0-60m	X	0-70m	-	-
P-15	Pyandzh	Burka	-	X	-	-	-

Note **Bold**: Priority Villages SP: Measurement of Spontaneous Potential T logging: Temperature logging

X: carried out -: not carried out

9.4.1 OBSERVATION BY BOREHOLE CAMERA

Observation by borehole camera was carried out to confirm the conditions inside the boreholes. This observation revealed that there are many boreholes buried by fine sand intruded into the borehole from aquifers through screen pipe during the operation of submersible pumps. This type of screen is a perforated pipe with around 13mm hole. Diameter of gravel packed in the annular space between the screen pipe and the wall of the borehole is larger than the holes, a maximum of 15mm. Therefore, fine sand can easily intrude into the borehole during the operation of the water supply systems.

9.4.2 MEASUREMENT OF SPONTANEOUS POTENTIAL (SP)

Spontaneous potential (SP) shows the tendency of groundwater potential. The Study Team measured SP at existing water supply systems listed in *Table 9.4.1*.

(1) Kabodiyon, Shakhritus and Nosiri-Khisrav Area

It is considered that groundwater receives a recharge from the Kofarnihan River and flows from north to south direction along the tectonic valley. SP values are in a range between 170mV (at K-1 Lenin, K-11 Bolshevik and S-4 Vatan) and 1,768mV (S-2 Rudaki), averaging 600mV. High SP value shows high groundwater potential. At K-11 Bolshevik, SP value was quite low, 211mV, however, very high groundwater yield was confirmed by the pumping test. Therefore, it is concluded that groundwater potential in these three (3) Rayons are generally high based on SP values.

(2) Pyandzh Area

SP values are distributed in a range between 63mV and 1,780mV, averaging 824mV. SP values more than 800mV show high groundwater potential, they appeared at P-1 Tugul, P-5 Komsomol, P-11 Guliston, P-12 Shakardasht and P-13 Sarmantoy. High potential areas were distributed in the central and southern area in the Pyandzh Rayon. This suggests that the Pyandzh River flowed through these areas in the past.

9.4.3 TEMPERATURE LOGGING

The data of existing boreholes is scarcely available in the Study Area, therefore, temperature logging was carried out to confirm the depth and the position of the screen pipes in the boreholes. However, many boreholes were buried by stones in the Pyandzh area and buried by fine sand in Kabodiyon, Shakhritus and Nosiri-Khisrav areas. It prevented the confirmation of the position of the screen. *Figure 9.4.1* shows an example of data which detected the position of the screen pipe (S-5 Sultanabod).

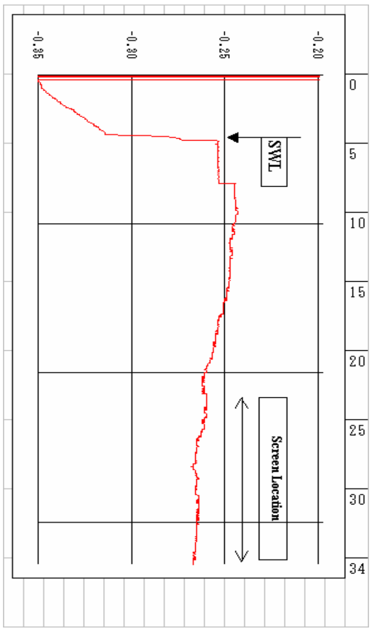

Figure 9.4.1 Result of Temperature Logging

9.4.4 PUMPING TEST

A pumping test was carried out at all the priority systems selected in *Section 9.3* (*Table 9.3.4*) except K-7 Jarkurgan, Kabodiyon Rayon because it was impossible to remove the fine sand deposited in the borehole due to the large diameter of the casing pipe. Prior to the pumping test, removal work of sand from the boreholes was carried out in order to make the pumping test possible in Kabodiyon, Shakhritus Nosiri-Khisrav and Pyandzh Rayons under supervision by the Study Team.

Contents of pumping test are shown in *Table 9.4.2*.

Table 9.4.2 Contents of Pumping Test

Test Item	Duration
Preliminary Test	-
Step Drawdown test	5 steps, 2 hours/step
Constant Discharge Test	48 hours
Recovery Test	Time to recover up to 90% of initial water level

Results of pumping test are summarized in *Table 9.4.3 and Attached Figure 9.1- 9.9.*

Groundwater yield is generally very high, from 22.3 to 37.8 m^3/hour. Drawdown against the maximum yield is extremely small, between 1.28 and 3.65m except Yangi Yul and Navruz villages. In Yangi Yul and Navruz villages, it is rather large, 5.08 and 7.65m. Time for recovery of water level after stopping the pumping is quite fast, it is from 1 to 6 minutes. In case of Kabla village, it is rather slow, 1 hour:

The groundwater potential of priority systems is evaluated as enough against the water demand of each village except Nosiri-Khisrav Rayon where the available groundwater source is limited in the Chashma area.

Aquifer constants were analyzed using the pumping test results (*Table 9.4.4*).
Most of wells show relatively high transmissivity in an order between 10^{-2} and 10^{-1}. Permeability is in a range from 10^{-3} to 10^{-1}.

Table 9.4.3 Results of Pumping Test

No.	Rayon	Village	Step 1		Step 2		Step 3		Step 4		Step 5		Constant		Recovery
			Q_1	DD	Q_2	DD	Q_3	DD	Q_4	DD	Q_5	DD	Q_c	DD	(minutes)
K-2	Kabodiyon	Yangi Yul	22.7	2.13	28.4	2.50	33.1	3.73	35.3	4.43	37.8	5.02	37.8	5.08	2
K-5	Kabodiyon	Navruz	14.8	5.29	17.3	6.63	18.4	7.29	21.6	7.48	22.3	7.61	22.3	7.65	6
K-7	Kabodiyon	Jarkurgan	Not carried out												
K-9	Kabodiyon	Kabla (Boshkala)	3.2	0.20	18.0	1.00	36.0	2.30	N.A	N.A	N.A	N.A	36.0	2.00	60
K-11	Kabodiyon	Bolshevik	22.7	0.87	28.4	1.16	33.1	1.57	35.3	1.82	37.8	1.92	37.8	2.01	6
N-1	Nosiri-Khisrav	44 Chashma	22.7	1.42	25.2	2.15	28.4	2.47	33.1	3.01	37.8	3.44	37.8	3.65	1
S-4	Shakhritus	Vatan	22.7	0.73	25.2	0.83	28.4	1.07	33.1	1.17	37.8	1.28	37.8	1.32	3
S-5	Shakhritus	Sultanabod	22.7	0.62	28.4	0.96	33.1	1.26	35.3	1.41	37.8	1.55	37.8	1.59	3
S-9	Shakhritus	Binokor	3.6	0.21	10.8	0.53	18.0	1.35	25.2	1.46	36.0	1.51	36.0	1.28	4
P-13	Pyandzh	Sarmantoy	22.7	1.11	28.4	2.33	33.1	4.08	35.3	5.02	37.8	6.17	37.8	5.47	23

Unit Q_1 (Groundwater yield for the Step 1): m^3/hour DD (Drawdown against the yield): m

Table 9.4.4 Results of Hydrogeological Analyses of Pumping Test

Village	Well depth (m)	Pump depth (m)	Pumping Rate (l/s)	Water Level Before Test (m)	Pumping Water Level (m)	Draw down (m)	Specific Capacity (l/sec/m)	Transmissivity (cm3/sec/cm)			Conductivity (cm/sec)			Storativity
								Jacob	Theis	Recovery	Jacob	Theis	Recovery	
K-02 Yangi-Yul	53	25	10.5	12.27	17.35	5.08	2.067	1.01E+02	2.08E+01	1.20E+02	1.90E-02	3.92E-03	2.27E-02	1.61E-04
K-05 Navruz	44	25	6.2	3.78	11.43	7.65	0.810	4.43E+01	1.02E+01	1.28E+02	1.01E-02	2.31E-03	2.91E-02	1.84E-05
K-09/2 Kabla (Boshkala)	55	22	10.0	4.90	6.90	2.00	5.000	2.16E+02	4.17E+01	2.68E+02	3.92E-02	7.59E-03	4.88E-02	7.94E-03
K-11 Bolshevik	54	25	10.5	10.49	12.50	2.01	5.224	2.02E+02	5.41E+01	1.02E+02	3.75E-02	1.00E-02	1.88E-02	2.97E-04
S-04 Vatan	48	22	10.5	2.80	4.12	1.32	7.955	6.43E+02	8.27E+01	2.87E+02	1.34E-01	1.72E-02	5.97E-02	1.57E-04
S-05/1 Sultanabod	40	25	10.5	4.72	6.31	1.59	6.604	2.92E+02	6.75E+01	2.04E+02	7.30E-02	1.69E-02	5.11E-02	1.34E-04
S-09/2 Binokor	50	25	10.0	3.80	4.57	0.77	12.987	1.56E+02	1.20E+02	1.11E+02	3.13E-02	2.40E-02	2.22E-02	8.49E-04
N-01/1 Oltinsoy	55	25	10.5	8.00	11.65	3.65	2.877	2.64E+02	3.01E+01	2.17E+02	4.79E-02	5.47E-03	3.94E-02	1.20E-04
P-13/2 Sarmantoy 2	25	20	10.5	3.85	9.32	5.47	1.920	1.36E+02	1.92E+01	4.20E+01	5.45E-02	7.66E-03	1.68E-02	1.63E-04

9.4.5 WATER QUALITY OF PRIORITY SYSTEMS

(1) Water Quality Items Analyzed

In Tajikistan, "GOST 2874-82" is applied as the drinking water quality standard. The water quality of the existing water supply systems was analyzed by the items shown in *Table 9.4.5*. Groundwater samples were collected during the pumping test on the priority systems. Water quality in the summer season was analyzed during the "Inventory Survey of existing Water Supply System". As for water quality in winter season it was not able to be analyzed because Tajikistan suffered from severe energy crises which caused a break of the electric power supply to the rural area. The existing water supply systems use electric power to pump the groundwater. Therefore, water samples could not be collected.

Table 9.4.5 Water Quality Items Analyzed (Priority Systems)

Water Supply System	Water Quality Items
Existing rural water supply systems	Total Coliform, Escherichia Coli, pH, Temperature (T), Electric Conductivity (EC), Total Dissolved Solid (TDS), Iron (Fe), Fluoride (F), Arsenic (As), Chloride (Cl), Nitrate (NO_3)
Priority systems	Total Coliform, Escherichia Coli, pH, Temperature (T), Electric Conductivity (EC), Total Dissolved Solid (TDS), Iron (Fe), Fluoride (F), Arsenic (As), Chloride (Cl), Nitrate (NO_3), Na、Mg、K、Ca、Cl、SO_4、NO_3、CO_3

9 - 11

(2) Water Quality of Priority Systems

Water samples were collected during the pumping test of nine (9) of the priority systems: the Pumping test was not carried out at Jarkurgan Village. Water quality items shown in *Table 9.4.5* were analyzed in the laboratory. Results are shown in *Table 9.4.6*.

Table 9.4.6 Water Quality of Priority Water Supply Systems

	Standard	K−2	K−5	K−7	K−9	K−11	N−1	S−4	S−5	S−9	P−13
	GOST	Yangi Yul	Navruz	Jarkurgan	Kabla (Boshkala)	Bolshevik	44 Chashma	Vatan	Sultanabod	Binokor	Sarmantoy
T. Coli.	100	0	0	N.A	0	0	0	0	0	0	0
E. Coli.	3	0	0	N.A	0	0	0	0	0	0	0
pH	6.0−9.0	7.43	7.84	N.A	7.1	7.2	7.7	7.35	7.9	7.31	7.71
T	−	19.2	19	N.A	16	16	17.5	17.7	14.3	18.8	18.2
EC	−	117.6	71.3	N.A	98.1	97.8	110.1	92.2	63.2	120.2	72.2
TDS	1500	598	384	N.A	530	495	590	470	325	628	370
Fe	0.3	<0.05	<0.05	N.A	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
F	0.7	0.4	N.D	N.A	N.D	N.D	N.D	N.D	N.D	N.D	N.D
As	0.05	<0.2	<0.2	N.A	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Na	−	0.002	0.002	N.A	0.002	0.002	0.002	0.001	0.002	11	0.001
Mg	−	9	10	N.A	12	14	14	11	13	10	9
K	−	0.1	0.1	N.A	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Ca	−	112	95	N.A	103	110	112	102	101	98	102
Cl	350	<0.1	<0.1	N.A	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
SO4	−	25	21	N.A	22	29	27	22	21	24	22
NO3	−	2	2	N.A	2	2	2	1	2	1	2
CO3	−	2	3	N.A	3	4	4	3	4	2	2

Analyzed Laboratory: Center of State Sanitary and Epideomiological Control (SES) of Kabodiyon Rayon

9.5 REHABILITATION AND EXTENSION PLAN OF PRIORITY SYSTEMS

9.5.1 BASIC POLICY OF REHABILITATION AND EXTENSION PLAN

(1) Issues confirmed in the Field Survey

All the water supply systems were not operating when the field survey was carried out, due to mal-function or deterioration. Therefore, it was not possible to confirm the deteriorated sections of the system such as pipeline. Necessary information was collected by visual inspection by the Study team and interviewing relevant personnel to the water supply system. Following issues were identified by the field survey.

1) Since most of water wells have not proper well structure, it is impossible to prevent sand intrusion into the well from the aquifers. It is not able to rehabilitate such wells. Accordingly, new water wells with proper well structure shall be constructed.

2) Deterioration of pipes might be progressed after stopping of operation, because material of pipe is mostly steel. It is impossible to confirm deteriorated sections by visual inspection. Construction of new pipeline is recommended.

3) Some distribution tanks are deteriorated. Capacity of tank is mostly 25m^3. However, suitable capacity of tank shall be constructed.

4) All the water supply systems were not expanded after construction although the residential areas were much expanded due to increasing of population. Such areas shall be included in the water supply service areas..

(2) Basic Concept of Rehabilitation and Extension Plan

A rehabilitation and extension plan was prepared for the priority water supply systems in Kabodiyon, Shakhritus, Nosiri-Khisrav and Pyandzh Rayons tabulated in *Table 9.3.4*. In the formulation of the plan, the following concepts are applied.

1) Construction of necessary number of new boreholes are considered. Because existing boreholes have unsuitable well structure against the fine materials of the aquifers and subsidence of ground around the borehole is proceeding. Therefore, construction of suitable structure of borehole is considered.

2) All the target water supply systems stopped their operation at least one year ago. Accordingly, deterioration of the facilities may the proceeding. However, it cannot be confirmed by visual inspection. Therefore, complete replacement of transmission line and distribution lines is considered.

3) Most of existing distribution tanks is likely deteriorated, however, it cannot be confirmed by visual inspection. Some distribution tanks have not enough height compared with the elevation of the service area. Therefore, construction of new tank is considered.

4) Extension of distribution lines to newly settled areas after construction of a water supply facility is considered, because the facilities were constructed almost 30 years ago and the area of the village was expanded due to many immigrants coming to the villages after construction.

5) No booster station is considered in the distribution lines. A booster station in the transmission lines are considered only for e system N-1 Chashma. Water is basically distributed by gravity flow.

9.5.2 TARGET WATER SUPPLY SYSTEMS AND THEIR SERVICE AREA

The target water supply systems for the formulation of the rehabilitation and extension plan are located in 10 villages as mentioned in *Table 9.3.4*. Among them, some systems apply to two (2) to four (4) villages. Accordingly, the total number of villages receiving service from the priority systems are 19 villages. The total population in the service area is around 60.5 thousand persons (*Table 9.5.1*).

Table 9.5.1 Target Water Supply Systems, Service Area and Population

Rayon	Jamoat	No.	Village (System)	Service Area (Village)	Population (persons) (2007)	
						Total
Kabodiyon	S. Khudoikulov	K-2	Yangi Yul	Yangi Yul	3,618	3,618
	Navobod	K-5	Navruz	Navruz	820	820
	S. Khudoikulov	K-7	Jarkurgan	Jarkurgan	3,917	3,917
	U. Nazarov	K-9	Kabla	Kabla	6,180	6,180
			Boshkala	Boshkala	6,874	11,384
				Chaparyq-1	3,200	
				Chaparyq-2	1,310	
	S. Khudoikulov	K-11	Bolshevik	Bolshevik	3,816	3,816
Nosiri-Khisrav		N-1	44 Chashma, (4 systems)	Oltinsoy	1,500	7,100
				Olzu	900	
				Traganov	1,300	
				Bahor	3,400	
Shakhritus	Obshoron	S-4	Vatan	Vatan	5,300	5,300
	Pakhtaobod	S-5	Sultanabod	Sultanabod	3,750	6,065
				Yangabod	2,315	
	Obshoron	S-9	Binokor	Binokor	2,642	2,642
Pyandzh	Sarmantoy	P-13	Sarmantoy	Sarmantoy-1	2,500	5,900
				Sarmantoy-2	3,400	
Total			14 systems	19 villages	56,742	56,742

Source of Population Data: Inventory survey by the Study Team (2007)

(1) Estimation of Water Demand

1) Target Year

The target year for the rehabilitation and expansion plan for the priority systems is set as 2015, because it is mentioned in the request of the Study from the government of Tajikistan to the government of Japan to develop a water supply plan by the year 2015.

2) Projection of Population in Target Year 2015

The population to be served by the priority systems is approximately 60.5 thousand in 2007 as shown in *Table 9.5.1*. In *Table 9.5.2*, the projected population in 2015 is tabulated. The rate of increase of population is considered to be 2.5% based on statistical data from 2002 to 2007 (National Census Office 2006). An arithmetic series is applied to project the population. Total population served by the priority systems will increase to approximately 70.8 thousand in 2015.

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Table 9.5.2 Population to be Served by the Priority Systems

No.	Rayon	Jamoat	Village	Population to be Served	
				2007	2015
K-2	Kabodiyon	S. Khudoikulov	Yangi Yul	3,618	4,342
K-5	Kabodiyon	Navobod	Navruz	820	984
K-7	Kabodiyon	S. Khudoikulov	Jarkurgan	3,917	4,700
K-9	Kabodiyon	U. Nazarov	Kabla	6,180	7,416
			Boshkala	11,384	13,661
K-11	Kabodiyon	S. Khudoikulov	Bolshevik	3,816	4,579
N-1	Nosiri-Khisrav	Istiklol	Oltinsoy	1,500	1,800
			Olzu	900	1,080
			Traganov	1,300	1,560
			Bahor	3,400	4,080
S-4	Shakhritus	Obshoron	Vatan	5,300	6,360
S-5	Shakhritus	Pakhtaobod	Sultanabod	6,065	7,278
S-9	Shakhritus	Obshoron	Binokor	2,642	3,170
P-13	Pyandzh	Sarmantoy	Sarmantoy	5,900	7,080
Total				56,742	68,090

3) Estimation of Water Demand

No data is available on the current water use in the villages where the priority systems are located. The Study Team interviewed a couple of community people who were fetching water from handpumps to their house. The fetching distance is several hundred meters. The amount of fetching water is from 90 to 180 l/day for a six (6) persons/family. Therefore, current water use in the villages is estimated between 15 and 30 l/capita/day. If the rehabilitation and expansion of the priority systems is carried out, the fetching distance will be much reduced. It is approximately 200m in maximum and sometimes a tap is introduced into the yard of each house. Reduced water fetching time will cause a change in life style of the community people. Considering these improved circumstances, it is estimated that domestic water use will increase to around 50 l/capita/day.

There are institutional facilities in the villages. They are basically one (1) school and sometimes a hospital in each village. Such schools in the villages are day schools, not boarding schools. The number of beds in the hospitals is not much, generally less than 15. Thus, water demand for pupils is included in that village. However, a certain amount of water demand of schools is considered. Some other facilities also exist in the villages, such as garages, cotton factories, .etc. Estimation of each water demand of such institutional facility is difficult, therefore, 15% of water demand of domestic water demand is considered including water loss.

Thousands of animals (cows and small livestock) are kept in the villages. However, water demand for animals is not considered because the Study Team confirmed the following situation. In the winter season in 2007/2008, Tajikistan suffered from severe energy crises: electric power supply to villages was cut and no water supply systems were available. Under this situation, animals could survive in the village using water from handpumps, irrigation canal, rivers, etc.

Accordingly, water demand in each village is estimated as shown in *Table 9.5.3*. Total water demand is approximately 4.1 thousand m^3/day in 2015.

Table 9.5.3 Estimated Water Demand in 2015

No.	Rayon	Jamoat	Village	Population to be Served (2007)	Population to be Served (2015)	Domestic	Insti.	Total
K-2	Kabodiyon	S. Khudoikulov	Yangi Yul	3,618	4,342	87	13	100
K-5	Kabodiyon	Navobod	Navruz	820	984	20	3	23
K-7	Kabodiyon	S. Khudoikulov	Jarkurgan	3,917	4,700	94	14	108
K-9	Kabodiyon	U. Nazarov	Kabla (1/2)	6,180	7,416	148	22	171
			Boshkala	11,384	13,661	273	41	314
K-11	Kabodiyon	S. Khudoikulov	Bolshevik	3,816	4,579	92	14	105
N-1	Nosiri Khisrav	Istiklol	Oltinsoy	1,500	1,800	36	5	41
			Olzu	900	1,080	22	3	25
			Bahor	3,400	4,080	82	12	94
			Traganov	1,300	1,560	31	5	36
S-4	Shakhritus	Obshoron	Vatan	5,300	6,360	127	19	146
S-5	Shakhritus	Pakhtaobod	Sultanabod	6,065	7,278	146	22	167
S-9	Shakhritus	Obshoron	Binokor	2,642	3,170	63	10	72
P-13	Pyandzh	Sarmantoy	Sarmantoy	5,900	7,080	142	21	163
Total				56,742	68,090	1,362	204	1,565

9.5.3 REHABILITATION AND EXTENSION PLAN

(1) Field Survey of Current Situation of Priority Systems

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No drawings are available for the priority systems. Therefore, the Study Team carried out a field survey on the priority systems in order to get the following information.

- Total area of village
- Layout of water supply system (location of borehole and distribution tanks, transmission line, distribution lines, etc.)
- Confirmation of problems of the water supply facility
- Water tariff system
- Area of village (initial area of village when constructed and expanded area after construction)

As a result of the survey, total area of the village (including layout of roads) and layout of water supply facilities were confirmed. The results are shown as *Figure 9.5.2 - Figure 9.5.11* at the end of this chapter. All the priority systems were constructed in 1970's and most of them have not been extended although the villages have been much expanded from the original area. Those expanded areas are left without a water supply by the priority systems. No data on population and/or number of households served by the priority systems when they were working are available.

All the priority systems have some problems. They are, for example, malfunctioning of the submersible pump, deterioration of pipes and insufficient capacity of the systems). Therefore, rehabilitation of those facilities should be considered.

Although the layout of existing water supply systems was surveyed during the field survey, the following information completely depends on the memory of person(s) concerned with the operation of those water supply systems.

- Layout (Transmission and distribution lines)

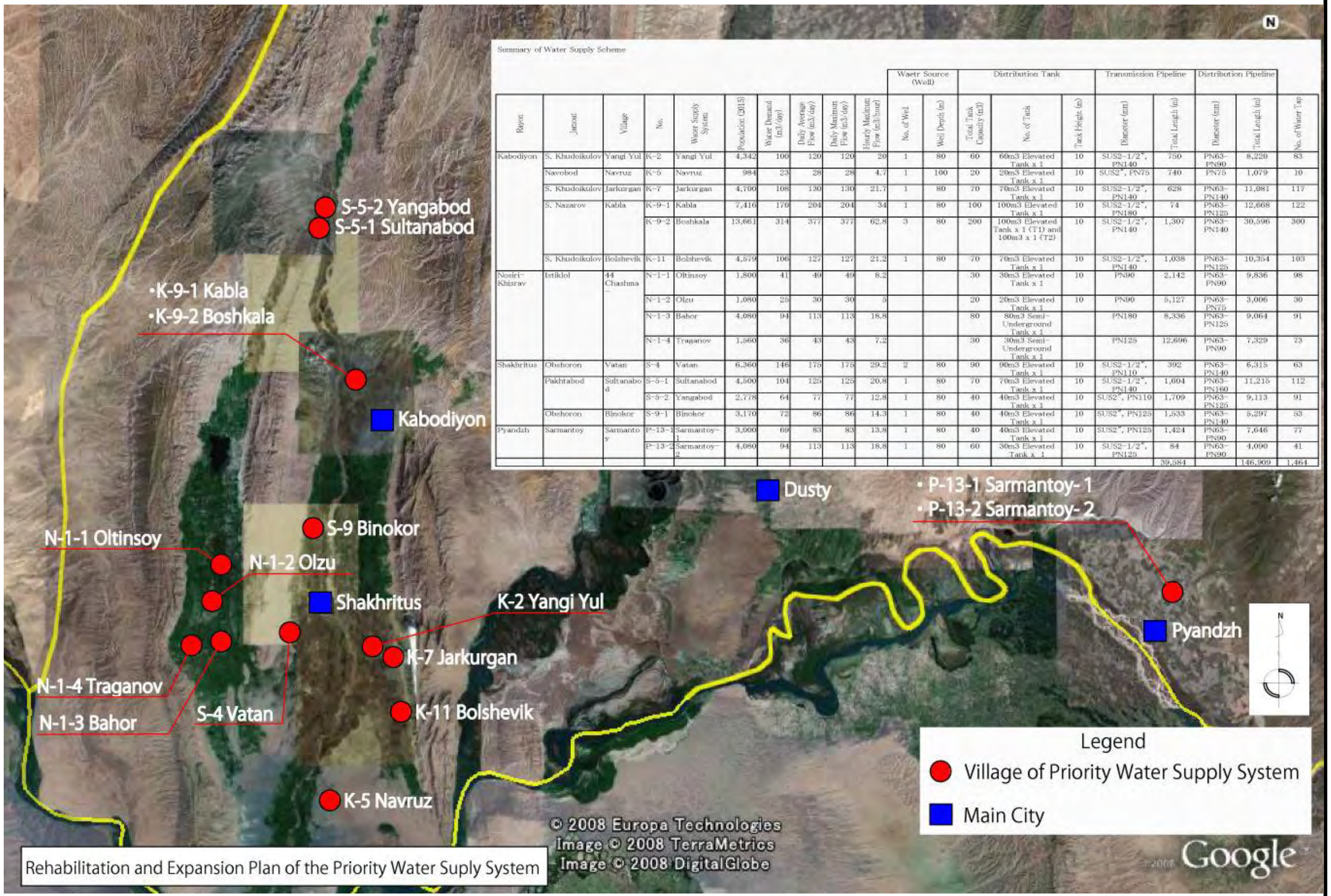
- Diameter of pipes
- Materials of pipes
- Location of valves

In *Figure 9.5.2 - Figure 9.5.11*, this information is expressed as much as possible. However, there is a possibility that some mistakes exist because such data depends completely on the memory of relevant persons.

The expansion plan of existing water supply systems to cover the expanded area is also expressed in the figures without specifications. Approximate cost estimation will be presented in the Draft Final Report.

(2) Rehabilitation and Extension Plan of Priority Systems

All the systems stopped operation due to malfunction or cutting of electric power supply during the field survey, therefore, the deteriorated section of pipes and other facilities could not be directly confirmed. Information on required rehabilitation works of systems is collected by observation of the Study team and interviews with the relevant persons about the water supply. As a result the following plan was prepared. Summary of the rehabilitation and expansion plan of the priority systems are shown in *Figure 9.5.1*.



Summary of Water Supply Scheme

Rayon	Jamoat	Village	No.	Water Supply System	Population (2015)	Water Demand (m3/day)	Daily Average Flow (m3/day)	Daily Maximum Flow (m3/day)	Hourly Maximum Flow (m3/hour)	Waetr Source (Well): No. of Wel	Waetr Source (Well): Well Depth (m)	Distribution Tank: Total Tank Capacity (m3)	Distribution Tank: No. of Tank	Distribution Tank: Tank Height (m)	Transmission Pipeline: Diameter (mm)	Transmission Pipeline: Total Length (m)	Distribution Pipeline: Diameter (mm)	Distribution Pipeline: Total Length (m)	No. of Water Tap
Kabodiyon	S. Khudoikulov	Yangi Yul	K-2	Yangi Yul	4,342	100	120	120	20	1	80	60	60m3 Elevated Tank x 1	10	SUS2-1/2", PN140	750	PN63-PN90	8,220	83
	Navobod	Navruz	K-5	Navruz	984	23	28	28	4.7	1	100	20	20m3 Elevated Tank x 1	10	SUS2", PN75	740	PN75	1,079	10
	S. Khudoikulov	Jarkurgan	K-7	Jarkurgan	4,700	108	130	130	21.7	1	80	70	70m3 Elevated Tank x 1	10	SUS2-1/2", PN140	628	PN63-PN140	11,081	117
	S. Nazarov	Kabla	K-9-1	Kabla	7,416	170	204	204	34	1	80	100	100m3 Elevated Tank x 1	10	SUS2-1/2", PN180	74	PN63-PN125	12,668	122
			K-9-2	Boshkala	13,661	314	377	377	62.8	3	80	200	100m3 Elevated Tank x 1 (T1) and 100m3 x 1 (T2)	10	SUS2-1/2", PN140	1,307	PN63-PN140	30,596	300
	S. Khudoikulov	Bolshevik	K-11	Bolshevik	4,579	106	127	127	21.2	1	80	70	70m3 Elevated Tank x 1	10	SUS2-1/2", PN140	1,038	PN63-PN125	10,354	103
Nosiri-Khisrav	Istiklol	44 Chashma	N-1-1	Oltinsoy	1,800	41	49	49	8.2			30	30m3 Elevated Tank x 1	10	PN90	2,142	PN63-PN90	9,836	98
			N-1-2	Olzu	1,080	25	30	30	5			20	20m3 Elevated Tank x 1	10	PN90	5,127	PN63-PN75	3,006	30
			N-1-3	Bahor	4,080	94	113	113	18.8			80	80m3 Semi-Underground Tank x 1		PN180	8,336	PN63-PN125	9,064	91
			N-1-4	Traganov	1,560	36	43	43	7.2			30	30m3 Semi-Underground Tank x 1		PN125	12,696	PN63-PN90	7,329	73
Shakhritus	Obshoron	Vatan	S-4	Vatan	6,360	146	175	175	29.2	2	80	90	90m3 Elevated Tank x 1	10	SUS2-1/2", PN110	392	PN63-PN140	6,315	63
	Pakhtabod	Sultanabod	S-5-1	Sultanabod	4,500	104	125	125	20.8	1	80	70	70m3 Elevated Tank x 1	10	SUS2-1/2", PN140	1,604	PN63-PN160	11,215	112
			S-5-2	Yangabod	2,778	64	77	77	12.8	1	80	40	40m3 Elevated Tank x 1	10	SUS2", PN110	1,709	PN63-PN125	9,113	91
	Obshoron	Binokor	S-9-1	Binokor	3,170	72	86	86	14.3	1	80	40	40m3 Elevated Tank x 1	10	SUS2", PN125	1,533	PN63-PN140	5,297	53
Pyandzh	Sarmantoy	Sarmantoy	P-13-1	Sarmantoy-1	3,000	69	83	83	13.8	1	80	40	40m3 Elevated Tank x 1	10	SUS2", PN125	1,424	PN63-PN90	7,646	77
			P-13-2	Sarmantoy-2	4,080	94	113	113	18.8	1	80	60	30m3 Elevated Tank x 1	10	SUS2-1/2", PN125	84	PN63-PN90	4,090	41
																39,584		146,909	1,464

FIGURE 9.5.1 SUMMARY OF REHABILITATION AND EXPANSION PLAN OF PRIORITY SYSTEMS

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**

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1) Yangi Yul Village (K-2), Kabodiyon Rayon (Figure 9.5.2, Attached Figure 9.10)

The system covers one (1) village, Yangi Yul. The water is exploited from one (1) well in the pumping station in the village and transmitted to the elevated tanks (25m^3). Approximately 70 public taps were distributed: they were mostly located along the street and a few of taps were constructed in the yard of houses. Approximately four to five households share one (1) tap.

Expanded areas are located in the eastern, western and southern side of the village.

Water demand in 2015 is estimated as 100 m^3/day. The potential of the borehole is evaluated as 28 m^3/hour by the pumping test. 3.6 hours of pumping will be required to meet the water demand in 2015. It is likely that number of boreholes is enough.

2) Navruz Village (K-5), Kabodiyon Rayon (Figure 9.5.3, Attached Figure 9.11)

The system distributes water to one (1) village, Navruz. The pumping station is located in the adjacent village and water is transmitted to the elevated distribution tank (40m^3) in the village around 2km from the pumping station. The system has another tank (25m^3) beside the distribution tank for emergency. There are 12 public taps along the streets.

The deterioration of transmission line is proceeding and leakage of water has been recognized. The line outcrops in places although it was originally laid down under the ground. Leakage of the water from elevated tank is also recognized. Apart from the water supply facilities, transformer of electric power supply to the pumping station is shared with other purposes in other villages. This sometimes causes trouble of the transformer resulting in the stoppage of water supply service in the village. Therefore, it is preferable to provide a transformer independently from other usage. No expansion of the village is recognized.

Water demand in 2015 is estimated as 23 m^3/day. Potential of the borehole is evaluated as 17m^3/day by the pumping test. 1.3 hours of pumping is required to meet the water demand in 2015. It is likely that number of boreholes is enough. In order to minimize the transmission distance, a new borehole is to be drilled near the elevated tank in the village.

3) Jarkurgan Village (K-7), Kabodiyon Rayon (Figure 9.5.4, Attached Figure 9.12)

The system distributes water to one (1) village, Jarkurgan. The pumping station is located in the center of the village and water is transmitted to the elevated distribution tank (25m^3) in the pumping station. Another borehole exists at the southern side of the village and it is directly connected to the distribution line due to lack of yield of boreholes in the pumping station caused by deposition of intruded sand into the borehole. More than 10 rehabilitations of the submersible pump were carried out by the contribution of village people. There are 22 public taps along the streets.

Expanded areas are distributed surrounding the original village. Extension of the system should be considered. However, the height of the elevated tank may be insufficient due to the expanded area developed in the eastern side of the village because the elevation becomes higher toward the east. Water demand in 2015 is estimated as 108 m^3/day. A pumping test was not carried out in the village. However, the borehole in the pumping station was yielding 16m^3/hour. Therefore, same potential is expected after rehabilitation. As for the another borehole, it has a capacity of 40m^3/hour. Therefore, about 2 hours/day of pumping will be required to meet the water demand in 2015 if both boreholes are operated together.

Since the height of the existing elevated tank is insufficient, a new ground tank is to be constructed on the hill in the eastern side of the village.

4) Kabla Village (K-9), Kabodiyon Rayon (Figure 9.5.5 (1/3) - (3/3), Attached Figure 9.13 (1/2) - (2/2))

There are two (2) water supply systems in the villages guided by the RWSA as Kabla village. The two (2) systems are independent of each other. One system supplies only to Kabla Village (*Figure 9.5.5 (2/3)*). The other system supplies Boshkala, Chapryq-1 and Chapryq-2

Villages (*Figure 9.5.5 (3/3)*). Both systems supplied a farm area in Kabla Village, but they were not connected.

(i) Kabla Village (Figure 9.5.5 (2/3) , Attached Figure 9.13 (1/2))

The water is pumped from one (1) borehole and sent to an elevated tank (25m^3) in the pumping station. Furthermore, two (2) elevated tank exist at the northwestern and southeastern sides of distribution lines. There are around 100 taps. The expanded area is distributed in the southwestern side of the village.

Water demand in 2015 will reach 171 m^3/day. The potential of borehole is 22 m^3/hour according to the pumping test. Therefore, 7.8 hours/day of pumping is necessary to fulfil the water demand.

(ii) Boshkala, Chapryq-1 and Chapryq-2 Villages (Figure 9.5.5 (3/3) , Attached Figure 9.13 (2/2))

The system has one (1) borehole and one (1) elevated tank (25m^3) in the pumping station. The expanded area is widely distributed in the eastern side of the village. Another expansion area is located in the north. The size of the expanded areas is more than twice the original village area.

Water demand in 2015 will reach 314 m^3/day. The potential of the borehole is 22 m^3/hour. Thus, 14.3 hours/day of pumping is necessary to fulfil the water demand..

5) Bolshevik Village (K-11), Kabodiyon Rayon (Figure 9.5.6, Attached Figure 9.14)

Bolshevik Village is the target village for the pilot project. Water exploited from a borehole is transmitted to two (2) ground tanks (250m^3 and 500m^3, total 750m^3) constructed on a hill. The Distribution lines start from each tank and they meet at the eastern corner of the system. The Study Team confirmed 65 public taps under the control of the operator of the system. Most taps are constructed along the streets, but several taps are introduced into the yard of houses. Spacing of taps is generally less than 50m, but it is rather wide in the northern part of the system due to lack of pressure. Expanded areas are distributed in the north and south of the village.

Water demand in 2015 reaches 105 m^3/day. The potential of the borehole is 28 m^3/hour. Therefore, 3.8 hours/day of pumping is necessary to fulfil the water demand. It is likely that number of borehole is sufficient.

6) 44 Chashma (N-1), Nosiri-Khisrav Rayon (Figure 9.5.7 (1/5) - (5/5), Attached Figure 9.15 (1/4) - (4/4))

44 Chashma is a pumping station of a group water supply system distributing water to four villages: Oltinsoy, Olzu. Bahor and Traganov. Among them, Bahor Village is the center of the Nosiri-Khisrav Rayon and the water supply system is owned and operated by the HCSE which has jurisdiction over Vodokanal.

(i) 44 Chashma Pumping Station

In 44 Chashma pumping station, there are three (3) boreholes. One (1) of the boreholes was collapsed. The remaining two (2) boreholes are used; however, the submersible pumps of both boreholes were burned. Therefore, the RWSA replaced one (1) pump by its own expense in February 2008. Exploited water is collected in two (2) collection tanks (250m^3x2, total 500m^3). Then, water is sent to four (4) villages through two (2) lines. One line is for Oltinsoy and Bahor Villages and the other is for Olzu and Traganov Villages. Three (3) booster pumps are equipped in the pumping station, but two (2) pumps were burned and not working now.

(ii) Oltinsoy Village (N-1/1) (Figure 9.5.7 (2/5), Attached Figure 9.15 (1/4))

Water is supplied directly from the 44 Chashma pumping station by the pressure of a booster

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pump. One (1) tank is in the village but it is not in use. There are around 10 public taps. Expanded areas are distributed in the north and east sides of village, and the opposite side of a canal.

(iii) Olzu Village (N-1/2) (Figure 9.5.7 (3/5), Attached Figure 9.15 (2/4))

Olzu Village consists of several sub-villages. The nearest sub-village to the 44 Chashma is receiving water from the pumping station. Others have independent water supply systems. Therefore, the nearest sub-village is included in the study. There are two (2) elevated distribution tanks, however both tanks are not in use. Routes of the transmission line to the tanks are unclear. Water is supplied directly from the 44 Chashma pumping station by the pressure of a booster pump. All the taps were destroyed and the total number of taps is unclear. Around 15 taps are to be constructed. The village has expanded to the north. The southern expanded area requires three (3) taps.

(iv) Bahor Village (N-1/3) (Figure 9.5.7 (4/5), Attached Figure 9.15 (3/4))

Bahor village is the center of Nosiri-Khisrav Rayon. Water is transmitted from 44 Chashma pumping station to a booster pump station in the village, then water is sent to three distribution tanks constructed on a hill around 0.9km southwest from the center of the village. Total number of taps is unknown. The northeastern part of the village is an expansion area. Another expansion is observed to the east of the village.

(V) Traganov Village (N-1/4) (Figure 9.5.7 (5/5), Attached Figure 9.15 (4/4))

Traganov Village shares a transmission line with Olzu Village. Water is transmitted from 44 Chashma pumping station to a booster pump station in the village, then water is sent to three distribution tanks constructed on the hill around 1.4km west from the center of the village. There are 14 public taps. The village expanded to the area around the original village.

(Vi) Required rehabilitation and extension of water supply systems for 44 Chashma

Total water demand in four (4) villages in 2015 will be 196 m3/day. The potential of the borehole is 26.5 m^3/hour/well. If one borehole is rehabilitated, the number of production wells becomes two (2). Therefore, 7.4 hours of operation is enough to meet water demand.

7) Vatan Village (S-4), Shakhritus Rayon (Figure 9.5.8, Attached Figure 9.16)

The water supply system in Vatan Village has one (1) borehole and one (1) elevated tank (160m^3, around 20m high). The system was once rehabilitated by UNDP in 2001 and stopped operation again because the submersible pump was burned. There are 75 taps. According to the operator, 75% of distribution lines are deteriorated. The village is expanded to the west.

Water demand in 2015 is around 146 m^3/day. According to the pumping test, the borehole has a capacity of 26.5 m^3/day.

8) Sultanabod Village (S-5), Shakhritus Rayon (Figure 9.5.9 (1/3) - (3/3), Attached Figure 9.17 (1/2) - (2/2))

The system distributes water to two (2) villages, Sultanabod and Yangabod. However, water supply to Yangabod village stopped due to stolen distribution pipes during the civil war. The pumping station is located in Sultanabod and has three (3) boreholes. Among them only one (1) borehole (No. 2 Borehole) has no problem. Submersible pump in the No. 1 borehole was burned in 2005 after rehabilitation by the UNDP. No. 3 Borehole has no pump. Water is exploited from the boreholes and directly distributed from the pumping station without a distribution tank. Two (2) elevated tanks (25m^3 x 2) for an emergency exist near both ends of distribution lines in Sultanabod. There are 22 public taps along the streets in Sultanabod. Furthermore, taps connected to the yard of each house exist along the main street in front of the pumping station in Sultanabod. The number of taps in Yangabod is unknown.

The present area of Sultanabod is very wide although the original area of the village was very narrow. The area of the village expanded to more than twice the original area. In order to cover all the area of the village, construction of a new distribution tank is required on the hill to the west of the village.

Sultanabod and Yangabod are currently sharing a water supply system. However, the service area is too wide to supply by one system. Therefore, it is considered to divide the system into two systems independently for Sultanabod Village and Yangabod Village

9) Binokor Village (S-9), Shakhritus Rayon (Figure 9.5.10, Attached Figure 9.18)

Binokor Village is located near the center of Shakhritus Rayon. The water supply system distributes water to Binokor and Gidrostroiteley Villages. There are three (3) boreholes in the pumping station. Only one (1) borehole is working. Other two (2) boreholes stopped operation due to burning of the submersible pump. There are 80 public taps. The village expanded slightly to the northwest.

Water demand in 2015 is around 135 m^3/day. According to the pumping test, the borehole has a capacity 25 m^3/day by the pumping test. If electric power is supplied more than 2.7 hours/ day, the boreholes are capable of yielding enough groundwater against the water demand in 2015 because there are two (2) boreholes after rehabilitation.

The water supply system in Gidrostroiteley Village was once connected to the water source of the water supply system in Binokor and operated by Vodokanal in Shakhritus.. However, transmission line between tow (2) systems were broken and/or deteriorated. Furthermore, a distribution tank is completely broken. However, Vodokanal is constructing a distribution tank at the southwestern side of the service area. Therefore, the water supply system in Gidrostroiteley Village was excluded from the priority systems.

10) Sarmantoy Village (P-13), Pyandzh Rayon (Figure 9.5.11 (1/3) - (3/3) , Attached Figure 9.19 (1/2) - (2/2))

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The village, Sarmantoy, is composed of two (2) villages, Sarmantoy-1 and Sarmantoy-2. There was third village, Lenin, however, it is now merged with Sarmantoy-2. The pumping station is located in Sarmantoy-2 and the two (2) elevated distribution tanks are located in Sarmantoy-1. The basement of the elevated tanks is deteriorated, therefore, new construction of an elevated tank is required. The distribution main in Sarmantoy-1, the length of which is around 2km, is to be replaced due to deterioration. Every tap are leads to the yard of each house.

Sarmantoy-1 village has expanded on both the east and west sides. Sarmantoy-2 village has widely expanded in the southwestern side of the village. The number of new households is 63 according to the Hukmat of Sarmantoy Jamoat. Therefore, the same number of yard connections is required.

Water demand in 2015 is 163 m^3/day. The potential of groundwater yield is estimated as 28 m^3/hour. Therefore, 5.8 hours of pump operation is necessary. Construction of a new borehole is required in the future.

9.5.4 PRELIMINARY DESIGN AND COST ESTIMATION

Rehabilitation and extension plan for priority systems are presented in paragraph *9.5.3*. Preliminary design for the rehabilitation and extension plan, and preliminary cost estimation are presented in the Interim Report.

(1) General Concept of Preliminary Design

Basic concept of rehabilitation and extension plan is presented in paragraph 9.5.1.

Water source is groundwater for 15 systems; no surface water is used as the water source. In order to minimize both construction and maintenance costs, only chlorination facility is included for water treatment.

(2) Water Demand

Water demand is estimated as shown in Table 9.5.3. Unit water demand is 20 L/c/d even though it will increase up to 50 L/c/d in future.

(3) Design Conditions

Water supply facilities for priority system are composed of intake, transmission line, distribution tank, distribution line and public water point. Design conditions considered in the designing of the water supply facilities are summarized in *Table 9.5.4*.

Table 9.5.4 Design Conditions of Water Supply System

1. Duration of water supply: 6 hours (3 hours in the morning and 3 hours in the afternoon)		
2. Design flow		
Daily average flow	= (Daily water demand) + (Distribution losses)	
Daily maximum flow	= (Daily average flow)	
Hourly maximum flow	= (Daily maximum flow)/(6 hours)	
3. Distribution losses	20% of Daily Average Flow	
4. Facilities	Specification	
Intake	Daily operation hour	6 hours (=360 min)
	Capacity (m^3/hour)	Daily maximum flow (m^3/day) / 360 (min/day)
	Type of pump	Submersible pump
	Power source	Commercial electric power supply
Disinfection	Chlorine feeder	Dropping type, Sodium hypochlorite
Transmission line	Design flow	Daily maximum flow (m^3/day) / (360 min/day)
	Method of transmission	Pressure flow by submersible pump
	Material of pipe	Polyethylene Pipe
	Earth covering depth	1 m (minimum)
Distribution tank	Capacity (m^3)	Daily maximum flow x 50 %
	Type of tank	Elevated steel tank (Maximum capacity 50m3 Maximum height 16m) or Semi-underground Tank
	Low water level	Elevated steel tank: G.L + 10 m in minimum Semi-underground Tank: Tank floor + 0.2m
	No. of tank	1 to 4 tank(s) / scheme
	Material of tank	Steel or concrete
Distribution line	Design flow	= Hourly maximum flow
	Method of water supply	Gravity flow
	Material of pipe	Polyethylene pipe
	Earth covering depth	1 m (minimum)
Public water tap	Type of tap/	Single tap
	Number of tap	One tap per 100m of Distribution line
	Maximum number of user	100 persons/tap
	Maximum distance of access	100 m from household

(4) Facility Plan

Water supply facilities for the priority systems are designed following the design parameters shown in *Table 9.5.5*.

1) Layout plan

Facility plans of priority systems are summarized in *Table 9.5.5*. The layout of each water supply system is shown as *Figure 9.5.2 - Figure 9.5.11*.

9 - 23

2) Water Source and Intake Facility

Water source is groundwater. The source water is extracted by submersible pump from the intake facility and transmitted to the Distribution tank by pressure of the pump.

Depth of boreholes is 80 - 100 m. Each borehole has suitable well structure to prevent sand intrusion from the aquifers during the pumping.

The commercial electric power supply is available in each village. Therefore, it is used as the power source of the intake facility.

Design of the new borehole and the control house is shown in *Attached Figure 9.20* - *Attached Figure 9.21*, respectively.

3) Distribution tank

The capacity of distribution tank is determined to meet 50 % of the daily maximum flow which is considered same as the hourly maximum flow. As for the type of the tank, the ground tank and the elevated tank are planned considering the topographic condition and the service area. Material of the tank is planned to be of steel for elevated tank and concrete for semi-underground tank. Water level gauge and flow meter will be provided in each tank to facilitate proper operation and maintenance of the system.

Design of the distribution tank, elevated tank and semi-underground tank is shown in *Attached Figure 9.22.*and *Attached Figure 9.23.*, respectively.

4) Distribution line

The pipe routes are planned based on the results of the field survey by the Study Team. PVC pipes are proposed for the distribution lines. Diameter of pipes are determined based on the gravity flow.

5) Public Water Tap

A single tap will be installed at each public water point. One tap will be shared by 30 to 100 persons. Design of public tap is shown in *Attached Figure 9.24*.

Table 9.5.5 Summary of Water Supply Facilities

Rayon	Jamoat	Village	No.	Water Supply System	Population (2015)	Water Demand (m3/day)	Daily Average Flow (m3/day)	Daily Maximum Flow (m3/day)	Hourly Maximum Flow (m3/hour)	Waetr Source (Well): No. of Well	Waetr Source (Well): Well Depth (m)	Distribution Tank: Total Tank Capacity (m3)	Distribution Tank: No. of Tank	Distribution Tank: Tank Height (m)	Transmission Pipeline: Diameter (mm)	Transmission Pipeline: Total Length (m)	Distribution Pipeline: Diameter (mm)	Distribution Pipeline: Total Length (m)	No. of Water Tap
Kabodiyon	S. Khudoikulov	Yangi Yul	K-2	Yangi Yul	4,342	100	120	120	20	1	80	60	60m3 Elevated Tank x 1	10	SUS2-1/2″, PN140	750	PN63-PN90	8,220	83
	Navobod	Navruz	K-5	Navruz	984	23	28	28	4.7	1	100	20	20m3 Elevated Tank x 1	10	SUS2″, PN75	740	PN75	1,079	10
	S. Khudoikulov	Jarkurgan	K-7	Jarkurgan	4,700	108	130	130	21.7	1	80	70	70m3 Elevated Tank x 1	10	SUS2-1/2″, PN140	628	PN63-PN140	11,081	117
	S. Nazarov	Kabla	K-9-1	Kabla	7,416	170	204	204	34	1	80	100	100m3 Elevated Tank x 1	10	SUS2-1/2″, PN180	74	PN63-PN125	12,669	122
			K-9-2	Boshkala	13,661	314	377	377	62.8	3	80	200	100m3 Elevated Tank x 1 (T1) and 100m3 x 1 (T2)	10	SUS2-1/2″, PN140	1,307	PN63-PN140	30,596	300
	S. Khudoikulov	Bolshevik	K-11	Bolshevik	4,579	106	127	127	21.2	1	80	70	70m3 Elevated Tank x 1	10	SUS2-1/2″, PN140	1,038	PN63-PN125	10,354	103
Nosiri-Khisrav	Istiklol	44 Chashma -	N-1-1	Oltinsoy	1,800	41	49	49	8.2			30	30m3 Elevated Tank x 1	10	PN90	2,142	PN63-PN90	9,836	98
			N-1-2	Olzu	1,080	25	30	30	5			20	20m3 Elevated Tank x 1	10	PN90	5,127	PN63-PN75	3,006	30
			N-1-3	Bahor	4,080	94	113	113	18.8			80	80m3 Semi-Underground Tank x 1		PN180	8,336	PN63-PN125	9,064	91
			N-1-4	Traganov	1,560	36	43	43	7.2			30	30m3 Semi-Underground Tank x 1		PN125	12,696	PN63-PN90	7,329	73
Shakhritus	Obshoron	Vatan	S-4	Vatan	6,360	146	175	175	29.2	2	80	90	90m3 Elevated Tank x 1	10	SUS2-1/2″, PN110	392	PN63-PN140	6,315	63
	Pakhtabod	Sultanabod	S-5-1	Sultanabod	4,500	104	125	125	20.8	1	80	70	70m3 Elevated Tank x 1	10	SUS2-1/2″, PN140	1,604	PN63-PN160	11,215	112
			S-5-2	Yangabod	2,778	64	77	77	12.8	1	80	40	40m3 Elevated Tank x 1	10	SUS2″, PN110	1,709	PN63-PN125	9,113	91
	Obshoron	Binokor	S-9-1	Binokor	3,170	72	86	86	14.3	1	80	40	40m3 Elevated Tank x 1	10	SUS2″, PN125	1,533	PN63-PN140	5,297	53
Pyandzh	Sarmantoy	Sarmantoy	P-13-1	Sarmantoy-1	3,000	69	83	83	13.8	1	80	40	40m3 Elevated Tank x 1	10	SUS2″, PN125	1,424	PN63-PN90	7,646	77
			P-13-2	Sarmantoy-2	4,080	94	113	113	18.8	1	80	60	60m3 Elevated Tank x 1	10	SUS2-1/2″, PN125	84	PN63-PN90	4,090	41
																39,584		146,910	1,464

Chapter 9 Rehabilitation and Expansion Plan of Rural Water Supply System

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(5) Cost estimation

The approximate cost for implementation of the rehabilitation and extension of the priority systems is estimated at approximately 104 Million Somoni (30.6 Million US$ 3,272 Million Yen) as shown in *Table 9.5.6.*.

Table 9.5.6 Approximate Construction Cost

Item	Approximate Construction Cost		
	(Million Somoni)	(Million US$)	(Million Yen)
K-2 Yangi Yul	4.6	1.4	146
K-5 Navruz	1.7	0.5	52
K-7 Jarkurgan	6.1	1.8	192
K-9-1 Kabla	7.6	2.2	238
K-9-2 Boshkala	14.3	4.2	451
K-11 Bolshevik	6.4	1.9	200
N-1-1 Oltinsoy	5.7	1.7	178
N-1-2 Olzu	4.3	1.3	134
N-1-3 Bahor	11.3	3.3	354
N-1-4 Traganov	11.3	3.3	354
S-4 Vatan	5.2	1.5	162
S-5-1 Sultanabod	6.5	1.9	204
S-5-2 Yangabod	6.8	2.0	212
S-9-1 Binokor	4.3	1.3	135
P-13-1 Sarmantoy-1	5.8	1.7	183
P-13-2 Sarmantoy-2	2.4	0.7	77
Total	104.3	30.6	3,272

Note: 1 Somoni = 0.294 US$, 1 US$ = 107 Yen, 1 Somoni = 31.5 Yen

9.5.5 IMPLEMENTATION PLAN

Since number of the target water supply system is 19, implementation plan is propose as shown in *Table 9.5.7*

Table 9.5.7 Implementation Plan

Rayon	Jamoat	No.	Village	2009	2010	2011	2012	2013	2014
Kabodiyon	S. Khudoikulov	K-2	Yangi Yul	(Survey and Detailed Design)		(Construction)			
	Navobod	K-5	Navruz						
	S. Khudoikulov	K-7	Jarkurgan						
	S. Nazarov	K-9-1	Kabla						
		K-9-2	Boshkala						
	S. Khudoikulov	K-11	Bolshevik						
Nosiri-Khisrav	Istiklol	N-1-1	Oltinsoy						
		N-1-2	Olzu						
		N-1-3	Bahor			(Survey and Detailed Design)		(Construction)	
		N-1-4	Traganov						
Shakhritus	Obshoron	S-4	Vatan						
	Pakhtabod	S-5-1	Sultanabod						
		S-5-2	Yangabod						
	Obshoron	S-9-1	Binokor						
Pyandzh	Sarmantoy	P-13-1	Sarmantoy-1						
		P-13-2	Sarmantoy-2						

CHAPTER 9 REHABILITATION AND EXPANSION PLAN OF RURAL WATER SUPPLY SYSTEM

FIGURES

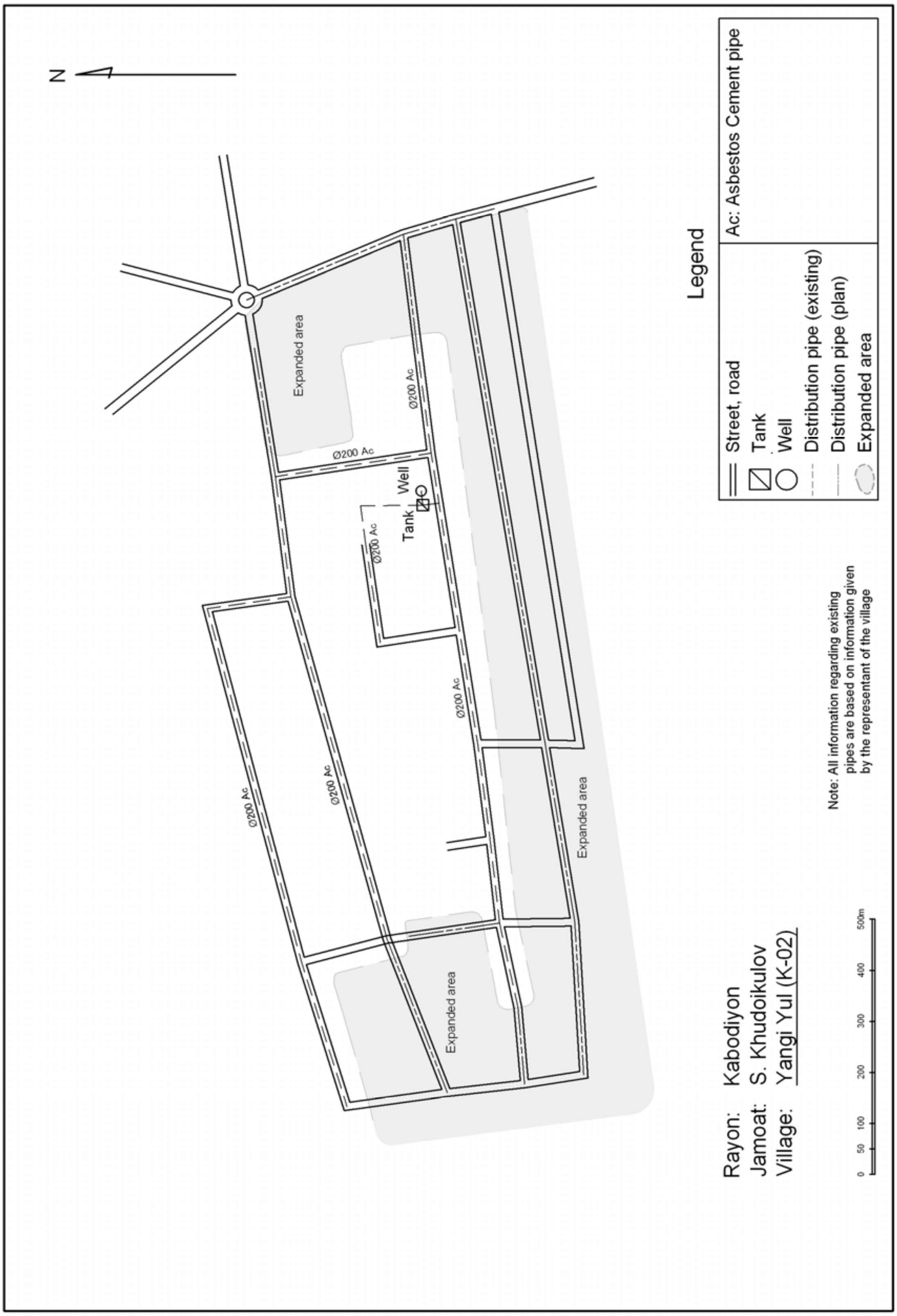

FIGURE 9.5.2 K-2 YANGI YUL

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**

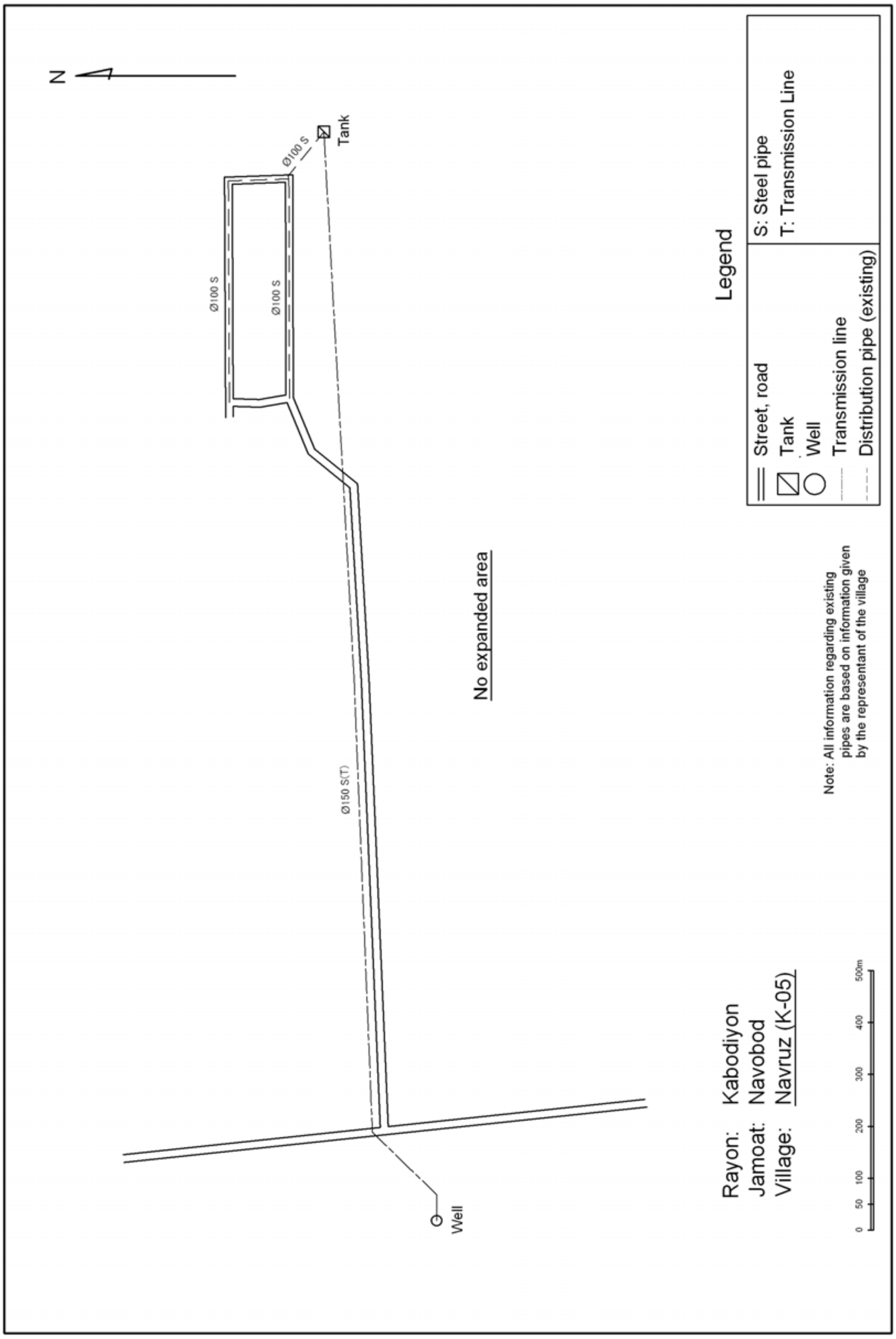

FIGURE 9.5.3 K-5 NAVRUZ

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

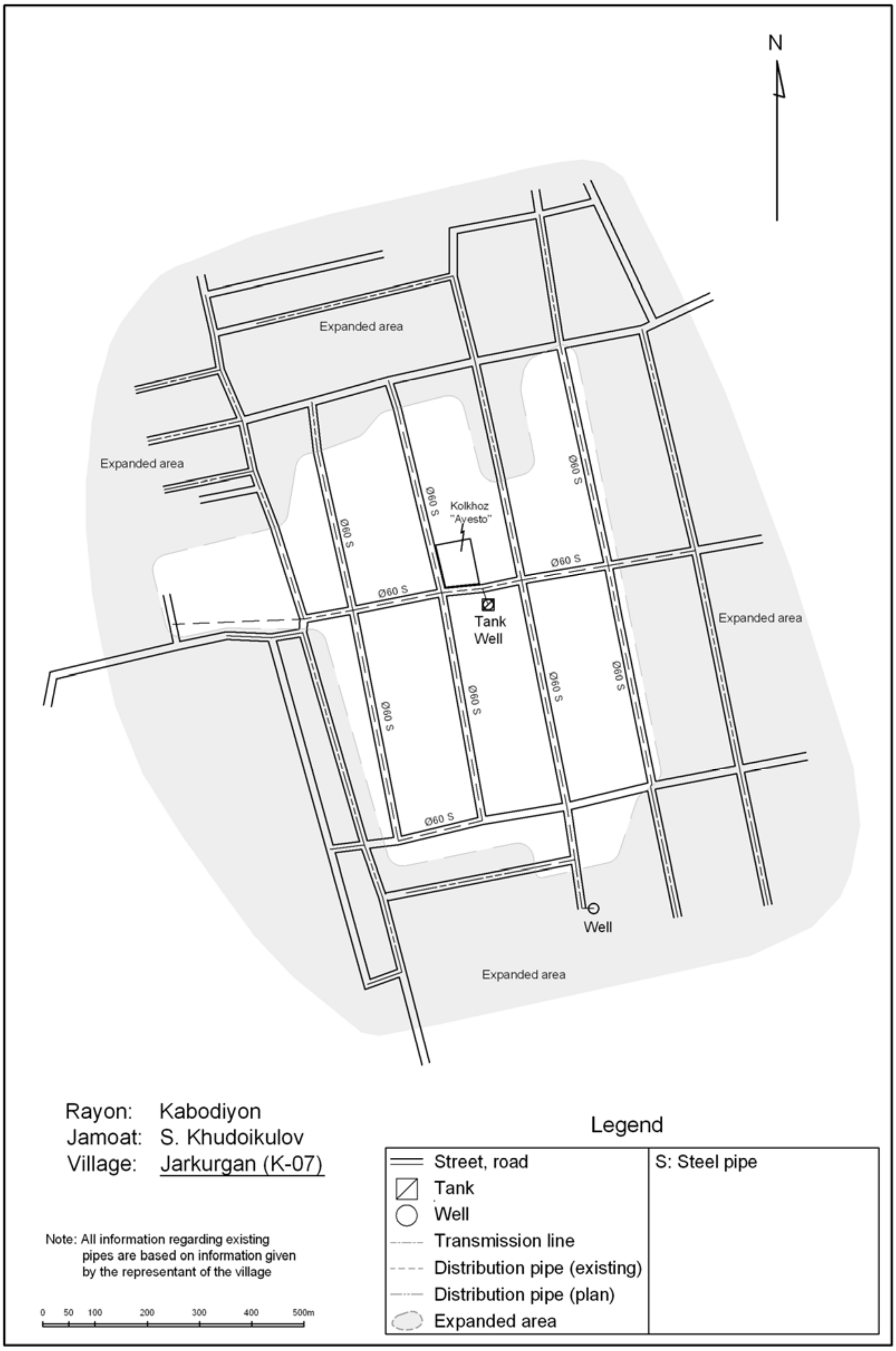

FIGURE 9.5.4 K-7 JARKURGAN

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**

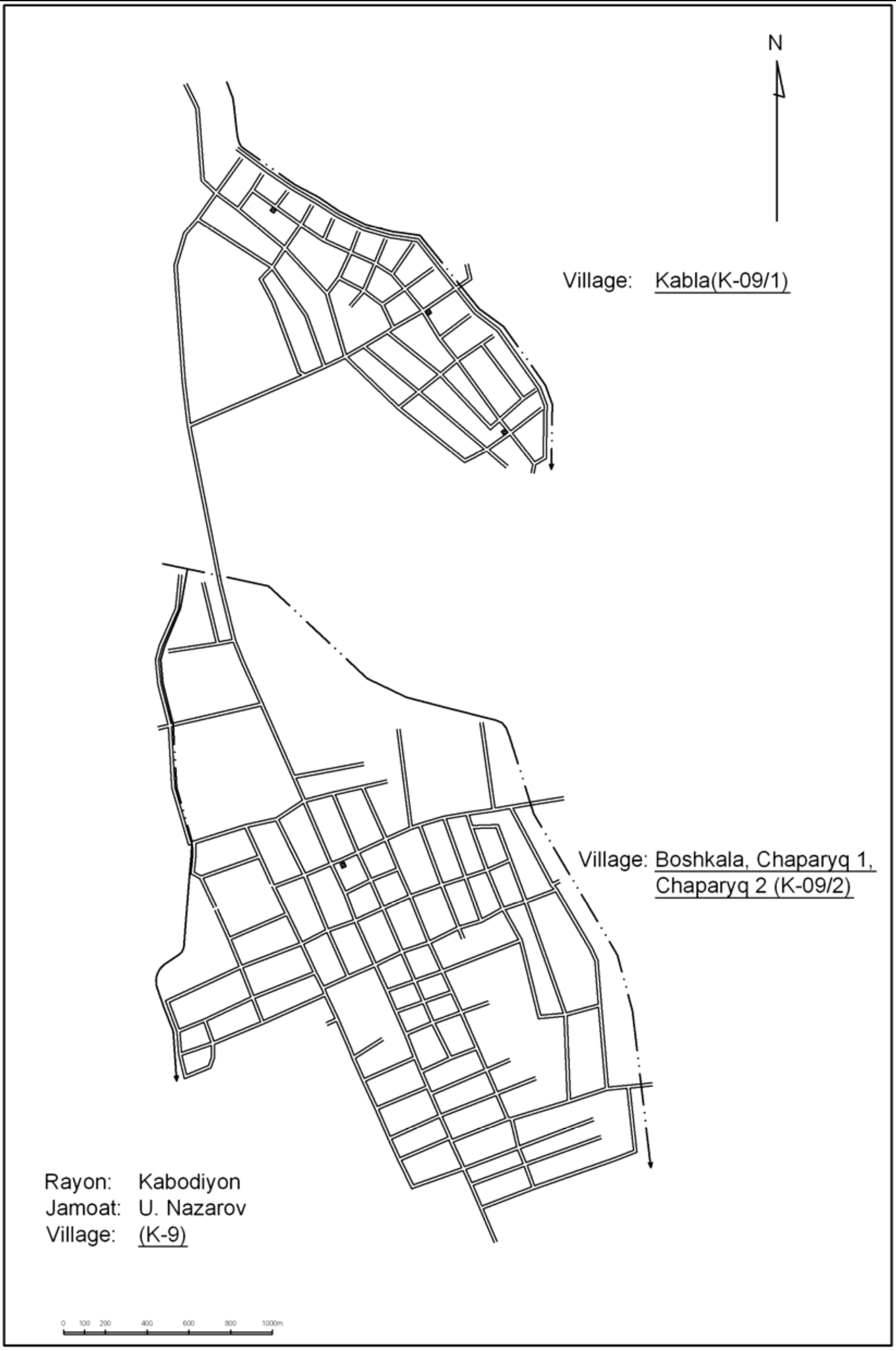

FIGURE 9.5.5 (1/3) K-9 KABLA (TOTAL AREA)

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

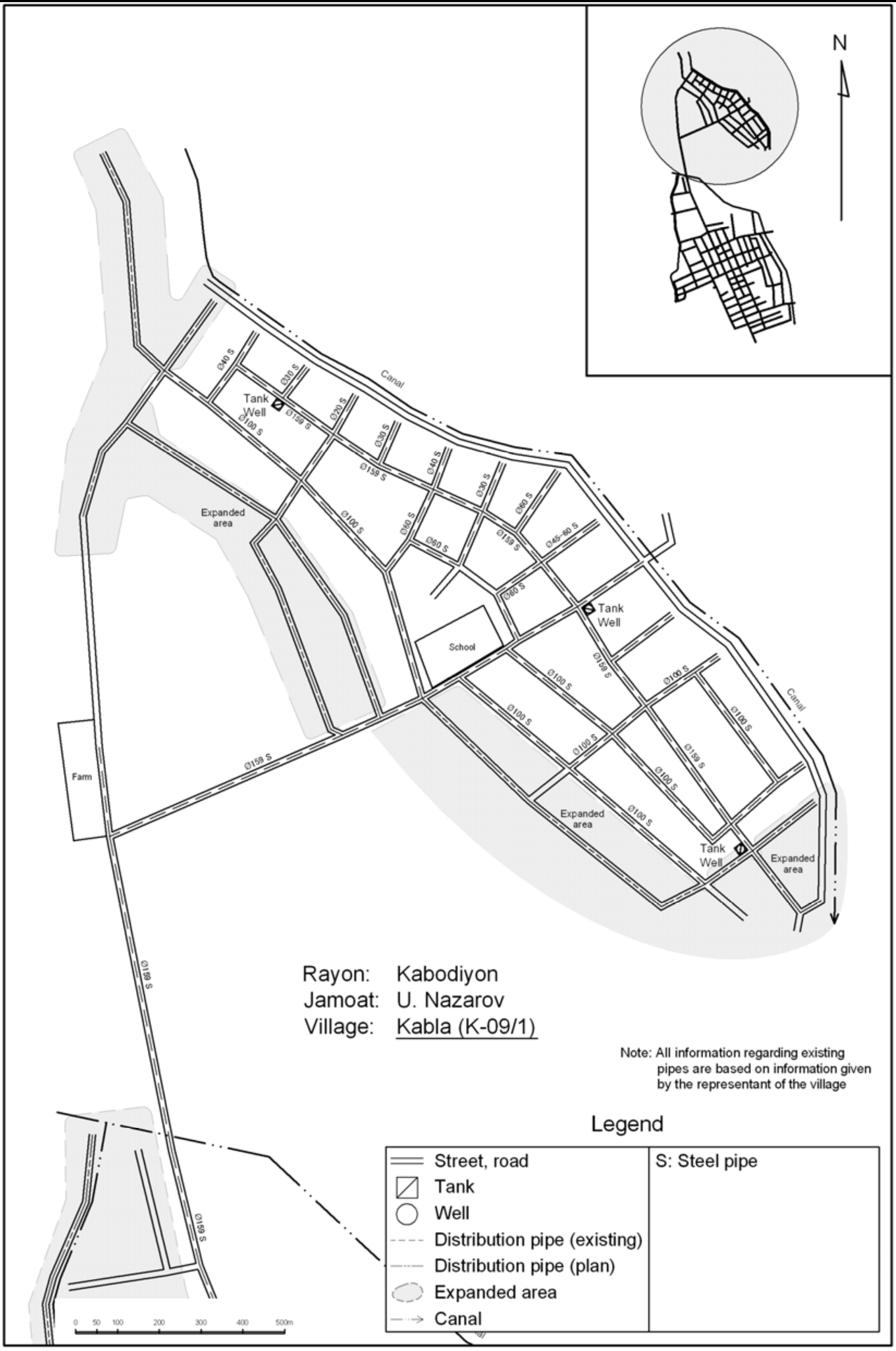

FIGURE 9.5.5 (2/3) K-9 KABLA: KABLA

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

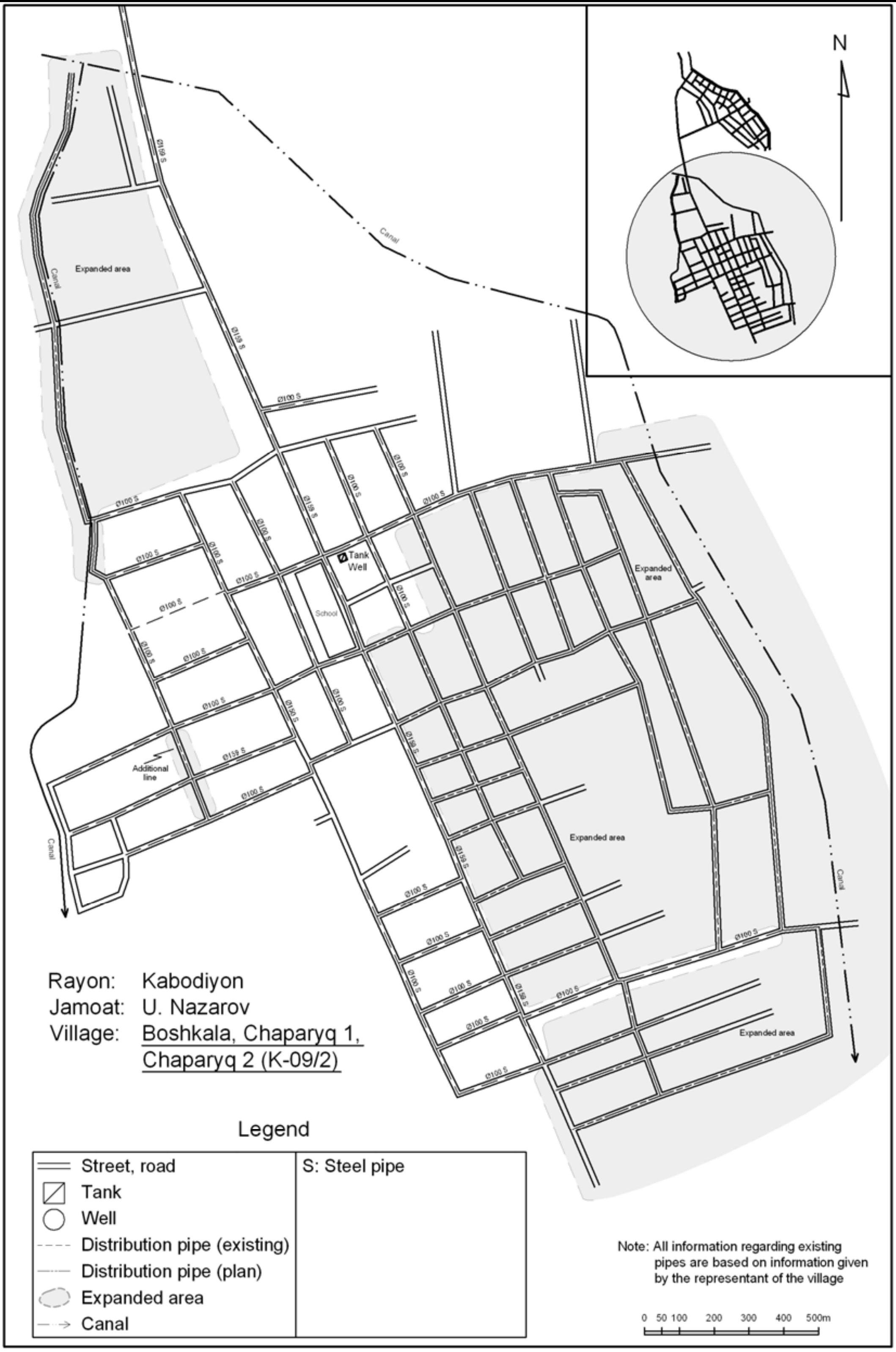

FIGURE 9.5.5 (3/3) K-9 KABLA: BOSHKALA

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

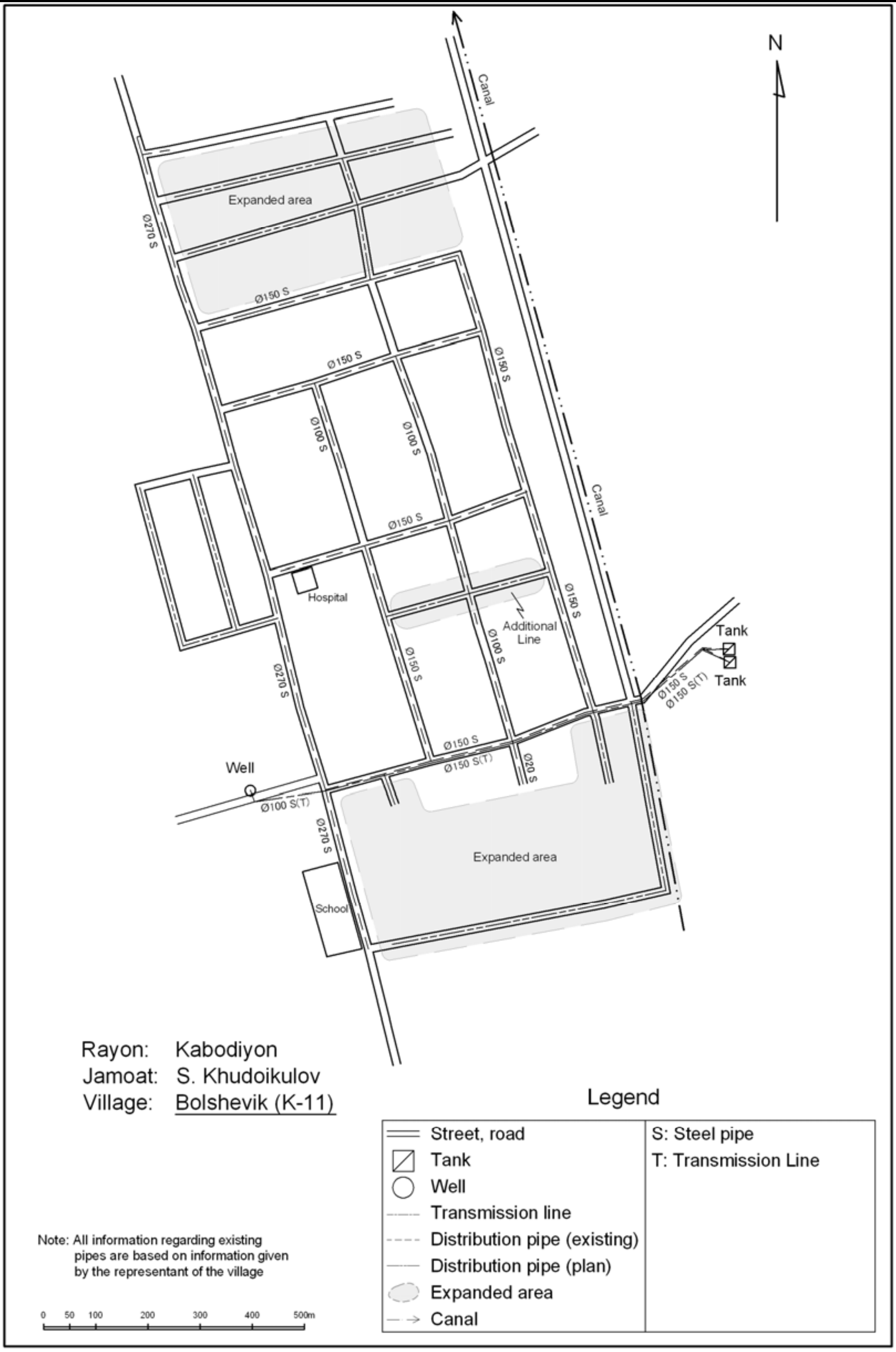

FIGURE 9.5.6 K-11 BOLSHEVIK

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

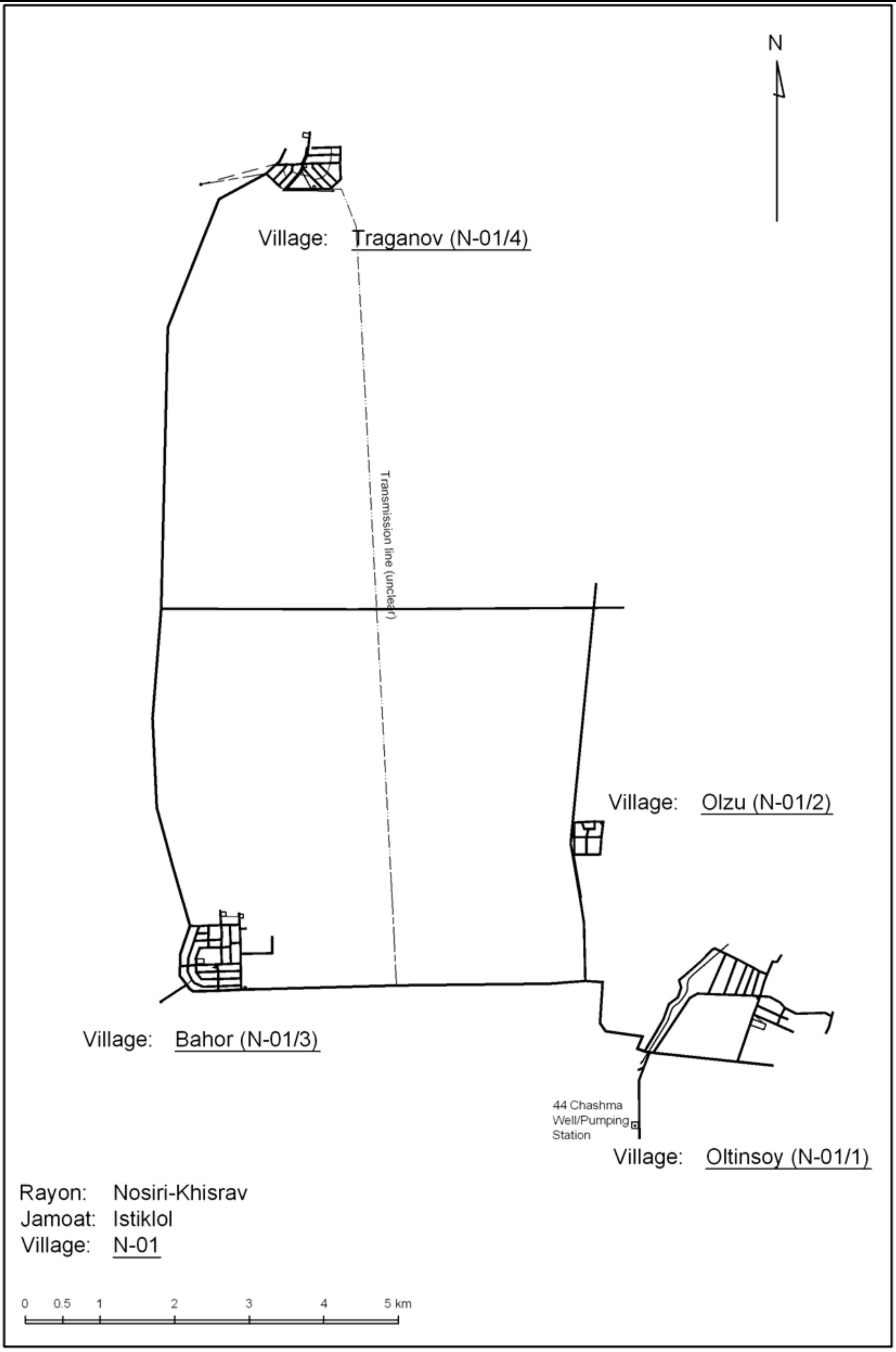

FIGURE 9.5.7 (1/5) N-1 44 CHASHMA: TOTAL AREA

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**

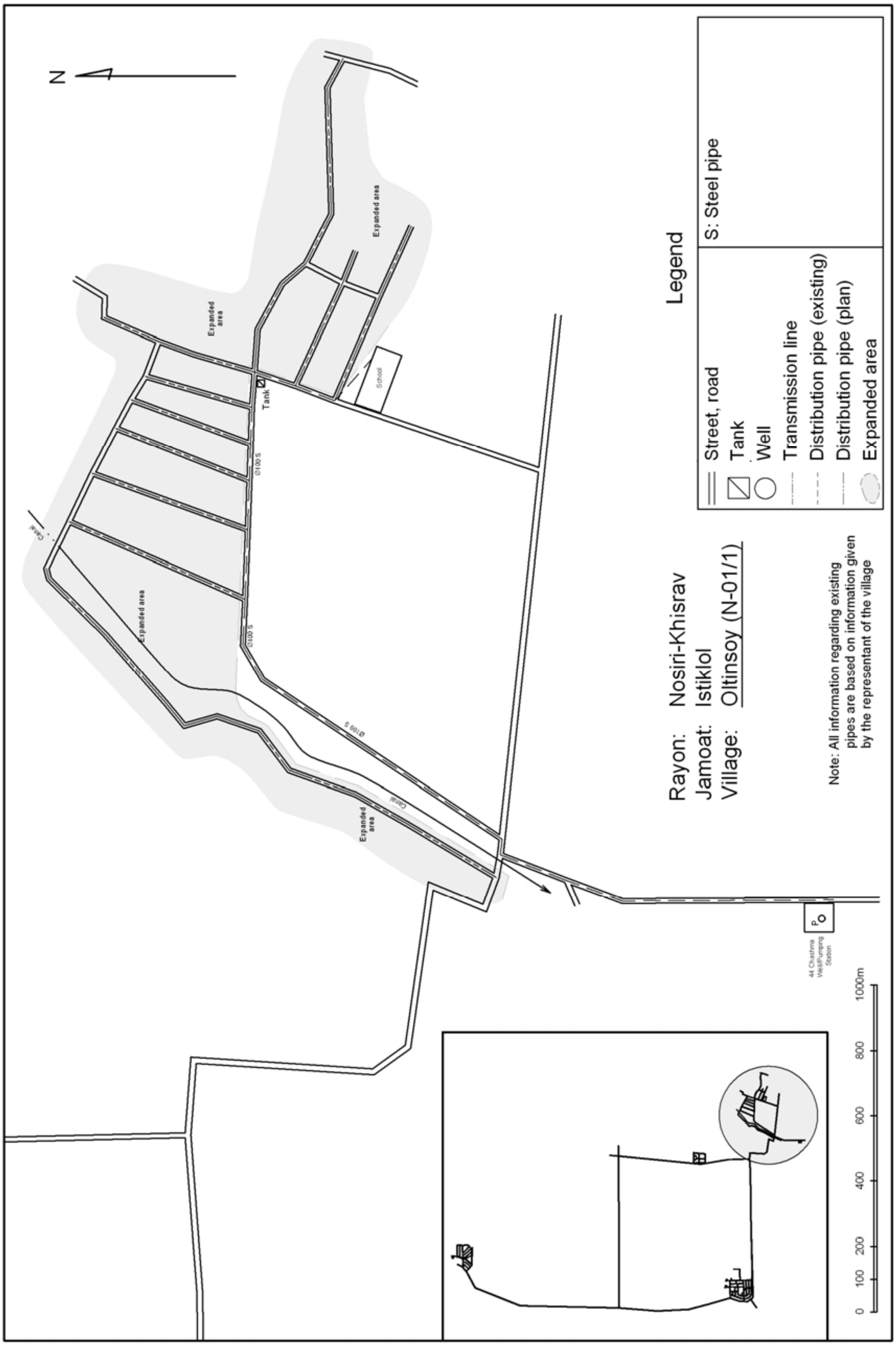

FIGURE 9.5.7 (2/5) N-1 44 CHASHMA: OLTINSOY

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**

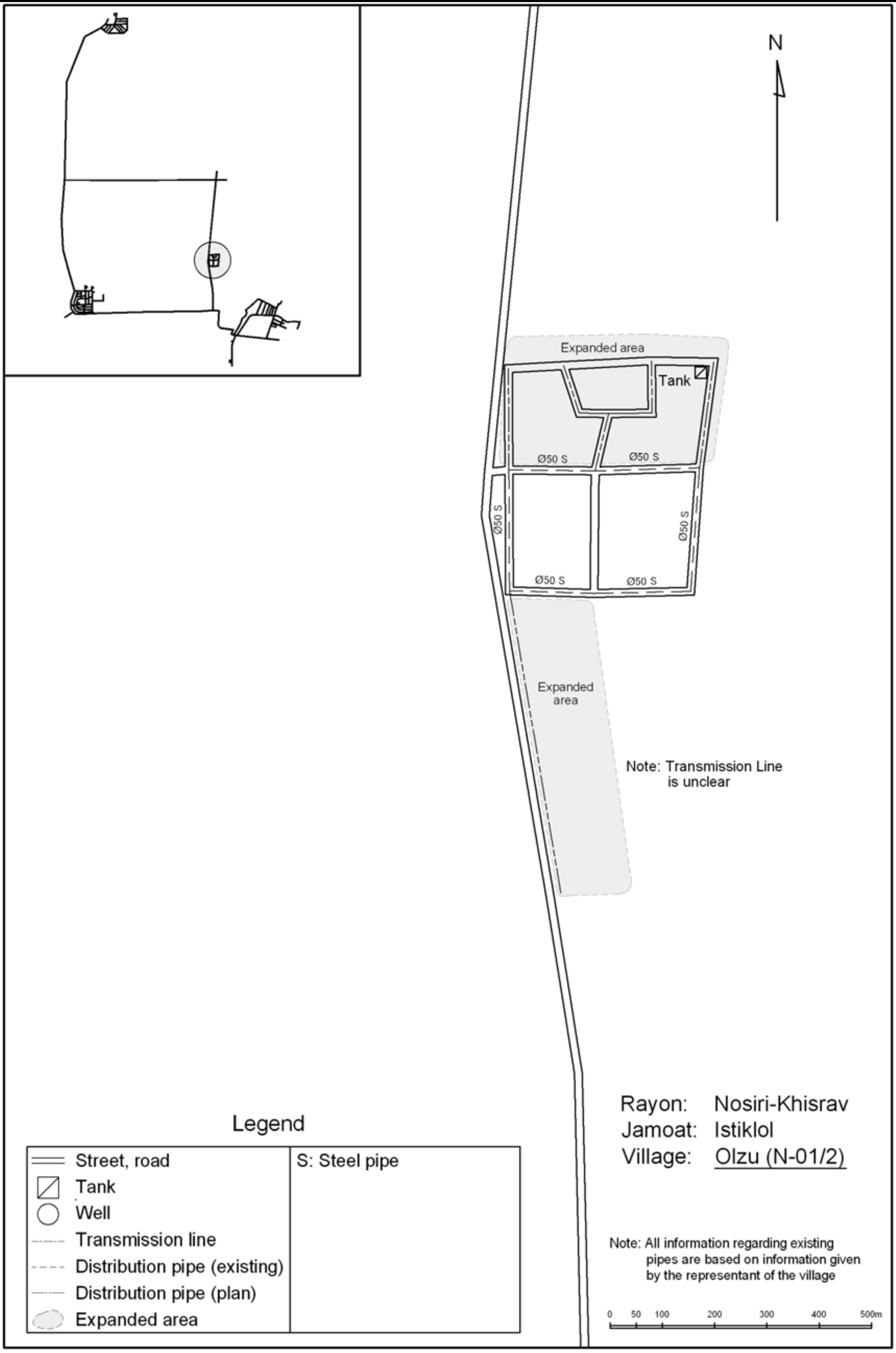

FIGURE 9.5.7 (3/5) N-1 44 CHASHMA: OLZU

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

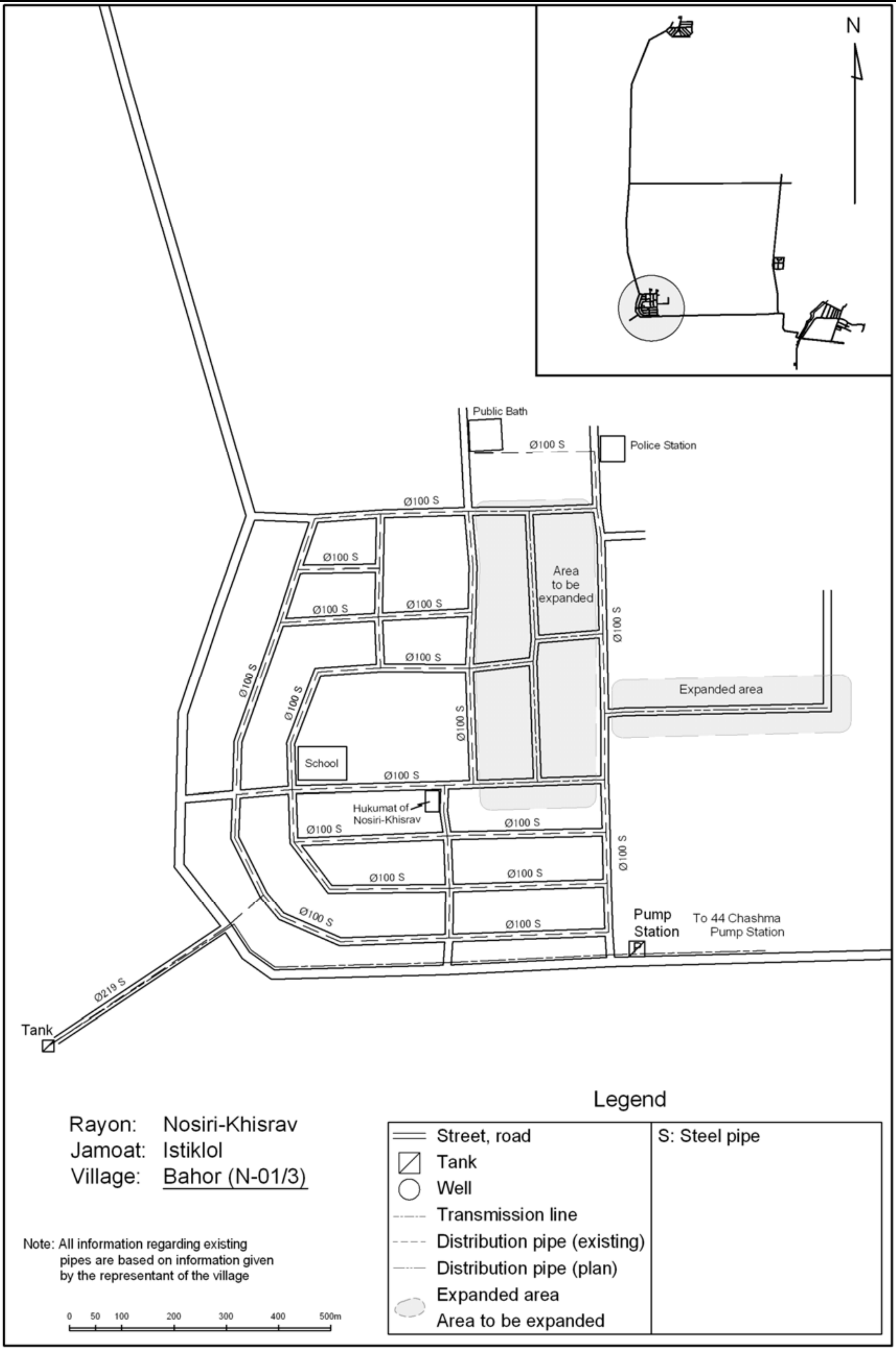

FIGURE 9.5.7 (4/5) N-1 44 CHASHMA: BAHOR

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

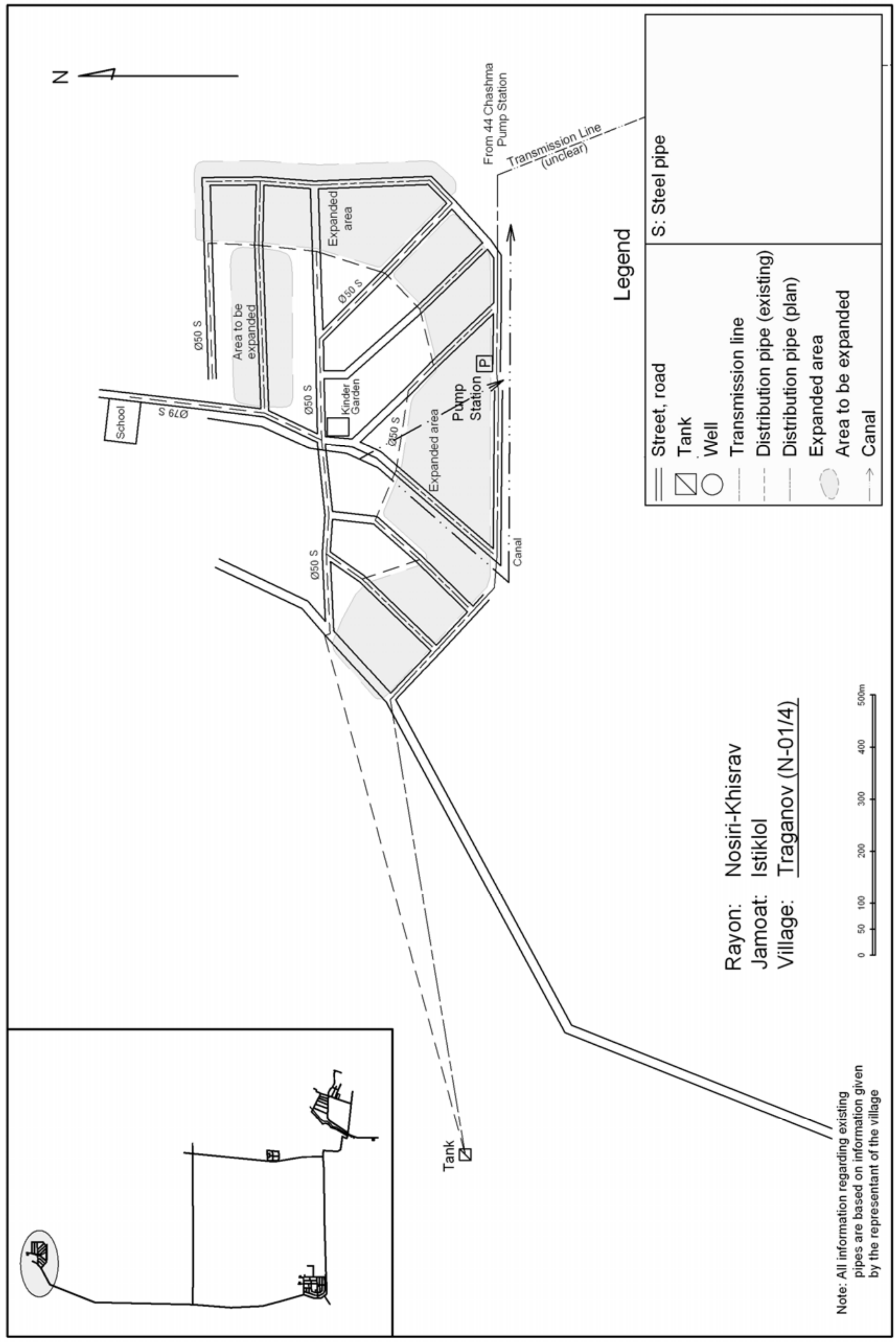

FIGURE 9.5.7 (5/5) N-1 44 CHASHMA: TRAGANOV

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**

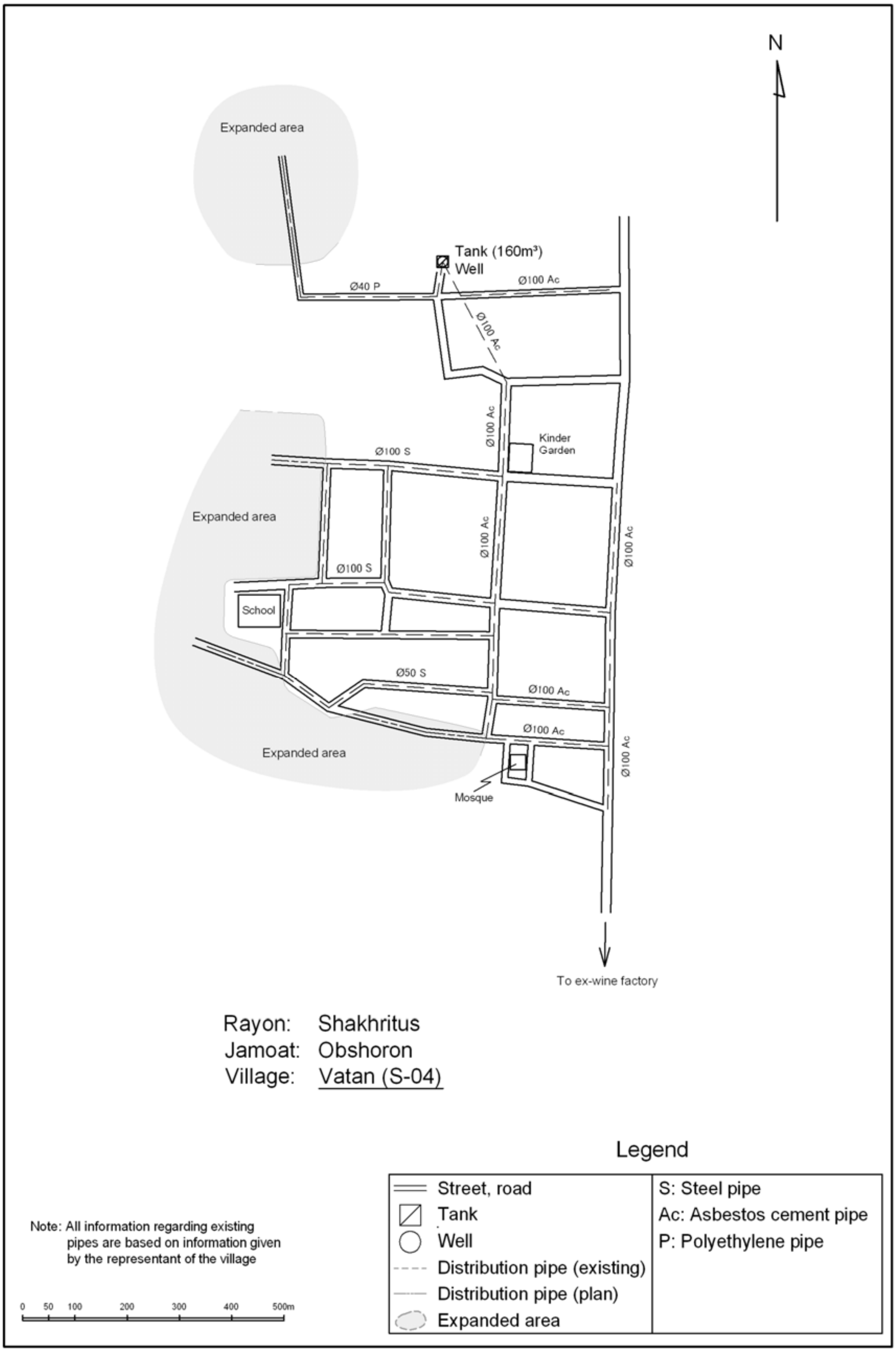

FIGURE 9.5.8 S-4 VATAN

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

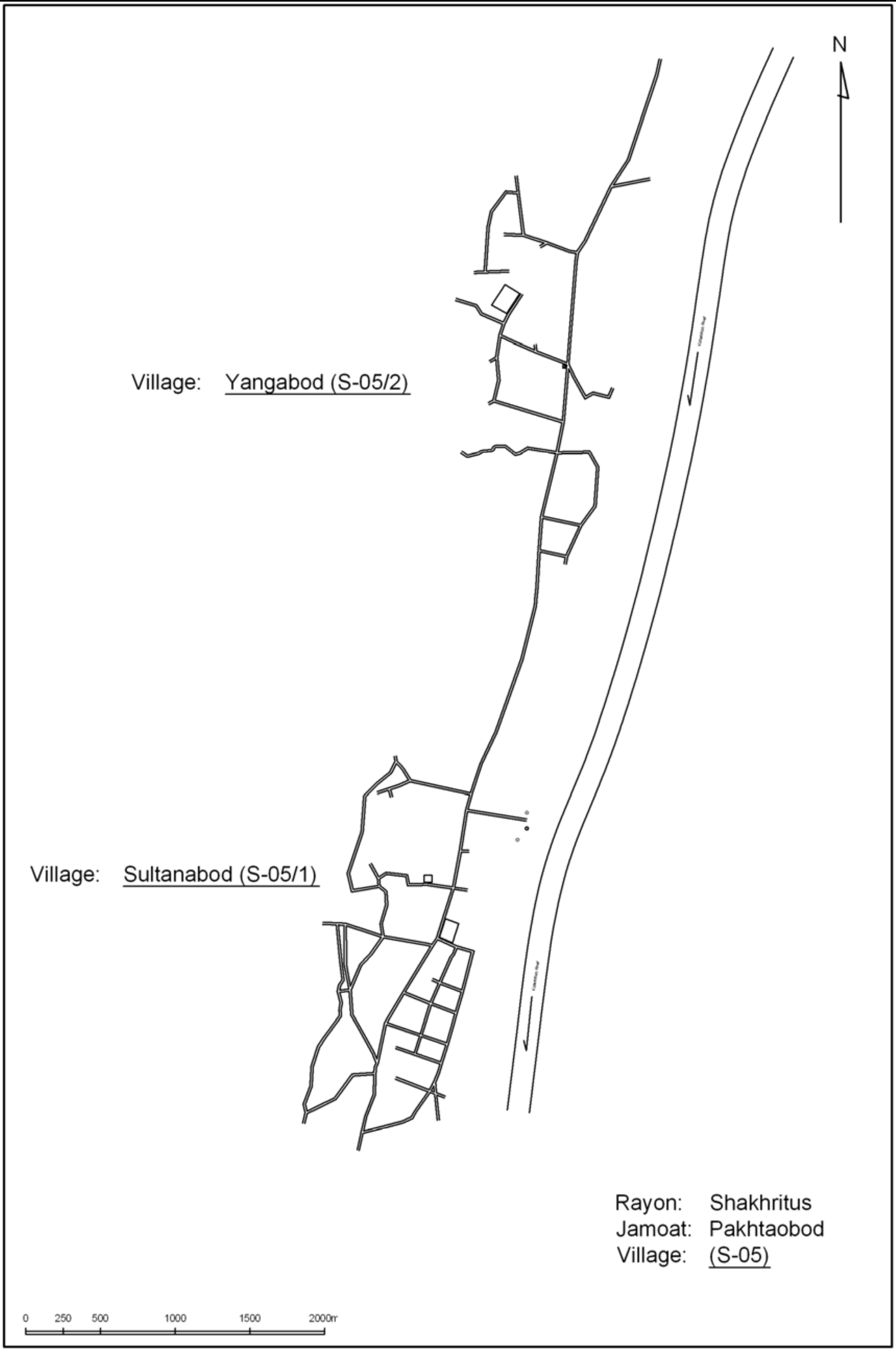

FIGURE 9.5.9 (1/3) S-5 SULTANABOD: TOTAL AREA

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**

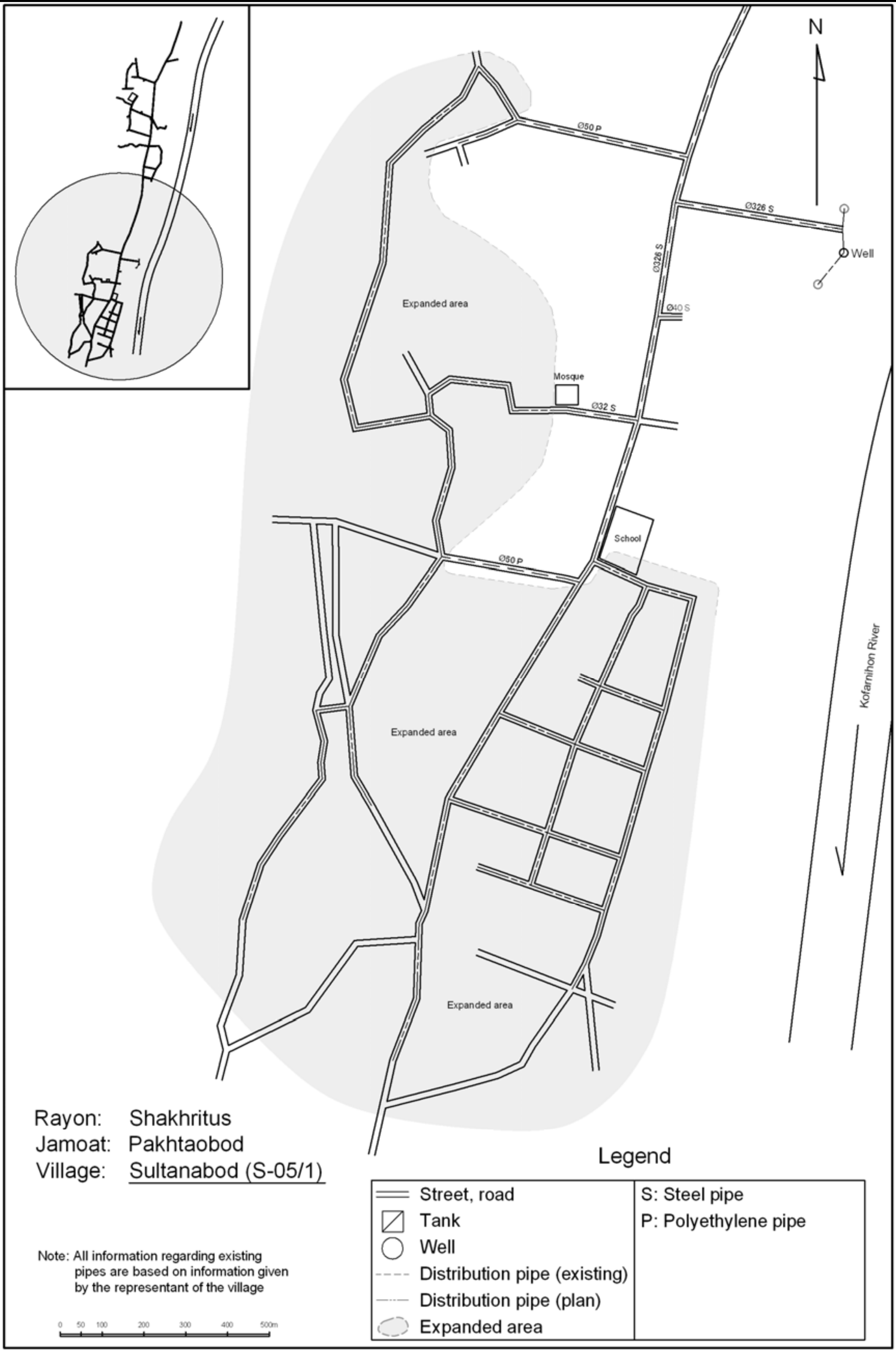

FIGURE 9.5.9 (2/3) S-5 SULTANABOD: SULTANABOD

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

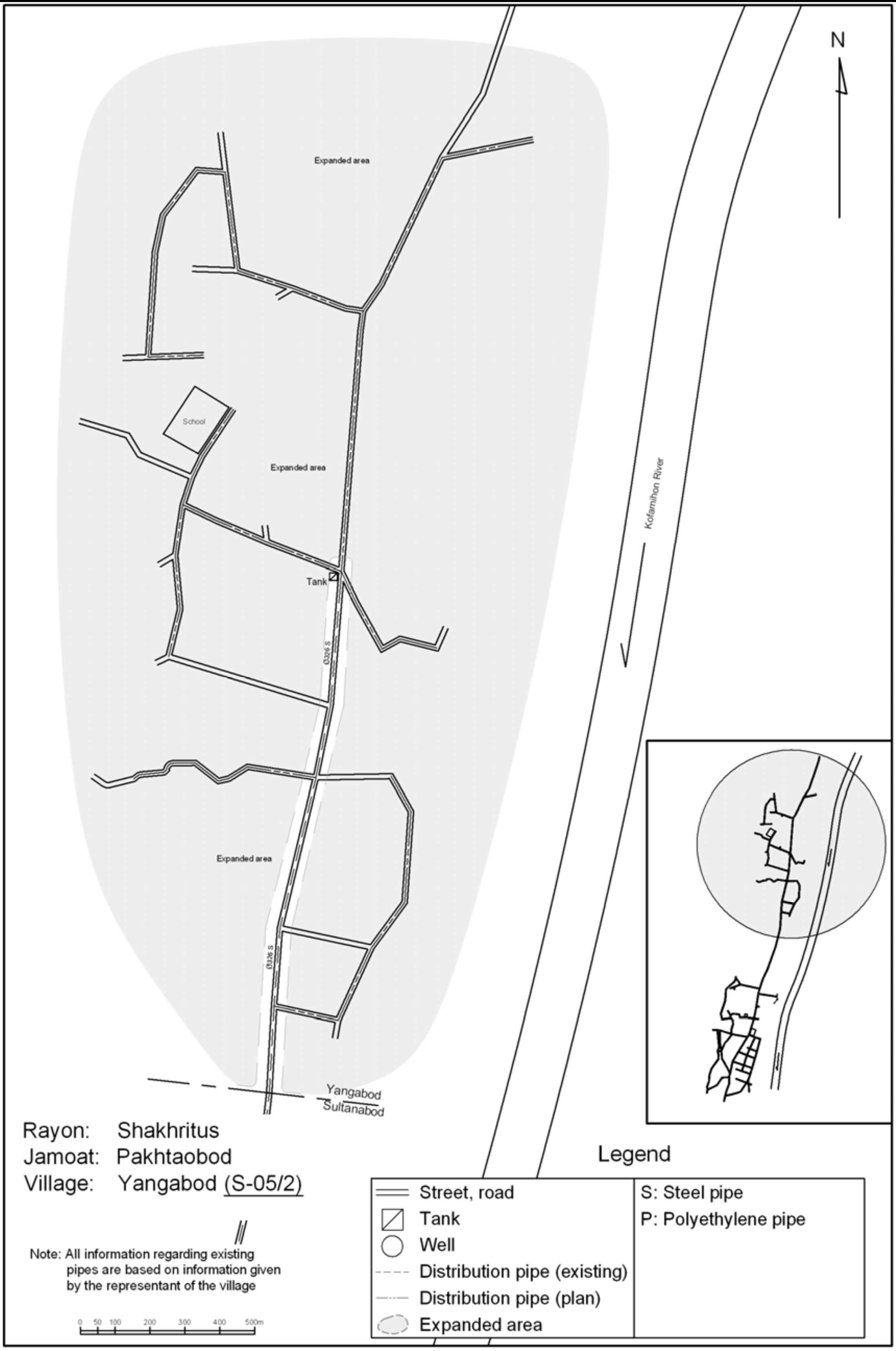

FIGURE 9.5.9 (3/3) S-5 SULTANABOD: YANGABOD

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

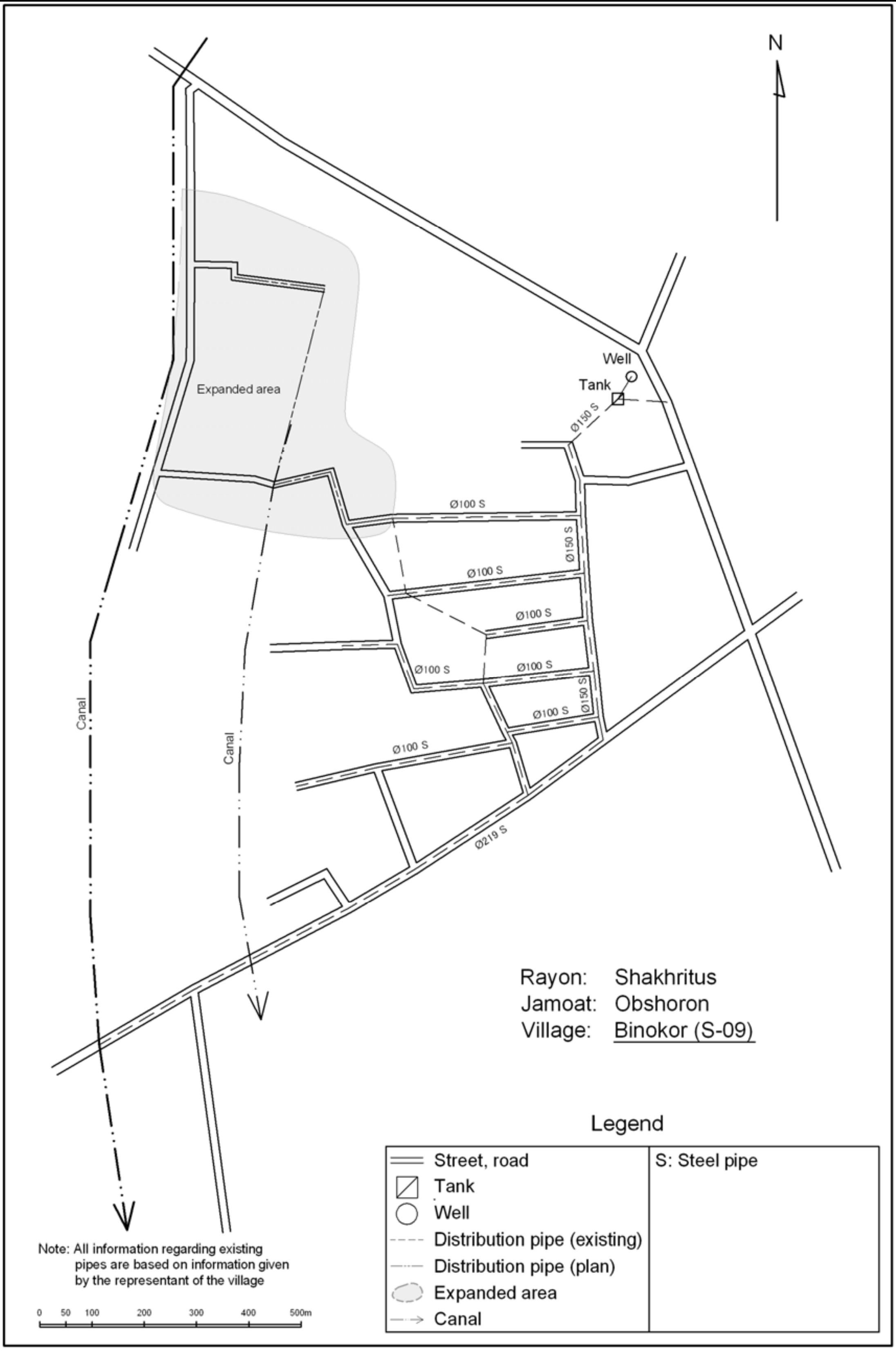

FIGURE 9.5.10 S-9 BINOKOR

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

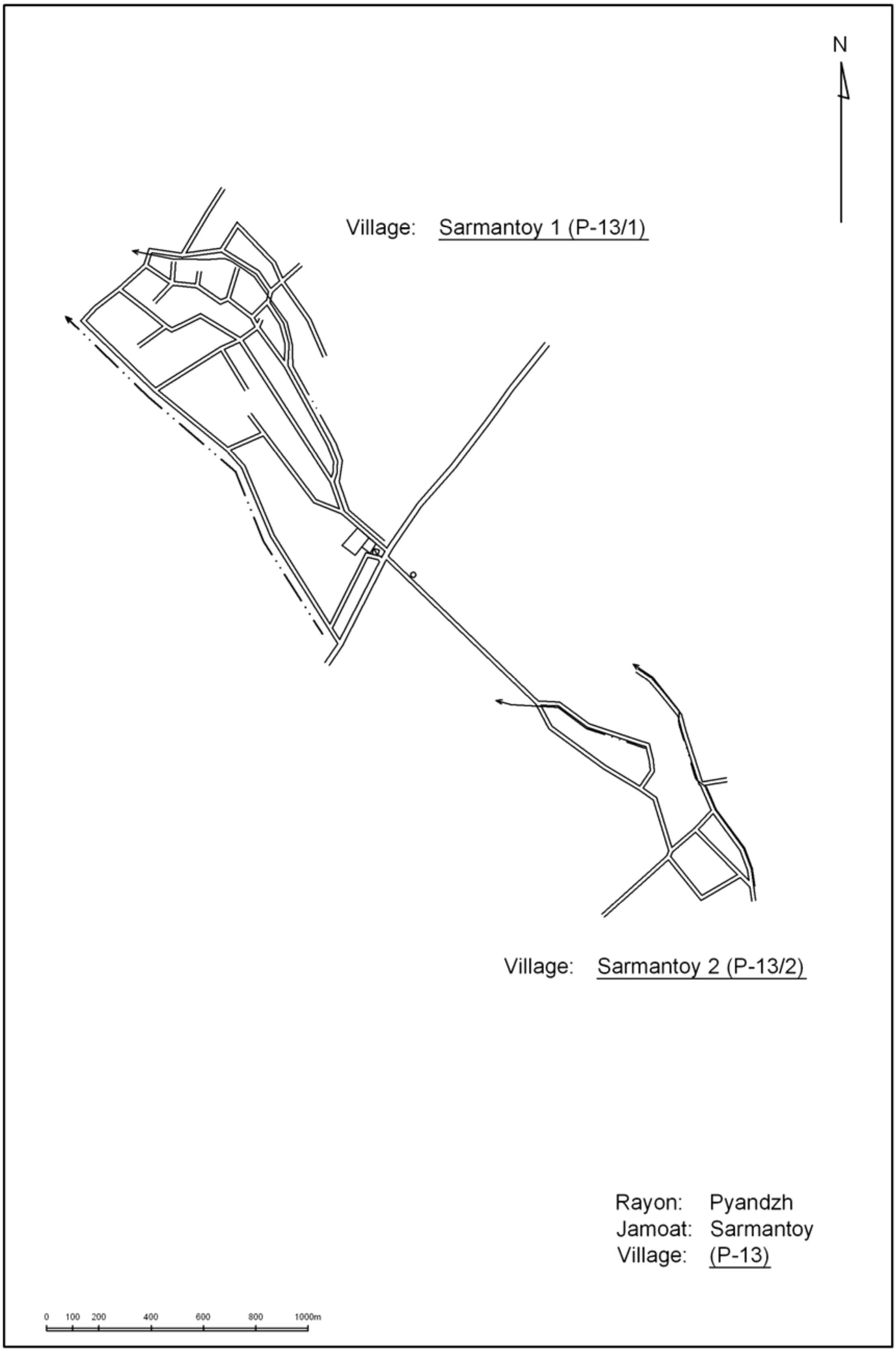

FIGURE 9.5.11 (1/3) P-13 SARMANTOY: TOTAL AREA

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**

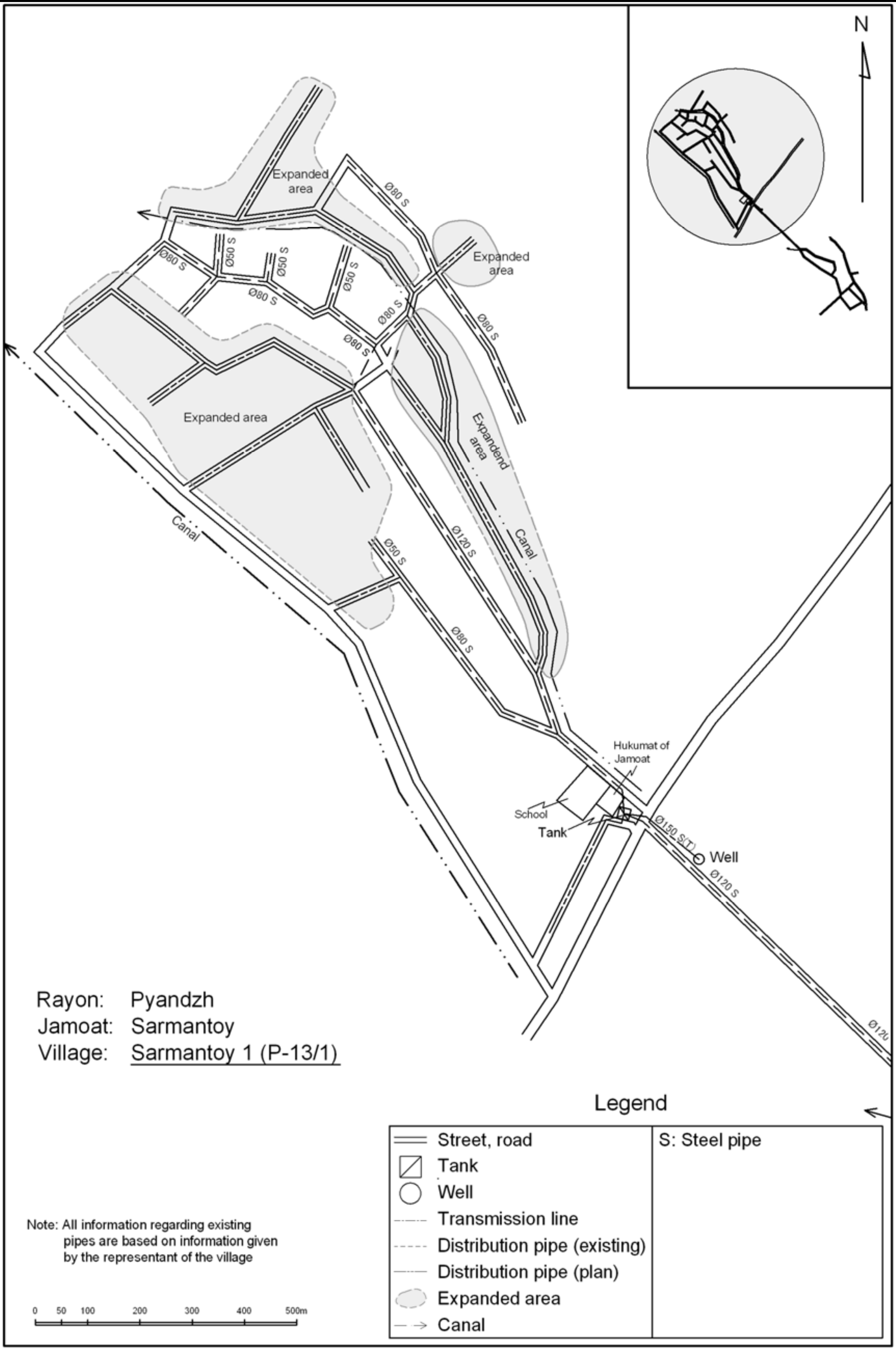

FIGURE 9.5.11 (2/3) P-13 SARMANTOY: SARMANTOY-1

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	JICA

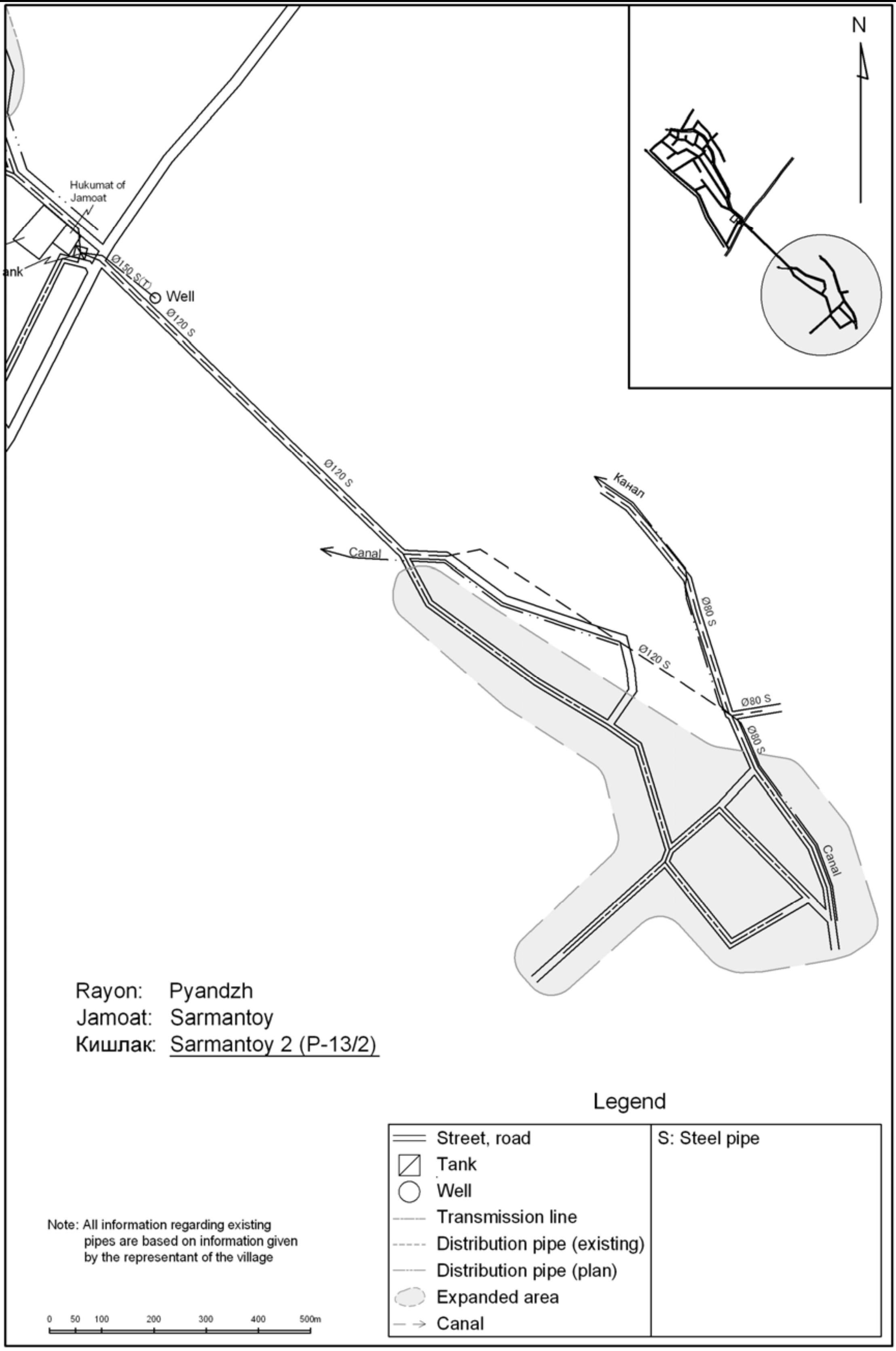

FIGURE 9.5.11 (3/3) P-13 SARMANTOY: SARMANTOY-2

THE STUDY FOR SUSTAINABLE RURAL WATER SUPPLY SYSTEM IN THE SOUTHERN KHATLON OBLAST, THE REPUBLIC OF TAJIKISTAN	**JICA**