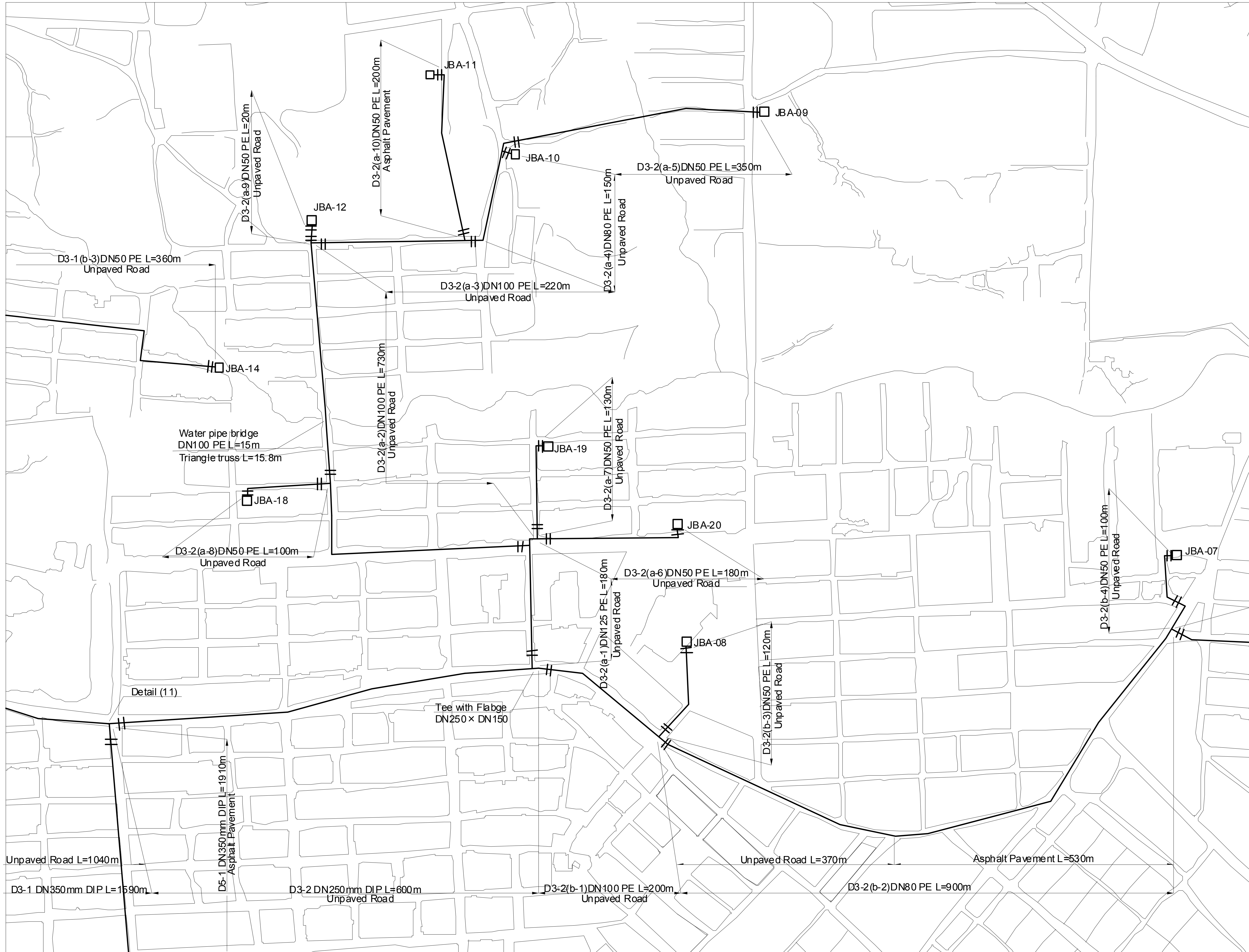
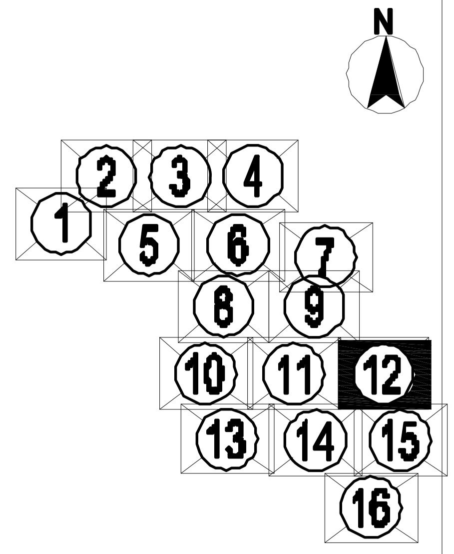
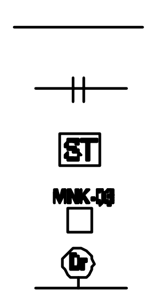



KEY PLAN

## LEGEND

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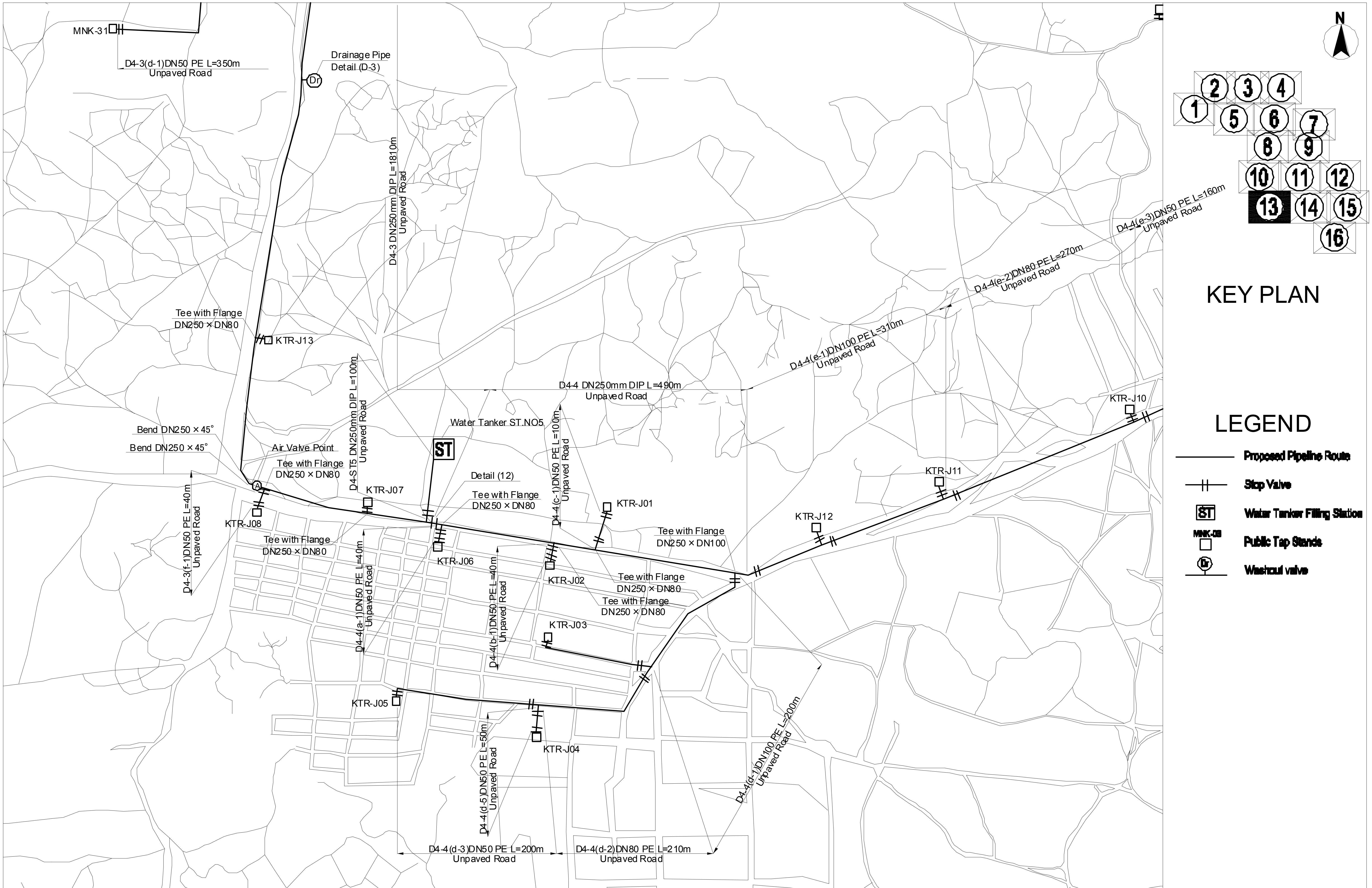
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Facility: Distribution Pipe | Title: Distribution Main and Secondary Pipelines- 12 | Scale: 1/5000 | Drawing No.: DSP-012 |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Nov. 2010 / Release: Rev. 1.0 |

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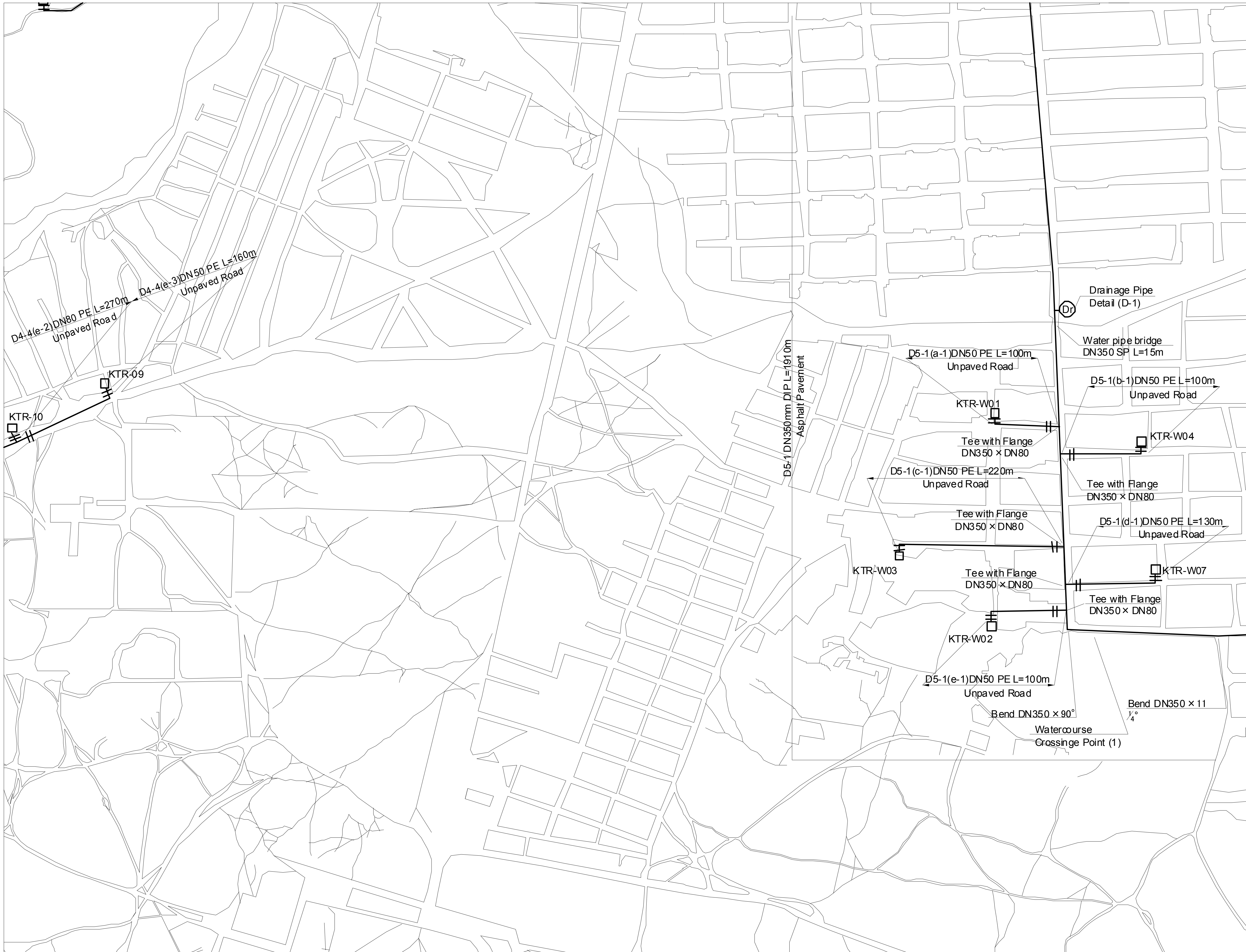
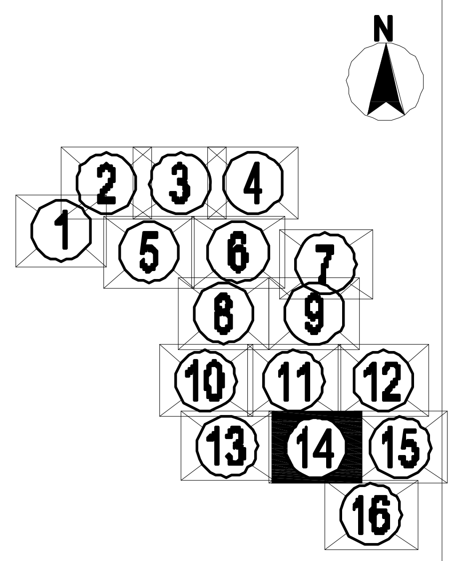
|---|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Facility: Distribution Pipe | Title: Distribution Main and Secondary Pipelines- 13 | Scale: 1/5000 | Drawing No.: DSP-013 | |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Nov. 2010 | Release: Rev. 1.0 |



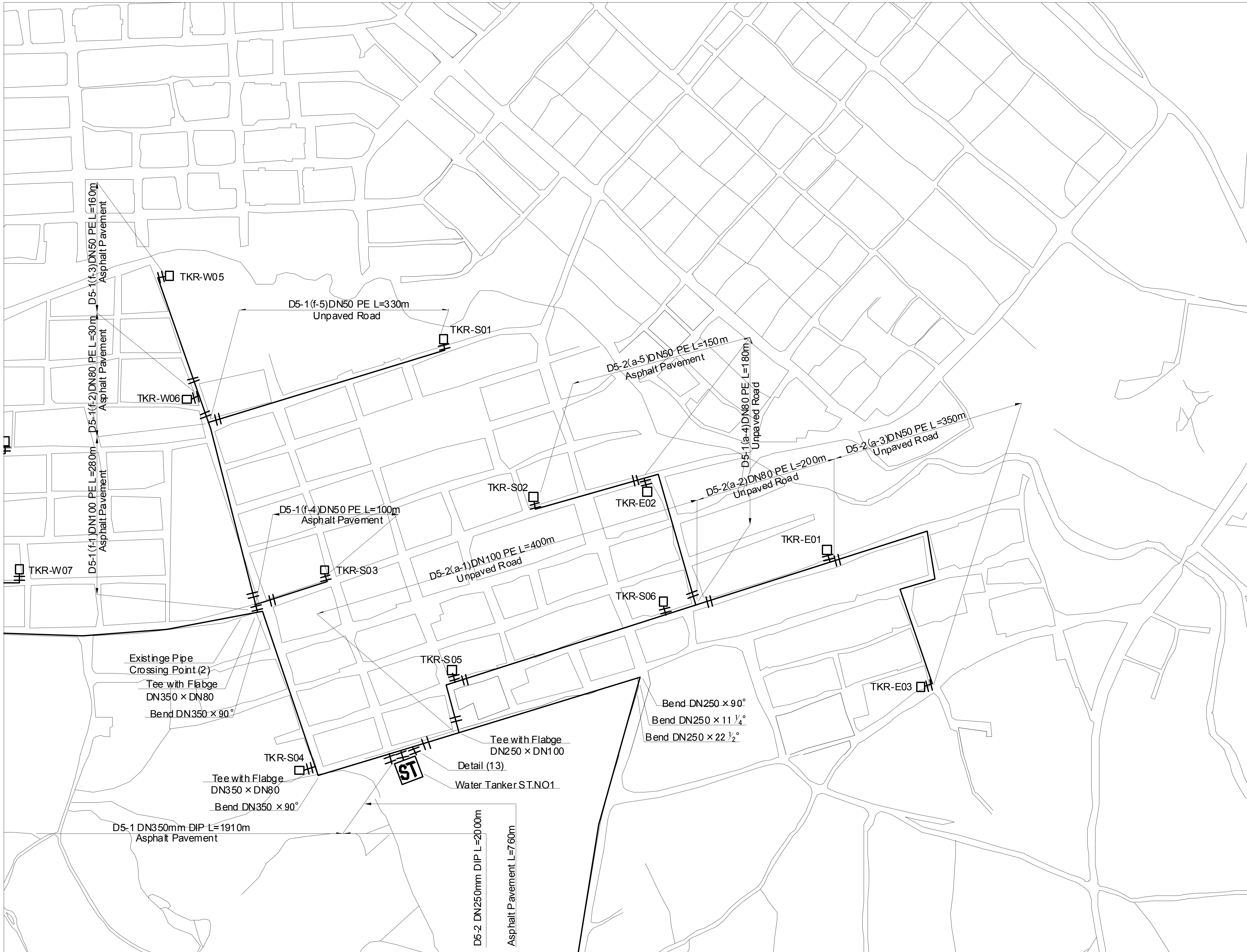



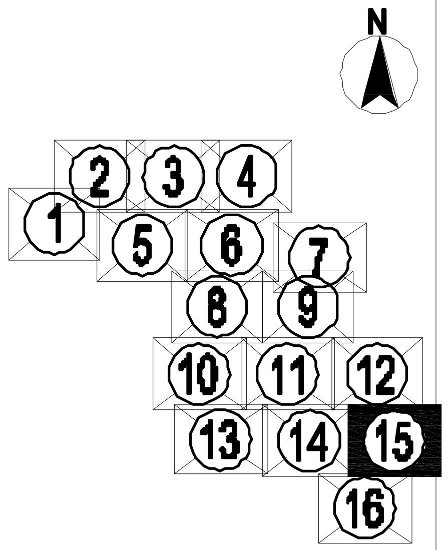

KEY PLAN

LEGEND

- Proposed Pipeline Route
- Stop Valve
- ST Water Tanker Filling Station
- MNK-03 Public Tap Stands
- Dr Washout valve

| | | | | | | |
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Facility: Distribution Pipe | Title: Distribution Main and Secondary Pipelines- 14 | Scale: 1/5000 | Drawing No.: DSP-014 |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Nov. 2010 / Release: Rev. 1.0 |



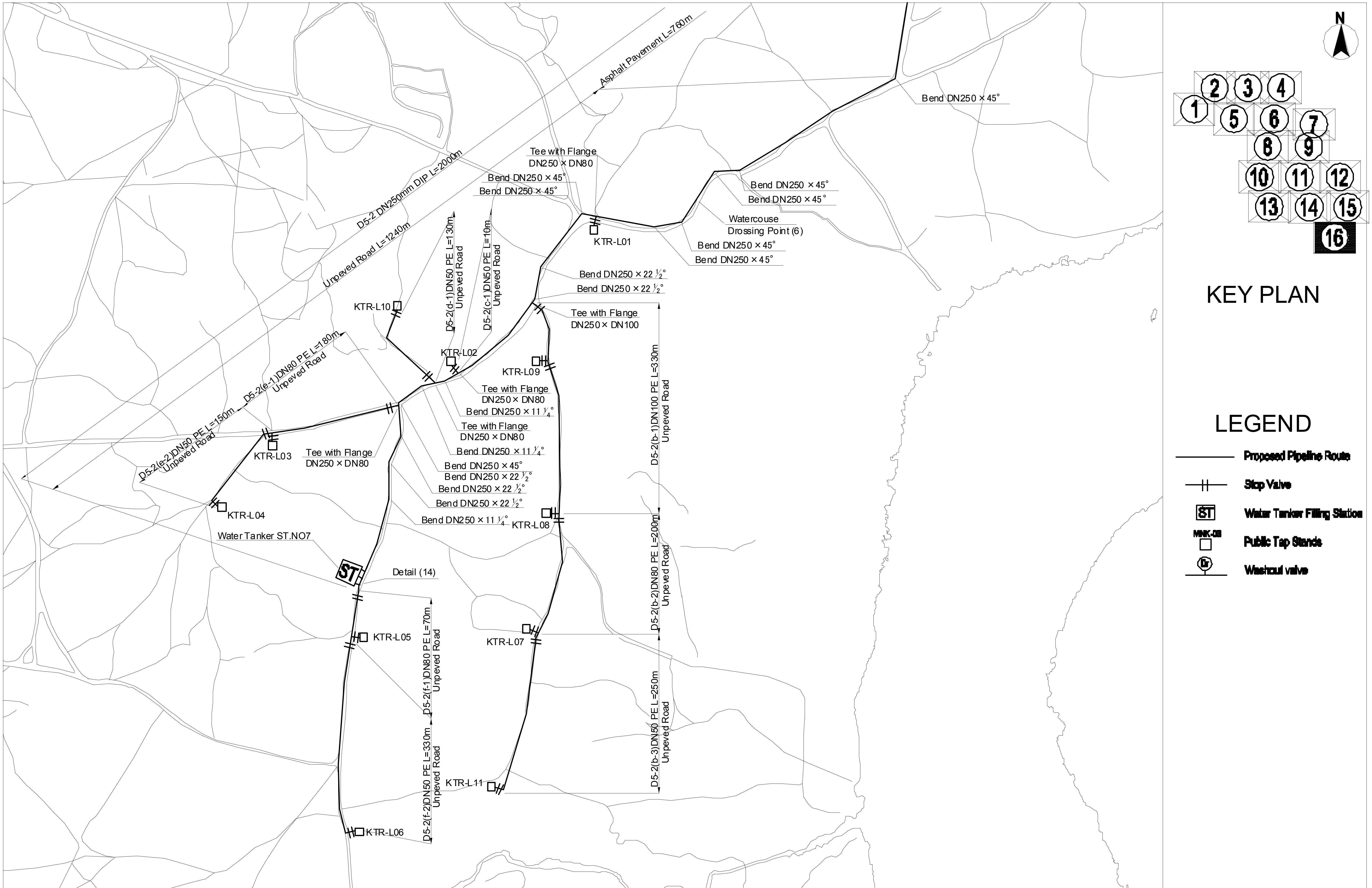




KEY PLAN

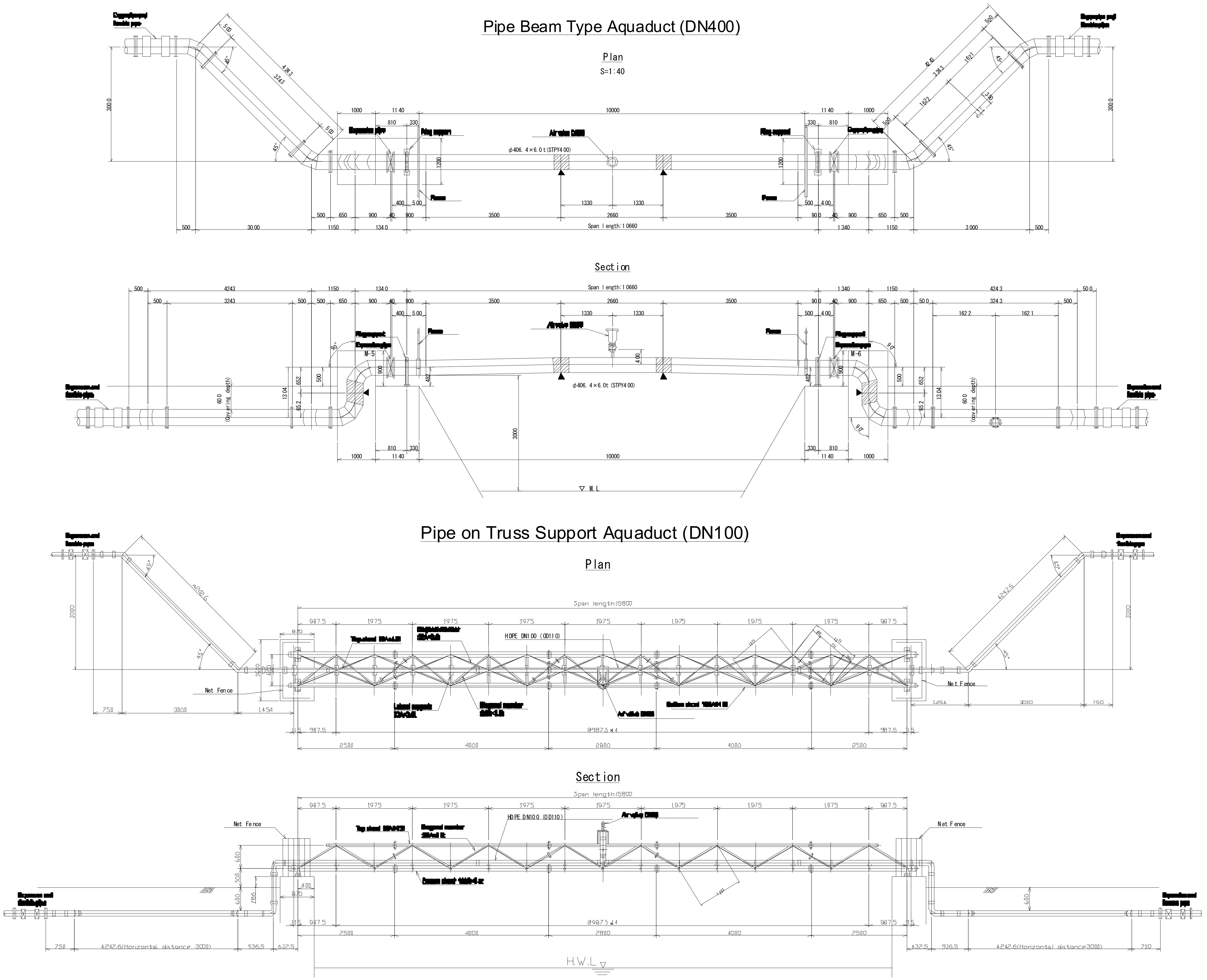
LEGEND

| | |
|---|---|
| | Proposed Pipeline Route |
| | Stop Valve |
| ST | Water Tanker Filling Station |
| MNK-03 | Public Tap Stands |
| Dr | Washout valve |

| | | | | | | |
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan<br>Southern Sudan Urban Water Corporation | Japan International Cooperation Agency (JICA)<br>Tokyo Engineering Consultants, Co., Ltd. | Facility: Distribution Pipe | Title: Distribution Main and Secondary Pipelines- 15 | Scale: 1/5000<br>Original Paper Size: A3 | Drawing No.: DSP-015<br>Date: Nov. 2010 / Release: Rev. 1.0 |




| | | | Facility: | Title: | Scale: | Drawing No.: |
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Distribution Pipe | Distribution Main and Secondary Pipelines- 16 | 1/5000 | DSP-016 |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Nov. 2010 / Release: Rev. 1.0 |

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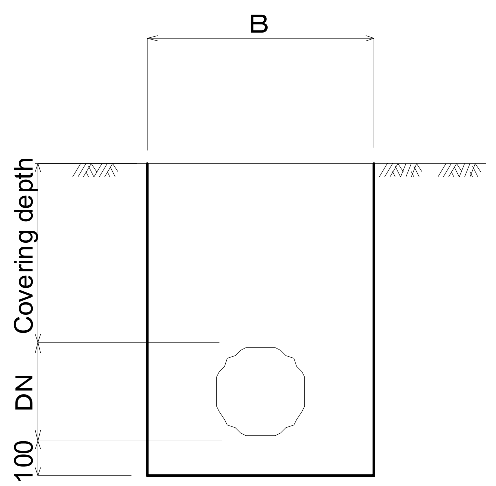
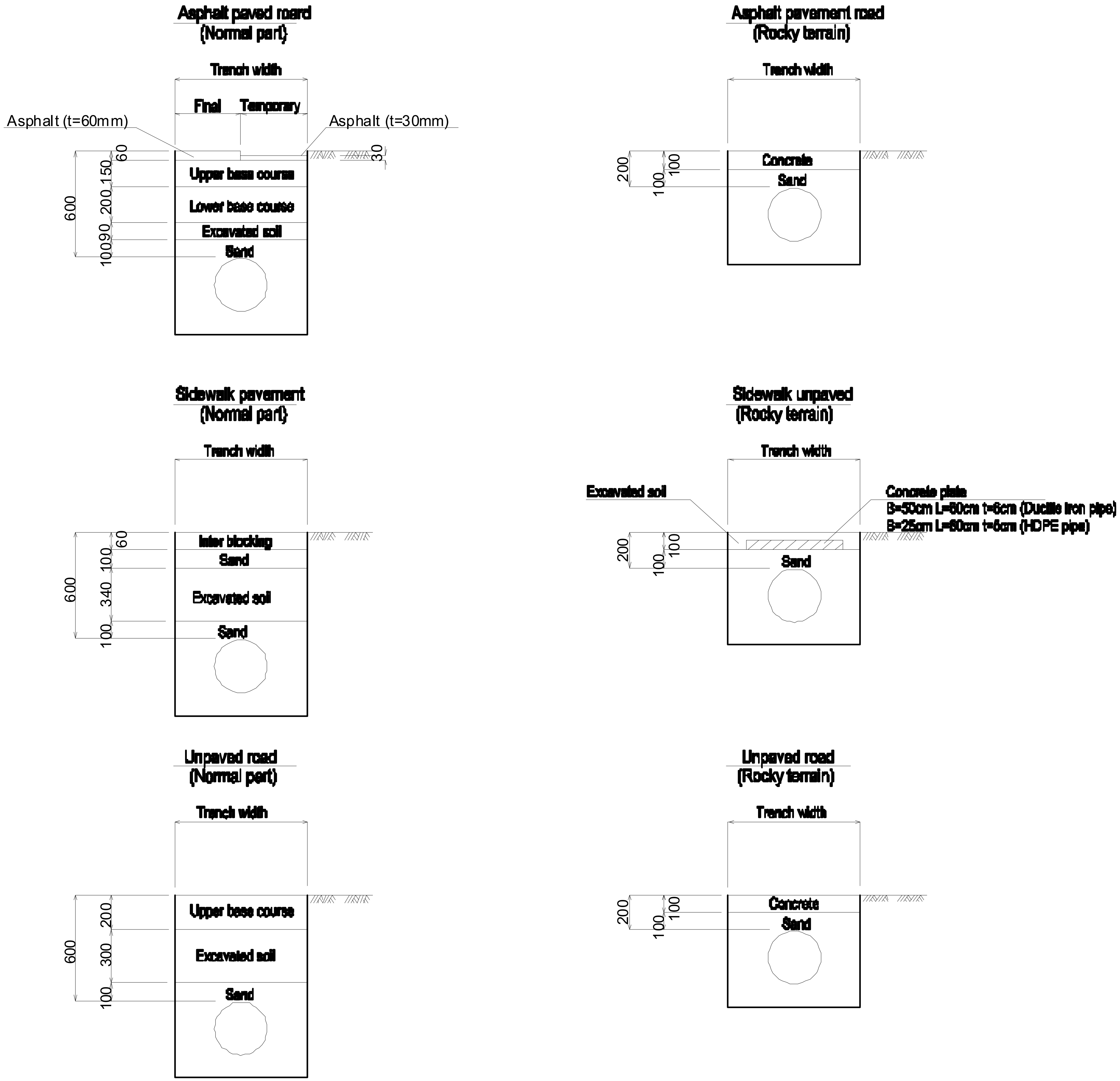
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Facility: Distribution Pipe | Title: Water Pipe Bridge | Scale: 1/100 | Drawing No.: DSP-017 |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Nov. 2010 / Revision: Rev. 1.0 |

# Standard drawing for restoration of pavement

## Standard Trench Section




| DN | B |
|---|---|
| 50 | 500 |
| 80 | 500 |
| 100 | 500 |
| 125 | 500 |
| 150 | 500 |
| 200 | 500 |
| 250 | 500 |
| 300 | 520 |
| 350 | 570 |
| 400 | 630 |
| 450 | 680 |
| 500 | 730 |

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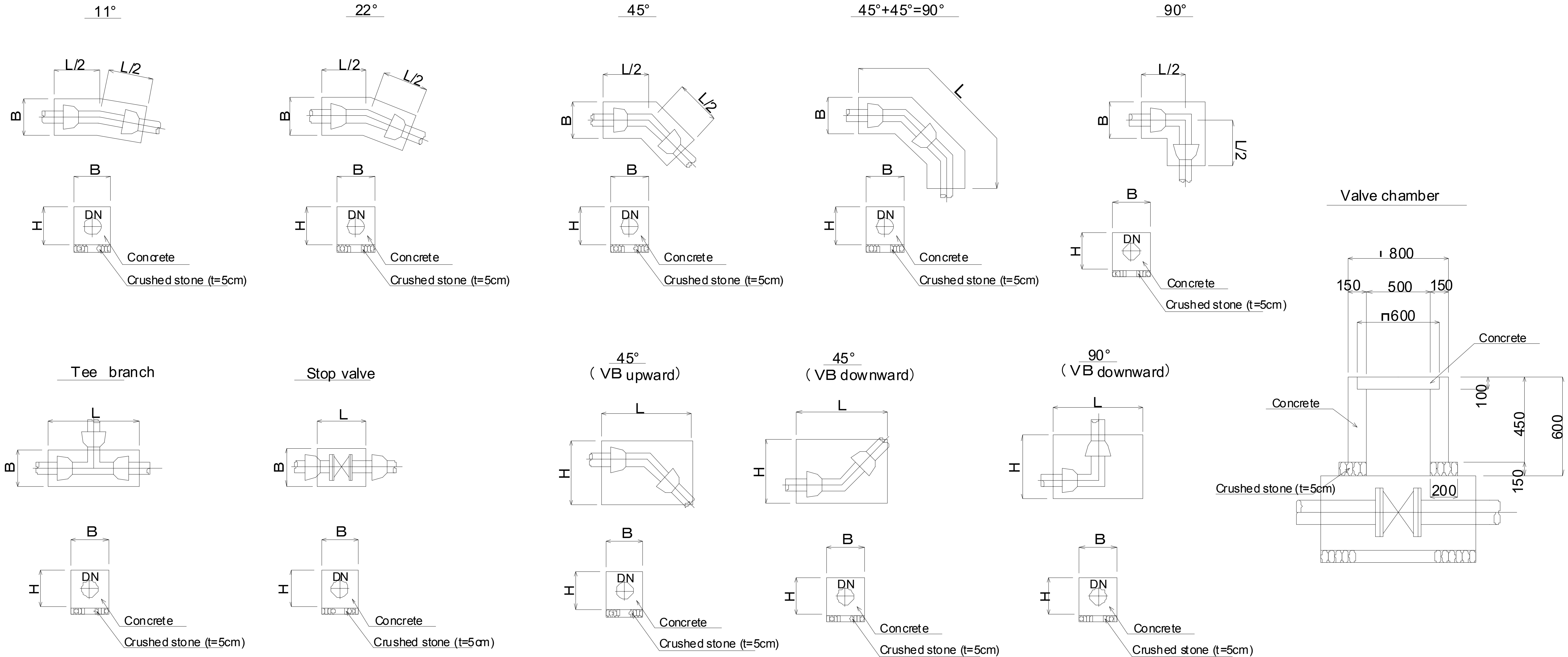
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resources and Irrigation Government of Southern Sudan / Southern Sudan Urban Water Corporation | Japan International Cooperation Agency (JICA) / Tokyo Engineering Consultants, Co., Ltd. | Facility: Transmission Pipeline | Title: Typical Section | Scale: NON / Original Paper Size: A3 | Drawing No.: DSP-018 / Date: Nov. 2010 / Revision: Rev. 1.0 |

# Concrete Thrust Anchor Block

( Static water pressure 1.0Mpa Surge pressure 0.50Mpa )




(mm)

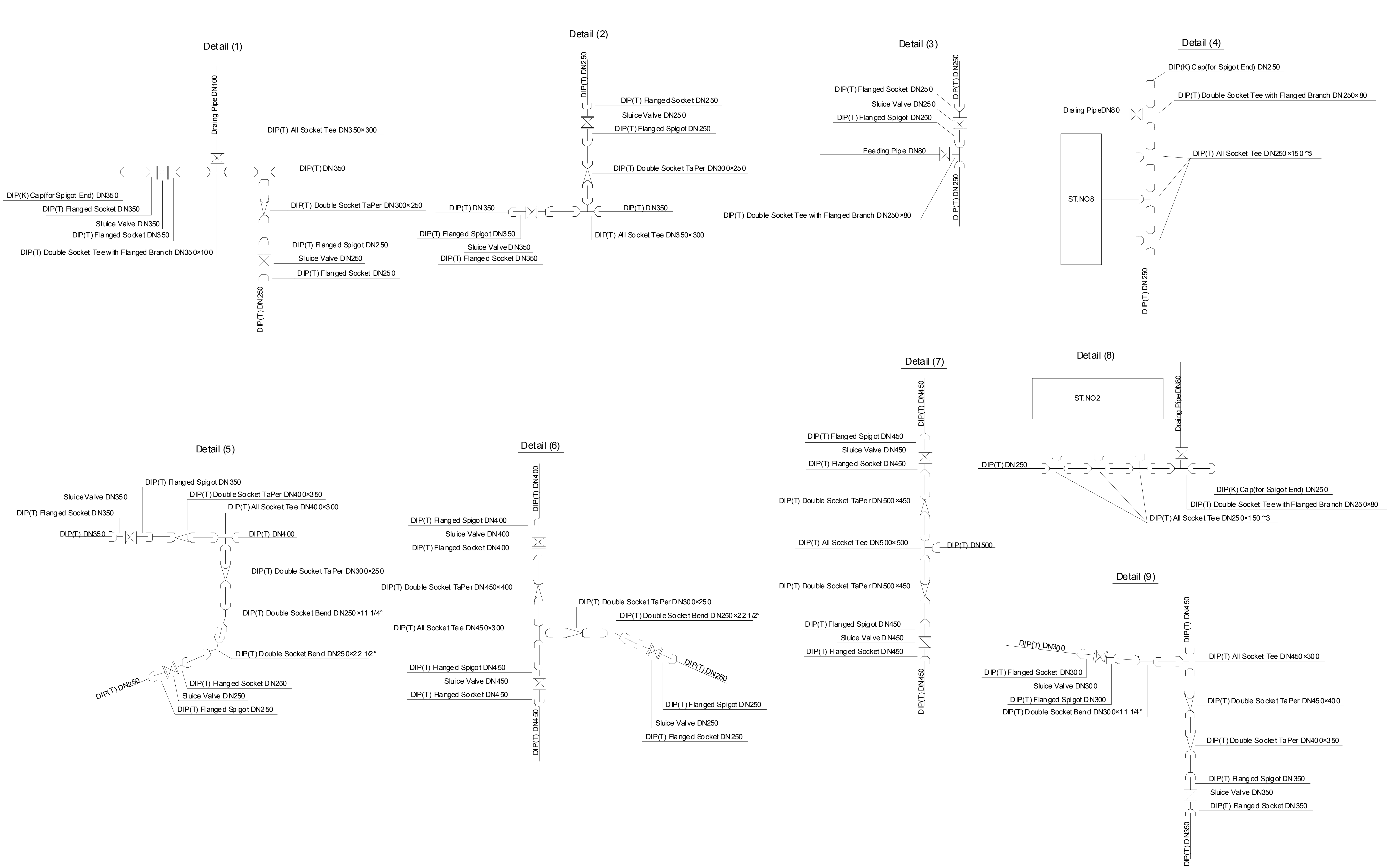
| DN | 11° B | 11° H | 11° L | 22° B | 22° H | 22° L | 45° B | 45° H | 45° L | 45°+45°=90° B | 45°+45°=90° H | 45°+45°=90° L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| 125 | | | | | | | | | | | | |
| 150 | | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 250 | 700 | 700 | 800 | 1000 | 1000 | 1100 | 1200 | 1200 | 1700 | 1600 | 1200 | 2800 |
| 300 | 800 | 800 | 1000 | 1200 | 1200 | 1200 | 1400 | 1200 | 2200 | 2100 | 1200 | 3000 |
| 350 | 900 | 900 | 1200 | 1300 | 1200 | 1500 | 1700 | 1200 | 2500 | 2300 | 1200 | 3600 |
| 400 | 1000 | 1000 | 1200 | 1500 | 1200 | 1700 | 2000 | 1200 | 2700 | 2500 | 1200 | 4000 |
| 450 | 1200 | 1200 | 1200 | 1700 | 1200 | 1900 | 2200 | 1200 | 3000 | 2700 | 1200 | 4400 |
| 500 | 1300 | 1200 | 1400 | 1800 | 1200 | 2200 | 2500 | 1200 | 3200 | 3000 | 1200 | 4600 |

| DN | 90° B | 90° H | 90° L | Tee branch B | Tee branch H | Tee branch L | Stop valve B | Stop valve H | Stop valve L |
|---|---|---|---|---|---|---|---|---|---|
| 50 | | | | | | | 300 | 250 | 300 |
| 80 | | | | | | | 500 | 450 | 600 |
| 100 | | | | | | | 650 | 500 | 900 |
| 125 | | | | | | | 650 | 600 | 900 |
| 150 | | | | | | | 850 | 700 | 1200 |
| 200 | | | | | | | 1200 | 900 | 1400 |
| 250 | 1600 | 1200 | 2800 | 1300 | 1200 | 2100 | 1400 | 1200 | 1500 |
| 300 | 2100 | 1200 | 3000 | 1600 | 1200 | 2600 | 1800 | 1200 | 1700 |
| 350 | 2300 | 1200 | 3600 | 1900 | 1200 | 2900 | 2150 | 1200 | 1800 |
| 400 | 2500 | 1200 | 4000 | 2300 | 1200 | 3000 | 2350 | 1200 | 2200 |
| 450 | 2700 | 1200 | 4400 | 2600 | 1200 | 3200 | 2500 | 1200 | 2800 |
| 500 | 3000 | 1200 | 4600 | 2800 | 1200 | 3500 | 2800 | 1200 | 3000 |

| DN | 45° Upward vertical band B | 45° Upward vertical band H | 45° Upward vertical band L | 45° Downward vertical band B | 45° Downward vertical band H | 45° Downward vertical band L | 90° Downward vertical vend B | 90° Downward vertical vend H | 90° Downward vertical vend L |
|---|---|---|---|---|---|---|---|---|---|
| 50 | | | | | | | | | |
| 80 | | | | | | | | | |
| 100 | | | | | | | | | |
| 125 | | | | | | | | | |
| 150 | | | | | | | | | |
| 200 | | | | | | | | | |
| 250 | — | — | — | — | — | — | 1600 | 1600 | 1900 |
| 300 | — | — | — | — | — | — | — | — | — |
| 350 | 1700 | 1200 | 2800 | 1700 | 1200 | 1700 | 2000 | 2000 | 2300 |
| 400 | 2100 | 1200 | 3000 | 2100 | 1200 | 1800 | 2200 | 2200 | 2400 |
| 450 | — | — | — | — | — | — | 2400 | 2400 | 2600 |
| 500 | — | — | — | — | — | — | — | — | — |

| | | | | | | |
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Facility: Distribution Pipe | Title: Thrust Anchor Block | Scale: NON | Drawing No.: DSP-019 |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Nov. 2010 / Revision: Rev. 1.0 |

# Detail OF Distribution Pipe (1)

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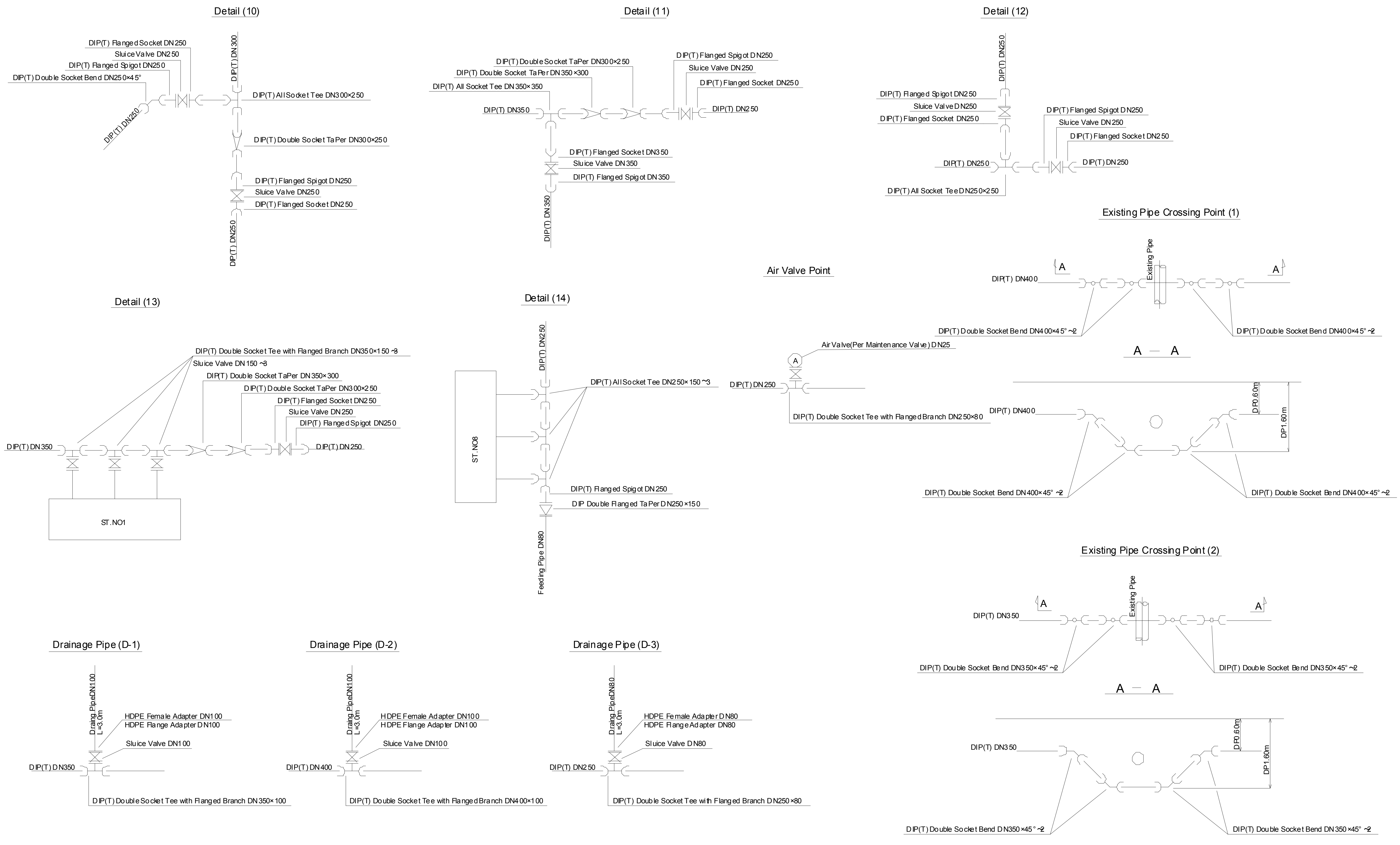
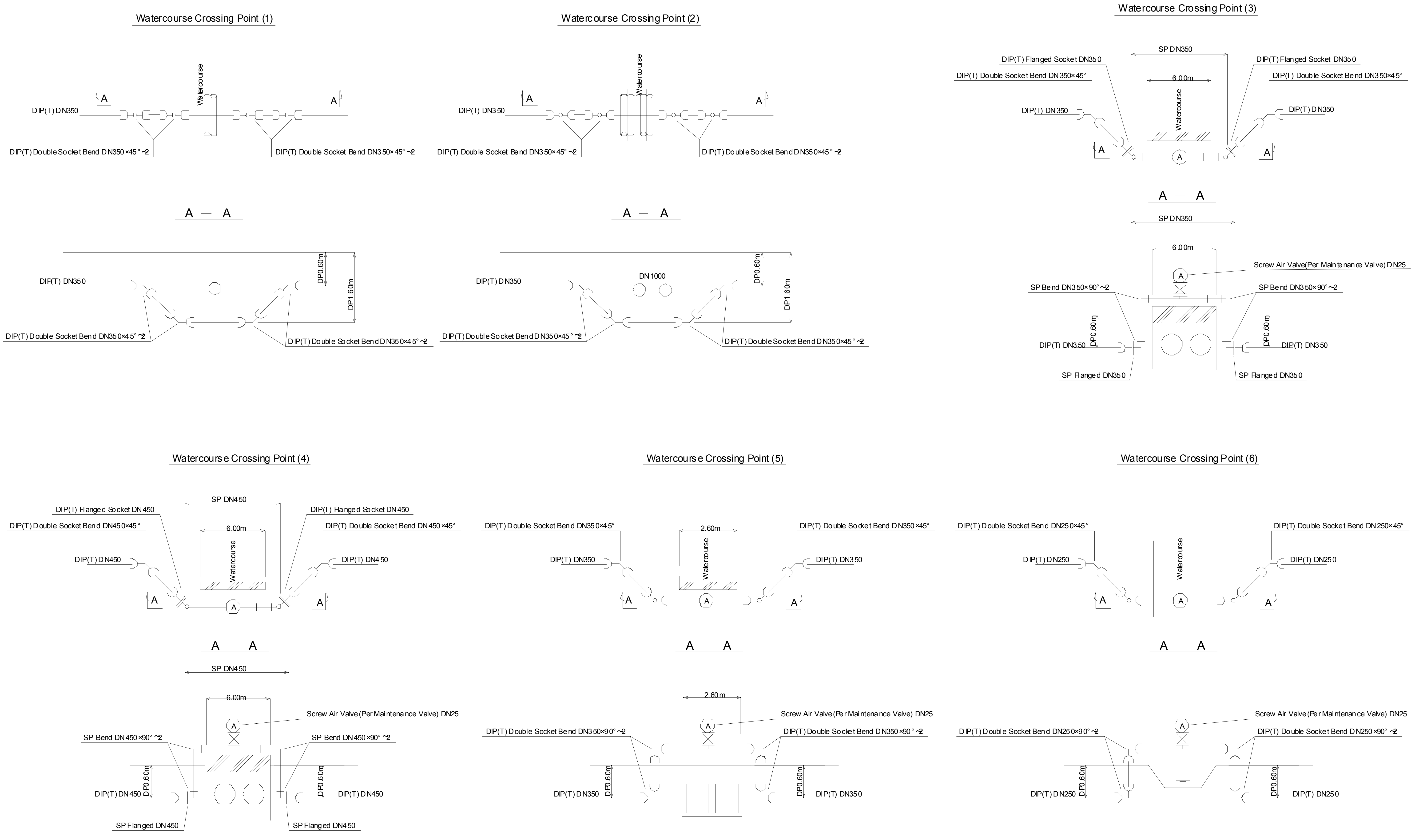
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Facility: Distribution Pipe | Title: Details of Distribution Pipe (1) | Scale: NONE | Drawing No.: DSP-020 |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Mar. 2011 / Revision: Rev. 2.0 |

# Detail OF Distribution Pipe (2)




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Facility: Distribution Pipe | Title: Details of Distribution Pipe (2) | Scale: NON | Drawing No.: DSP-021 | |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Nov. 2010 | Revision: Rev. 1.0 |

# Detail OF Distribution Pipe (3)




| | | | | | | |
|---|---|---|---|---|---|---|
| The Project for the Improvement of Water Supply System of Juba in Southern Sudan | Ministry of Water Resrources and Irrigation Government of Southern Sudan | Japan International Cooperation Agency (JICA) | Facility: Distribution Pipe | Title: Details of Distribution Pipe (3) | Scale: NON | Drawing No.: DSP-022 |
| | Southern Sudan Urban Water Corporation | Tokyo Engineering Consultants, Co., Ltd. | | | Original Paper Size: A3 | Date: Nov. 2010 / Revision: Rev. 1.0 |

# Appendix-8 Design Calculation

# Examination on Water Treatment Process

## 1. Raw water quality and target treated water quality

The substances to be removed in the treatment process is insoluble substances of about 30 NTU. The target treated water quality is set as 5 NTU of less according to the Draft Drinking Water Quality Guideline Value of Southern Sudan.

In the Development Study, three items of total iron, aluminum and antimony are pointed out the possibility of exceeding the guideline value. Among them, iron and aluminum are to be removed through the conventional coagulation and rapid filtration. Re-examination was carried out for antimony in this preparatory survey. As a result, it was confirmed that antimony contents is less than 0.002 mg/L which is lower than the guideline value of 0.005mg/L.

| | Target water quality (Drinking Water Quality Guideline Value of Southern Sudan) | Raw water quality | Remarks |
|---|---|---|---|
| Turbidity | 5NTU or less | 16.6 - 56.9NTU | Development Study (October 2008 – May 2009, 13 samples) |
| | | 0.89 - 48.5NTU (14.15NTU on average) | Operation record of the existing plant (April 2009 – September 2009, 125 samples) |
| Antimony | 0.005mg/L or less | Less than 0.002mg/L | Confirmed in this preparatory survey |

From the above, the design criteria is formed as bellow.

| Item | Criteria | Remarks |
|---|---|---|
| Production Capacity | 10,800m$^3$/day | |
| Turbidity of Raw Water | Ave. 15NTU, Max.60NTU | From water quality test results |
| Temperature of Raw Water | Ave. 28.4℃, Max.31℃ | From operation record of existing plant (Ave. 28.4℃, Min. 25℃, Max.30.8℃) |

## 2. Items to be taken into account from the evaluation of existing plant

Given the above raw water quality as well as target water quality, applicable water treatment processes are to be either of coagulation, sedimentation and rapid filtration, or membrane filtration. Considering the level of operation and maintenance technique, compatibility with the existing plant, economy, etc. the coagulation, sedimentation and rapid filtration is appropriate and adopted as the treatment process of the Project. Items to be taken into account in examination of the treatment process are as follows.

- According to operation record of the existing plant (April 8, 2009 – September 14, 2009) , turbidity of the treated water is average 1.87NTU, minimum 0.41NTU and maximum 5.1NTU, that almost meet the guideline value. However, it exceeds in some days.
- The existing facility is insufficient in coagulation due to inappropriate dosing point of coagulant dosage. And formation of flock is insufficient due to lack of retention time in flocculation basin (approx. 0.76 min.). This results in insufficiency of removal effect of the sedimentation basin.
- The existing sedimentation tank was originally designed as the solid-contact clarifier. However, in practice, it is operated as the conventional upflow sedimentation basin which doesn't form the sludge blanket zone. Currently, one out of two basins is stopped and emptied for a half day in two-three weeks in order to de-sludging and cleaning. In this case, water flow is not properly controlled that allows excessive water flow into the other operating basin which causes carrying-over of flock from the effluent. In addition, operation is re-started before sludge is thoroughly de-sludged, that causes stirring of sludge in the bottom and muddy water flows into the filter bed.
- The existing filtration basin has non-cascade type inflow and outflow is not controlled, that causes unequal inflow to the filter basins. This results in degradation of treated water due to excessive flow into a basin which is not clogged compared to the others. Water level of the outlet of filter is designed to be lower than the surface of filter bed, which causes little water level above sand bed. Therefore, surface of filter bed is easily disturbed in the beginning of filtration, which causes uneven filtration and instability of water quality due to negative pressure. Currently filter backwashing is performed once in a day. However, possibility of mad ball is pointed out due to insufficiency of washing time.
- Since the proposed facility is planned to be constructed in the existing plant site, constraints of land availability shall be taken into account.

## 3. Design of Sedimentation Tank

Considering that raw water quality is approx. 30 NTU in turbidity, constraints of land availability and level of operation technique, conventional upflow sedimentation tank is adopted. Since the conventional upflow sedimentation tank is not specified in the "Water Supply Facility Design Guideline (JWWA: Japan Water Works Association, 2000)", guideline values of "Integrated Design for Water Treatment Plant (1995, JWWA)" are referred to. Considering the level of operation technique, sludge scraper is installed as the existing plant.

Comparison on Sedimentation Tank

| Type | Horizontal flow | Solid-contact | Conventional upflow (Adopted in the Project) |
|---|---|---|---|
| Surface load | 15～30mm/min※1 | 40～60mm/min※1 | 22～31mm/min※2 |
| Required settling area | $275m^2$ or more | $138m^2$ or more | $266m^2$ or more |
| Retention time | 2.2 ～ 4.5 hours (Effective depth: 4m) | 1.5～2.0 hours※1 | 1.0～3.0 hours※2 |
| Applicable to intermittent operation | Applicable | Not applicable | Applicable |
| Site | Difficult to layout rectangular basin (1:3～1:8) | Possible to layout | Possible to layout |

※ 1 "Water Supply Facility Design Guideline（2000）"
※ 2 "Integrated Design for Water Treatment Plant（1995）"

Design Specification of Sedimentation Tank

| Item | Specification | Remarks |
|---|---|---|
| Production capacity (Q) | $11{,}880m^3$/day ($8.25m^3$/min) | $10{,}800m^3$/day×1.1（Plant loss 10%） |
| Number of tanks（N） | 2 tanks | 「Design Guideline」 |
| Surface load ($S_L$) | 29.1mm/min | 「Design Guideline」: 15～30mm/min（horizontal flow）<br>「Integrated design」: 22～31mm/min |
| Settling area（$A_0$） | $283.2m^2$ | $Q(m^3/min) \div S_L \times 10^{-3}(m/min)$ |
| Area per one tank（A） | $141.6m^2$/tank | 11.9m×11.9m（square） |
| Effective depth（H） | 5.3m | 「Integrated design」: 3～5m（radial upflow） |
| Effective volume（V） | $1{,}501m^3$ | $A(m^2) \times N$（tank）$\times H(m)$ |
| Retention time（T） | 3.03hours | $V(m^3) \div Q(m^3/day)$<br>「Design Guideline」: 2.2～4.5hours<br>「Integrated design」: 1.0～3.0hours |
| Weir overflow rates | $135m^3$/m/day | $Q(m^3/day) \div$（11.9m×4nos.×2tanks）<br>「Design Guideline」: $350m^3$/m/day or less<br>「Integrated design」: $168m^3$/m/day or less（radial upflow）<br>「Water Treatment (AWWA)」: $250m^3$/m/day or less(Conventional basin) |

In the proposed sedimentation tank, coagulation and flocculation process is enhanced so as to improve the removal efficiency of the sedimentation tank, while this process is not performed well in the existing plant. Desludging of the tank of the proposed facility will be carried out with ease by opening drain valve regularly without emptying the tank which is a practice done in the existing plant. Accordingly, current issues of overloading and dirty water intrusion will be prevented.

## 4. Design of Filter Basin

### (1) Items to be Taken into account

The following items are taken into account to design the new filtration facility.

1) Whereas the existing filter basin allows more water into a basin which is less clogged compared to the others, the proposed facility is equipped with inflow weir which allows equal inflow to the filter basin.

2) Water level of the outlet of filter is lower than the surface of filter bed, which causes disturbance of filter bed and uneven filtration. The outlet pipe of the proposed filter will be positioned at higher than the filter bed so as to keep the appropriate water level above sand bed. Therefore, filter bed will not be exposed in operation stop. In restarting, filtration rate increases according to increase of water level in filter bed (slow-start) which will not affect treated water quality.

3) The proposed filter bed will be equipped with drain of unstable quality of water immediately after the backwashing.

### (2) Examination on Filter Media

Rapid sand filtration is a final process of turbid removal where micro-flock not removed from the sedimentation tank is adhered to the filter media. From the retention amount of turbidity in the filtration as well as filtration hours, diameter of filter media is examined as follows.

Filtration hours are decided by turbidity of inflow and retention amount of turbidity. In case that size of filter media is 0.6mm in diameter with uniformity coefficient of 1.4 (Design Guideline of Water Supply Facility, Japan), filter works in the surface layer. Given this, retention amount of SS (Suspended Solid) is reported as 1.3-1.5 kg/m$^2$ from the pilot experiment by the filter media manufacture (Nihon Genryo Co., Ltd.). By using these data, design conditions are summarized as below:

**Turbidity of Inflow and Filtration Hours**

| ①Production capacity ($m^3$/day) | ②Turbidity of inflow (Degree)※1 | ③Load of inflowing turbidity (kg) | ④Total filter area ($m^2$) | ⑤Retention amount of turbidity (kg/$m^2$) | ⑥Filtration hours (1): 1.3kg/$m^2$ (Hr) | ⑦Filtration hours (2): 1.5kg/$m^2$ (Hr) |
|---|---|---|---|---|---|---|
| 11,880 | 20<br>(28.6 NTU) | 237.6 | 96.2 | 2.47 | 12.6 | 14.6 |
| 11,880 | 18 | 213.8 | 96.2 | 2.22 | 14.1 | 16.2 |

| ①Production capacity ($m^3$/day) | ②Turbidity of inflow (Degree)※1 | ③Load of inflowing turbidity (kg) | ④Total filter area ($m^2$) | ⑤Retention amount of turbidity ($kg/m^2$) | ⑥Filtration hours (1): 1.3kg/$m^2$ (Hr) | ⑦Filtration hours (2): 1.5kg/$m^2$ (Hr) |
|---|---|---|---|---|---|---|
| | (25.7 NTU) | | | | | |
| 11,880 | 16 (22.9 NTU) | 190.1 | 96.2 | 1.98 | 15.8 | 18.2 |
| 11,880 | 14 (20.0 NTU) | 166.3 | 96.2 | 1.73 | 18.0 | 20.8 |
| 11,880 | 12 (17.1 NTU) | 142.6 | 96.2 | 1.48 | 21.1 | 24.3 |
| 11,880 | 10 (14.3 NTU) | 118.8 | 96.2 | 1.23 | 25.4 | 29.3 |
| 11,880 | 8 (11.4 NTU) | 95 | 96.2 | 0.99 | 31.5 | 36.4 |
| 11,880 | 6 (8.6 NTU) | 71.3 | 96.2 | 0.74 | 42.2 | 48.6 |
| 11,880 | 5 (7.1 NTU) | 59.4 | 96.2 | 0.62 | 50.3 | 58.1 |
| 11,880 | 4 (5.7 NTU) | 47.5 | 96.2 | 0.49 | 63.7 | 73.5 |
| 11,880 | 2 (2.9 NTU) | 23.8 | 96.2 | 0.25 | 124.8 | 144.0 |

※1: Since turbidity is of silt matters, 1 degree of turbidity is equivalent to 1mg－SS/L.  1 NTU＝0.7 degree of turbidity as shown in the bracket.

As average and maximum turbidity of raw water is 15 and 60NTU respectively, filtration hours is expected to be approx. 63 hours (see the case of inflow turbidity 4NTU, retention amount 1.30kg/$m^2$) on condition that 6 NTU from the sedimentation tank. In operation of the facility, 48 hours of filtration hours are proposed in practice.

In case that filtration by whole layer by using filter media of about 1.0 mm is designed, filtration hours can be longer than the above case. However, this requires more thickness of filter bed and backwash water. Also there is a possibility of coarse effects of filtration. Therefore, in this Project size of filter media is designed to be 0.6mm as aforementioned.

### (3) Specification of filtration basin

Comparison between existing and proposed filtration basin is shown in table below.

| | Existing Facility | Proposed Facility |
|---|---|---|
| Type | Open type gravity flow | Open type gravity flow |
| Filtration area | 63 $m^2$ | 96.2 $m^2$ |
| Number of filter basin | 4basin（15.75$m^2$ per basin） | 6 basin（19.24$m^2$ per basin, including one standby） |
| Filtration rate | 120 m/day | 123 m/day |
| Filter media | Diameter: 0.7mm, Sand layer:750mm | Diameter: 0.6mm, Sand layer:700mm |
| Supporting gravel | Gravel layer: 450mm | Gravel layer: 200mm |
| Backwashing | Air + backwash | Air + backwash |

| | | |
|---|---|---|
| Backwash water | 0.83 m/min × 15.75$m^2$/basin × 10min=131$m^3$ | 0.70 m/min × 19.24$m^2$/basin × 6min=80.8$m^3$ |
| Under drain | Perforated pipe | Perforated block |
| Backwash tank | 150$m^3$, Head:12m | 137.9$m^3$, Head:4m |

# I　Intake Facility
## 1．Intake Pipe

1. Condition
① Intake capacity Q＝ 10,800 × 1.1 ＝ 11,880 [m3/day] ＝ 0.14 [m3/sec]
② No. of pipe N＝ 3 [nos] (inlcuding one standby) N' ＝ N － 0 ＝ 3 [nos]
③ Velocity 3 [m/sec] or less (Design Guideline for Water Supply Facility)

2. Required pipe diameter
On assuming velocity V＝ 1.5 [m/sec]

$$A = \frac{Q}{N' \times V} = \frac{0.14}{3 \times 1.5} = 0.0311 \quad [m^2]$$

$$\phi = \sqrt{(A \times 4/\pi)} = 0.199 \quad [m] \rightarrow \Phi 250mm$$

3. Summary

| | | |
|---|---|---|
| Diameter | φ250 | [mm] |
| Pipe No. | 3 | [nos] |
| Hydraulic gradient | 11.1 | [‰] |
| Velocity | 1.43 | [m/sec] |

## 2．Intake Pump

1. Condition
① Intake capacity Q＝ 10,800 × 1.1 ＝ 11,880 [m3/day] ＝ 8.25 [m3/min]
② No. of pump 3 [units] (including one standby)

2. Discharge capacity per pump
On assuming No. of pumps: 2 [units]

Q＝ Q÷ N＝ 8.25 ÷ 2.0 ＝ 4.125 [m3/min] 0.1375

3. Head
Given intake pipe = 80m, and transmission pipe = 70m, pipe head loss is:
$\triangle h_1$＝ I1×L1 ＋ I2×L2 ＝ 80 × 11.1 ‰＋ 70 × 4.1 ‰＝ 1.18 [m]

Actual head required:
$\triangle h_2$＝ 465.00 － 450.47 ＝ 14.53 [m]
(HWL of receiving well) (LWL of river)

Head loss around pump:
$\triangle h_3$＝ ＝ 5.00 [m]

Consequently, required pump head is:
$\triangle H = \triangle h_1 + \triangle h_2 + \triangle h_3$ ＝ 20.71 [m]

3. Summary

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Specification | φ200 | [mm] × | 4.1 | [m3/min] × | 21 | [m] × | 30 | [kW] |
| Number of pump | 3 | [units] | | | | | | |

## 3．Raw Water Transmission Pipe

1. Condition
① Intake capacity Q＝ 10,800 × 1.1 ＝ 11,880 [m3/day] ＝ 0.14 [m3/sec]
② number of pipe N＝ 1 [nos]
③ Velocity 3 [m/sec] or less (Desgin Guideline for Water Supply Facility)

2. Required pipe diameter

On assuming velocity: $V = \boxed{1.5}$ [m/sec]

$$A = \frac{Q}{V} = \frac{0.14}{1.5} = 0.0933 \quad [m^2]$$

$$\phi = \sqrt{(A \times 4/\pi)} = \boxed{0.345} \ [m] \rightarrow \Phi 400mm$$

3. Summary

| | | |
|---|---|---|
| Pipe diameter | $\phi$400 | [mm] |
| Number of pipe | 1 | [nos] |
| Hydraulic gradient | 4.1 | [‰] |
| Velocity | 1.11 | [m/sec] |

## Ⅱ Water Treatment Plant

### 1．Receiving Well

1.Condition

① Flow　Q＝ $\boxed{10,800}$ × 1.1 ＝ 11,880 [m3/day] ＝ $\boxed{8.25}$ [m3/min]

② No. of tank　$\boxed{1}$ [tank]

③ Retention time　1.5 [min] or more (Design Guideline for Water Supply Facility)

④ Others　To function also as grit removal basin

Surface Load　AL＝ 200 ～ 500 mm/min (Design Guideline for Water Supply Facility)

Ave. Velocity　Vh＝ 2 ～ 7 cm/sec (Design Guideline for Water Supply Facility)

2. Required capacity

On assuming retention time: $\boxed{10}$ [min]

$$V_0 = Q\times = \boxed{8.25} \times 10.0 = \boxed{82.5}\ [m^3]$$

3. Shape and Dimension

Recutangular, assuming one side B＝

Assuming one side B= $\boxed{2.5}$ [m] and effective depth H= $\boxed{3.4}$ [m]

the other side L=

$$L = \frac{V_0}{B\times H} = \frac{\boxed{82.5}}{\boxed{2.5}\times\boxed{3.4}} = \boxed{9.71} \rightarrow \boxed{9.85}\ [m]$$

4. Effective capacity

$$V = B\times L\times H = \boxed{2.5}\times 9.85 \times \boxed{3.4} = \boxed{83.7}\ [m^3]$$

5. Retention time

$$T = \frac{V}{Q} = \frac{\boxed{83.7}}{\boxed{8.25}} = \boxed{10.1}\ [min] > 1.5\ [min]$$

6. Surface load

$$AL = \frac{Q}{B\times L} = \frac{8.25}{2.5 \times 9.85} = 0.335\ m/min = 335\ mm/min$$

7. Velocity in tank

$$Vh = \frac{Q}{B\times H} = \frac{8.25}{2.5 \times 3.40} = 0.971\ m/min = 1.62\ cm/sec$$

8. Summary

Dimension　$\boxed{2.5}$ [mB] × $\boxed{9.85}$ [mL] × $\boxed{3.4}$ [mH]

No. of tank　$\boxed{1}$ [tank]

Retention time　$\boxed{10.1}$ [min]

Surface Load　$\boxed{335}$ mm/min

Velocity in tank　$\boxed{1.62}$ cm/sec

## 2. Rapid mixing tank

1. Condition

① Flow $Q = \boxed{10,800} \times \boxed{1.1} = \boxed{11,880}$ [m3/day] $= \boxed{8.3}$ [m3/min]

② No. of tank $\boxed{1}$ [tank]

③ Retention time 1～5 [min] (Design Guideline for Water Supply Facility)

④ G value $G =$ 150 [1/sec] or more → $\boxed{350}$ [1/sec]

2. Required capacity

Retention time $\boxed{1}$ [min] is assumed

$$V_0 = Q \times t = \boxed{8.3} \times \boxed{1} = \boxed{8.3} \ [m^3]$$

3. Shape and dimension

Square shape and one side $B = \boxed{2.5}$ [m] 、Effective depth $H = \boxed{1.5}$ [m] is assumed

The other side L:

$$L = \frac{V_0}{B \times H} = \frac{\boxed{8.3}}{\boxed{2.5} \times \boxed{1.5}} = \boxed{2.21} \rightarrow \boxed{2.5} \ [m]$$

4. Effective capacity

$$V = B \times L \times H = \boxed{2.5} \times \boxed{2.5} \times \boxed{1.5} = \boxed{9.4} \ [m^3]$$

5. Retention time

$$T = \frac{V}{Q} = \frac{\boxed{9.4}}{\boxed{8.3}} = 1.10 \ [min] \rightarrow 1\sim5 \ [min] \quad \text{O. K.}$$

6. Required height to drop

$$H = \frac{G^2 \times V \times \mu}{\rho \times Q \times g} = \frac{\boxed{350}^2 \times \boxed{9.4} \times \boxed{0.001}}{\boxed{1,000} \times \boxed{0.14} \times \boxed{9.8}} = \boxed{0.849} \ [m] \rightarrow \boxed{1.2} \ [m]$$

Where

$\mu$ : Viscosity coefficient $\boxed{0.001}$ [kg/m/sec]

$\rho$ : Specific gravity $\boxed{1,000}$ [kg/m$^3$]

g : Gravity acceleration $\boxed{9.8}$ [m/sec2]

7. G value

$$G = \sqrt{\frac{\rho \times Q \times g}{V \times \mu \times H}} = \sqrt{\frac{\boxed{1,000} \times \boxed{0.14} \times \boxed{9.8}}{\boxed{9.4} \times \boxed{0.001} \times \boxed{1.2}}} = \boxed{347} \ [1/sec]$$

8. Summary

| | |
|---|---|
| Dimension | 2.5 [mB] × 2.5 [mL] × 1.5 [mH] |
| No. of tank | 1 [tank] |
| Retention time | 1.10 [min] |
| G value | 347 [1/sec] |

## 3. Flocculation Basin

1. Condition

① Flow $Q = \boxed{10,800} \times 1.1 = 11,880$ [m3/day] $= \boxed{8.25}$ [m3/min]

② No. of tank $N = \boxed{2}$ [tank]

③ No. of train $D = \boxed{4}$ [train]

④ Retention time 20～40 [min] (Design Guideline for Water Supply Facility)

⑤ GT value $GT = \boxed{23,000} \sim \boxed{210,000}$

⑥ Type Horizontal buffled channel

2. Required capacity

Retention time $\boxed{20}$ [min] is assumed

$$V_0 = Q \times t = \boxed{8.25} \times \boxed{20} = \boxed{165} \quad [m^3]$$

3. Shape and dimension

Rectangular, one side $B = \boxed{1.20}$ [m] 、Effective depth $H = \boxed{1.6} \sim \boxed{2.2}$ [m] assumed

(Ave. 1.9 [m] )

$$L = \frac{V_0}{B \times H \times N \times D} = \frac{\boxed{165}}{\boxed{1.2} \times \boxed{1.9} \times \boxed{2} \times \boxed{4}} = \boxed{9.05} \rightarrow \boxed{9.95} \quad [m]$$

4. Effective capacity

$$V = B \times L \times H \times N \times D = \boxed{1.2} \times \boxed{9.95} \times \boxed{1.9} \times \boxed{2} \times \boxed{4} = \boxed{181.5} \quad [m^3]$$

5. Retention time

$$T = \frac{V}{Q} = \frac{\boxed{181.488}}{\boxed{8.25}} = \boxed{22.0} \text{ [min]} = \boxed{1,320} \text{ [sec]}$$

6. G T value

$$GT = \sqrt{\frac{\rho \times g \times \Delta h \times T}{\mu}} = \sqrt{\frac{\boxed{1,000} \times \boxed{9.8} \times \boxed{0.6} \times \boxed{1,320}}{\boxed{0.001}}} = 88,000$$

7. Head loss calculation

1) Head loss by 180 deg. bend. : $h_b$

$$h_b = f_b \times \frac{v_b^2}{2g}$$

Where,

$f_b$ : Head loss coefficient by 180 1.5

$v_b$ : Velocity at 180 deg. Bend Q÷opening area

| Flow (m3/sec) | Q/2 | 0.06875 (5,940m3/day/tank) | | | |
|---|---|---|---|---|---|
| Step (-) | | 1 | 2 | 3 | 4 |
| Channel width (m) | W | 0.3 | 0.3 | 0.3 | 0.3 |
| Channel height (m) | H | **0.5** | **0.57** | **0.7** | **0.8** |
| Opening area (m2) | A | 0.15 | 0.171 | 0.21 | 0.24 |
| Velocity (m/sec) | V | 0.458 | 0.402 | 0.327 | 0.286 |
| Head loss (m) | $h_{b1}$ | 0.0161 | 0.0124 | 0.0082 | 0.0063 |
| Number. (-) | n | 14 | 14 | 14 | 14 |
| Loss in step (m) | $h_b$ | 0.225 | 0.173 | 0.115 | 0.088 |
| Total head loss (m) | $\Sigma h_b$ | 0.601 | | | |

2) Head loss in open channel : hc

$$hc = \frac{L}{C^2 R} v_c^2 \qquad C^2 = \frac{1}{n^2} R^{1/3}$$

Where,

n : Manning's roughness coefficient 0.014 (Concrete)

R : Hydraulic radius

| Flow (m3/sec) | Q/2 | 0.06875 | (5,940m3/day) | | |
|---|---|---|---|---|---|
| Step (-) | | 1 | 2 | 3 | 4 |
| Ave. depth (m) | | 2.487 | 2.288 | 2.231 | 2.187 |
| Channel width (m) | B | 0.66 | 0.66 | 0.66 | 0.66 |
| Channel length (m) | L | 18 | 18 | 18 | 18 |
| Area (m2) | A | 1.642 | 1.51 | 1.472 | 1.443 |
| Hydraulic radius (m) | R | 0.291 | 0.288 | 0.287 | 0.287 |
| Chezy coefficient | $C^2$ | 3382.4 | 3370.7 | 3366.8 | 3366.8 |
| Velocity | Vc | 0.0419 | 0.0455 | 0.0467 | 0.048 |
| Loss in step (m) | $h_f$ | 0.000 | 0.000 | 0.000 | 0.000 |
| Total head loss (m) | $\Sigma h_f$ | 0.000 | | | |

8. Summary

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shape and dimens | 1.2 | [mB] × | 9.95 | [mL] × | 1.9 | [mH] |
| No. of tank | 2 | [tank] | | | | |
| No. of train | 4 | [train] | | | | |
| Retention time | 22.0 | [min] | | | | |
| GT Value | 88,000 | [—] | | | | |

## 4．Sedimentation Tank

1.Condition

① Flow $Q = \boxed{10{,}800} \times \boxed{1.1} = \boxed{11{,}880}$ [m3/day] $= \boxed{8.25}$ [m3/min]

② No. of tank $N = \boxed{2}$ [tank]

④ Surface Load $S_L = \boxed{15} \sim \boxed{30}$ [mm/min] $\rightarrow \boxed{30}$ [mm/min]

⑤ Retention time $T = \boxed{3} \sim \boxed{4}$ [hour]

2. Required settling area

$$A_0 = \frac{Q}{S_L \times 10^{-3}} = \frac{\boxed{8.25}}{\boxed{30.0} \times 10^{-3}} = \boxed{275.0} \ [m^2]$$

3.Shape and dimension

Rectangular, One side B= $\boxed{11.9}$ [m] is assumed

The other side L=

$$L = \frac{A_0}{B \times n} = \frac{275.0}{\boxed{11.9} \times \boxed{2}} = \boxed{11.6} \ [m] \rightarrow \boxed{11.9} \ [m]$$

Modified settling area

$A^* = B \times L =$ 11.9 × 11.9 = 141.6 [m²]

4.Effective capacity

Effective depth $H = \boxed{5.3}$ [m] is assumed.

$V =$ 11.9 × 11.9 × 5.3 = 750.5

5.Retention time

$$T = \frac{V \times N}{Q} = \frac{\boxed{750.5} \times \boxed{2}}{\boxed{8.25}} = \boxed{182} \ [min] = 3.03 \ [hour]$$

6. Modified surface Load

$$SL = \frac{Q}{A^* \times 10^{-} \times n} = \frac{\boxed{8.25}}{\boxed{141.6} \times 10^{-3} \times \boxed{2}} = \boxed{29.1} \ [mm/min]$$

7.Summary

| | | | | | |
|---|---|---|---|---|---|
| Shape and dimension | 11.9 [mB] | × | 11.9 [mL] | × | 5.3 [mH] |
| No. of tank | 2 [tank] | | | | |
| Retention time | 181.9 [min] | | | | |
| Surface Load | 29.1 [mm/min] | | | | |

## 5. Rapid Sand Filtration

1. Condition

① Flow Q = 10,800 × 1.1 = 11,880 [m3/day] = 8.3 [m3/min]
② Type: Open gravity type
③ Filtration rate 120～150 [m/day] (Design Guideline for Water Supply Facility)
④ Filter media: Silica sand  Filter depth 0.7 [m]
⑤ Backwash: Air + backwashing
⑥ Air wash flow qa = 0.9 [m3/day/m²]
⑦ Backwash flow qb = 0.7 [m3/day/m²]
⑧ Air wash time Ta = 5 [min]
⑨ Backwash time Tb = 10 [min]
⑩ Drain time Td = 15 [min]

2. Required filter area
Filtration rate: LV = 125 [m/day] is assumed

$$A_0 = \frac{Q}{LV} = \frac{11,880}{125} = 95 \ [m^2]$$

3. Shape and dimension
Calculated as follows:
No. of tank N = 6 [basin] (incl. standby 1 [basin]) → n' = 5 [basin]
Dimension B = 3.7 [m] × L = 5.2 [m] = 19.24 [m²/basin]
(96.2 [m²])

4. Effective filter area per basin

$$A = B \times L = 3.7 \times 5.2 = 19.24 \ [m^2]$$

5. Modified filtration rate

$$LV = \frac{Q}{A \times n'} = \frac{11,880}{19.24 \times 5} = 123 \ [m/day]$$

6. Air wash water volume

$$Qa = A \times qa \times Ta = 19.2 \times 0.9 \times 5 = 86.6 \ [m^3]$$

7. Backwash water volume

$$Qb = A \times qb \times Tb = 19.2 \times 0.7 \times 10 = 134.7 \ [m^3]$$

8. Drain water volume

$$Qc = A \times LV \times Tc = 19.2 \times 123 \times 15 / 24 / 60 = 24.7 \ [m^3]$$

9. Total discharged water volume

$$Q' = Qb + Qc + Qd = 134.7 + 24.7 + 38.0 = 197.4 \ [m^3]$$

Qd = Maximum water volume remained in filter at beginning of backwash = 38.0 [m³]

10. Summary

| | | |
|---|---|---|
| Shape and dimension | 3.7 [m] × 5.2 [m] | |
| No. of basin | 6 [basin] (incl. standby 1 [basin]) | |
| Filter area | 19.24 | [m²/basin] |
| Filtration rate | 123 | [m/day] |
| Discharged water volume | 197.4 | [m³] |

## 6. Clear Water Reservoir

1. Condition

① Water production $Q=$ $\boxed{10,800}$ [m3／day] = $\boxed{7.50}$ [m3/min]

② Retention time $T=$ $\boxed{60}$ [min] or more, to be 80 min. considering existing T=80min.

③ No. of tank $N=$ $\boxed{2}$ [tank]

2. Required capacity

$$V = Q \times T = 7.50 \times 80 = 600 \quad [m3]$$

3. Shape and dimension

Square, one side B= $\boxed{4.5}$ [m] 、Effective depth H= $\boxed{2.8}$ [m] is assumed

The other side L=

$$L = \frac{V_0}{B \times H \times N} = \frac{\boxed{600}}{\boxed{4.5} \times \boxed{2.8} \times \boxed{2.0}} = \boxed{23.8} \rightarrow 24.0 \quad [m]$$

4. Effective capacity

$$V = B \times L \times H \times N = \boxed{4.5} \times 24.0 \times \boxed{2.8} \times \boxed{2} = \boxed{604.8} \quad [m3]$$

5. Retention time

$$T = \frac{V}{Q} = \frac{\boxed{604.8}}{8} = 80.60 \ [min] = 1.34 \ [hour]$$

6. Summary

| | |
|---|---|
| Shape and dimension | 4.5 [m] W× 24.0 [m] L× 2.8 [m] H |
| No. of tank | 2 [tank] |
| Effective capacity | 604.8 [m²/tank] |
| Retention time | 80.6 [min] |

## 7. Chemical Dosing Facility

1. Post Chlorination by using Calcium Hypochlorite ($CaO \cdot 2CaOCl \cdot 3H_2O$)

Flow : 10,800 ($m^3$/D)

Dosing point : Inlet channel to clear water reservoir

Dosing rate : 1 ～ 5 (mg/l) (Ave. 3 mg/l)

Effective Chlori : 65 (%)

Dilution : 3 (%) ( 30 kg/$m^3$)

Specific gravity : 1.05 (-)

Dosage : $10{,}800 \times 1 \sim 5 \times \frac{100}{65} \times \frac{100}{3} \times \frac{1}{1.05} \times \frac{1}{24} \times \frac{1}{1000}$

= 22.0 ～ 109.9 (L/hr) → 20 ～ 110 (L/hr)
(Ave. 65.9 L/hr)

$10{,}800 \times 1 \sim 5 \times \frac{100}{65} \times \frac{1}{24} \times \frac{1}{1000}$

= 0.7 ～ 3.5 (kg/hr) → 0.63 ～ 3.47 (kg/hr)
(Ave. 2.08 kg/hr )

No. of dosing pump : 2 (units) (incl. one standby)

Dissolving chemical Capacity : To be capable of 1 day of ave. dosage

65.9 × 24 × 1 = 1.58 $m^3$/tank

Dimension : W 1.0 m × L 1.2 m × H 1.4 m ( 1.68 $m^3$/tank)

No. of tank : 4 tanks (same as the existing)

Dissolving cycle : Dissolving 1 day→Standing 1 day→Use 1 day → Cleaning, dissolving

Storage tank : 3 hours of ave. consumption

65.9 × 3.0 = 197.8 L → 200 L

Storage capacity : 60 day of ave. consumption as Calcium hypochlorite

2.1 × 24 × 60 = 2,995 kg : 67 bag (1bag 45kg)

2. Aluminum Sulfate $(Al_2(SO_4)_3 \cdot nH_2O)$

| | | |
|---|---|---|
| Flow | : | 11,880 ($m^3$/D) |
| Dosing point | : | Upstream of flow measurement weir of receiving well |
| Dosing rate | : | 20 ～ 50 (mg/l) ( Ave. 30 mg/ l ) |
| Effectiveness of Alumina | : | 17 (%) |
| Dilution | : | 8 (%) |
| Specific gravity | : | 1.05 (-) |
| Dosage | : | $11,880 \times 20 \sim 50 \times \frac{100}{8} \times \frac{1}{1.05} \times \frac{1}{24} \times \frac{1}{1000}$ |
| | | = 118.0 ～ 295.0 (L/hr) → 110 ～ 300 (L/hr) (Ave. 177 L/hr) |
| | | $11,880 \times 20 \sim 50 \times \frac{1}{24} \times \frac{1}{1000}$ |
| | | = 9.9 ～ 24.8 (k g/hr) → 9.2 ～ 25.2 (k g/hr) (Ave. 14.9 kg/hr) |
| No. of dosing pump | : | 3 (unit) (incl. one standby) |
| Dissolving chemical Capacity | : | To be capable of 1 day of ave. dosage |
| | | 177 × 24 × 1 = 4.25 m3/tank |
| Dimension | : | W 1.4 m× L 1.6 m× H 1.6 m ( 3.58 $m^3$/tank) |
| No. of tank | : | 3 tanks (same as the existing) |
| Dissolving cycle | : | Dissolv. 1 day→Use 1 day→Cleaning, dissolving |
| Storage tank | : | 2 hours of ave. consumption |
| | | 177.0 × 2.0 = 354 L → 300 L |
| Storage capacity | : | 30 day of ave. consumption as Aluminum Sulfate |
| | | 14.9 × 24 × 30 = 10,728 kg |

## 8. Sludge treatment

### 1. Sludge volume

1. Condition

| | | | | | | |
|---|---|---|---|---|---|---|
| ① Water production | | Q | = | 10,800 × 1.1 = 11,880 | [m3/day] |
| ② Turbidity of Raw water | (Ave.) | $Tu_a$ | = | 30 | [deg] |
| | (Max.) | $Tu_m$ | = | 100 | [deg] |
| ③ Iron in raw wate | (Ave.) | $Fe_a$ | = | 0 | [mg/l] |
| | (Max.) | $Fe_m$ | = | 0 | [mg/l] |
| ④ Alum dosing rate | (Ave.) | $\alpha_a$ | = | 30 | [mg/l] |
| | (Max.) | $\alpha_m$ | = | 50 | [mg/l] |
| ⑤ Turbidity−SS Conversion factor | | $E_1$ | = | 1.0 | [−] |
| ⑥ Sedimentation Sludge turbidity | (Ave.) | $Cs_a$ | = | 0.5 | [%] |
| | (Max.) | $Cs_m$ | = | 1 | [%] |
| ⑦ Wastewater discharged from sand filter | | Qw | = | 197.4 | [$m^3$] |

2. Generated solid volume (per one day)
To be calculated as follows:

$$Z = Q \times (Tu \times E1 + \alpha \times E2 \times \gamma / 100 + E3 \times Fe) \times 10^{-3} \ [\mathrm{kgDS/day}]$$

Where

$E_2$ : Ratio of Aluminum sulfate to oxidized aluminium $\boxed{0.234}$

Accordingly

① Average

$$Z_{ave} = \boxed{11,880} \times ( \boxed{30} \times \boxed{1.0} + \boxed{30} \times \boxed{0.234} \times 10^{-3} \ [\mathrm{kgDS/day}]$$

$$= \boxed{440} \ [\mathrm{kgDS/day}]$$

② Maximum

$$Z_{max} = \boxed{11,880} \times ( \boxed{100} \times \boxed{1.0} + \boxed{50} \times \boxed{0.234} \times 10^{-3} \ [\mathrm{kgDS/day}]$$

$$= \boxed{1,327} \ [\mathrm{kgDS/day}]$$

3. Sludge discharge volume (per one day)

$$Ys = Z \times (100 / Cs) \times 10^{-3} \ [\mathrm{m3/day}]$$

① Average

$$Ys = \boxed{439.8} \times (100 / \boxed{0.5}) \times 10^{-3} = \boxed{88.0} \ [\mathrm{m3/day}]$$

② Maximum

$$Ys = \boxed{1327.0} \times (100 / \boxed{1}) \times 10^{-3} = \boxed{132.7} \ [\mathrm{m3/day}]$$

## 2．Sludge treatment lagoon

Wastewater discharged in treatment process is from backwash water and sedimentation sludge
Backwash water is to be returned to river, and sedimentation sludge is to be treated
Sludge is received in lagoon for solid-liquid separation、effluent is discharged to river
Thickened sludge is dried to take out for disposal.

### 1.Condition

① No. of tank $\boxed{2}$ [tank] (Design Guideline)
② Effective height 0.5m、Allowance 0.3m
③ Surface load $\boxed{200}$ mm/min (Design Guideline : 200～500cm/sec)
④ Ave. velocity in tank $\boxed{7}$ cm/sec (Design Guideline : 2～7cm/sec)

### 2. Receiving Sludge Volume

Discharge flow from sedimentation tank is capable of emptying one tank by $\boxed{90}$ min

$$Qd = \frac{\boxed{11.9} \times \boxed{11.9} \times \boxed{5.7}}{\boxed{90}} = \boxed{9.0} \rightarrow \boxed{9} \quad [m3/min]$$

### 3. Required surface area

$$A0 = \frac{\boxed{9} \times \boxed{1000}}{\boxed{200}} = \boxed{45} \quad [m2]$$

### 4.Shape and dimension

Rectangular, one side B= $\boxed{5.0}$ [m]
The other side L=

$$L = \frac{A0}{B} = \frac{\boxed{45}}{\boxed{5}} = \boxed{9.0} \rightarrow \boxed{18.0} \quad [m]$$

### 5. Average Velocity in Tank

Ave. sludge depth $\boxed{0.5}$ m

$$Vh = \frac{\boxed{9.0} \times \boxed{100}}{\boxed{5.0} \times (\boxed{1.0} - \boxed{0.5}) \times \boxed{60}} = \boxed{6.0} \quad [cm/sec]$$

### 6. Days for Retention of Sludge

In Average Turbidity
Sludge contents: $\boxed{10}$ % at ave. turbidity

$$\text{Days for retention} \quad Nave = \frac{\boxed{5.0} \times \boxed{18.0} \times \boxed{0.5} \times \boxed{10} \times 1000}{\boxed{440} \times 100} = \boxed{10.2} \quad [day]$$

Accordingly,
$\boxed{10}$ days for receiving sludge of ave. turbidity
$\boxed{10}$ days for standing, discharge effulent and take away the dry sludge

In Maximum Turbidity
Sludge contents: $\boxed{10}$ % of max. turbidity

$$\text{Days for retention} \quad Nmax = \frac{\boxed{5.0} \times \boxed{18.0} \times \boxed{0.5} \times \boxed{10} \times 1000}{\boxed{1327.0} \times 100} = \boxed{3.39} \quad [day]$$

Accordingly,
$\boxed{3}$ days for receiving sludge of max. turbidity
$\boxed{3}$ days for standing, discharge effulent and take away the dry sludge

### 5.Summary

- Shape and dimensi $\boxed{5.0}$ [m] × $\boxed{18.0}$ [m] × Effective depth $\boxed{0.5}$ [m]
- No. of tank $\boxed{2}$ [tank]

## Ⅲ. Transmission Facility

### 1. Transmission Pipeline

1. Condition

① Flow Q = $\boxed{10,800}$ = 10,800 [m3/day] = $\boxed{0.13}$ [m3/sec]
② No. of pipe $\boxed{1}$ [pipe]
③ Velocity 3 [m/sec] or less (Design Guideline for Water Supply Facility)

2. Required Diameter

Velocity $\boxed{1.5}$ [m/sec] is assumed

$A = Q \div V = \boxed{0.13} \div 1.5 = \boxed{0.087}$ [$m^2$]

$\phi = \sqrt{(A \times 4/\pi)} = \boxed{0.333}$ [m] →to be 400mm in considering pipe head loss

3. Summary

| | | |
|---|---|---|
| Diameter | φ400 | [mm] |
| No. | 1 | [pipe] |
| Hydraulic Gradient | 3.3 | [‰] |
| Velocity | 1.1 | [m/sec] |

### 2. Transmission Pump

1. Condition

① Flow Q = $\boxed{10,800}$ = $\boxed{7.50}$ [m3/min] = $\boxed{0.125}$ [m3/sec]
② No. of pump N = $\boxed{4}$ [units] (incl. 1 standby)

2. Discharge capacity of one pump

No. of pump $\boxed{3}$ [unjits]

$Q = Q \div N = \boxed{7.5} \div 3.0 = \boxed{2.500}$ [m3/min]

3. Discharge Head

Whereas length of transmission pipeline is approx. 4,400 m
Hazen-Williams Formula

$\triangle h_1 = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L = \boxed{14.53}$ [m]

Actual pump head:
$\triangle h_2 = 511.80 - 456.00 = \boxed{55.80}$ [m]
(HWL of service reservoir)
(LWL of clear water reservoir)

Head loss around pump
$\triangle h_3 = \boxed{5.00}$ [m]

Total head required:
$\triangle H = \triangle h_1 + \triangle h_2 + \triangle h_3 = \boxed{75.33}$ [m]

4. Summary

Specification $\boxed{\phi 150}$ [mm] × $\boxed{2.5}$ [m3/min] × $\boxed{76}$ [m] × $\boxed{55}$ [kW
No. of pump $\boxed{4}$ [unijts] (incl. 1 standby)

# IV. Distribution facility

## 1. Service Reservoir

1.Condition

① Dist. capacity (Max. day) Q = 10,800 = 10,800 [m3/day] = 0.13 [m3/sec]
② Dist. capacity (hour peak) Q = 10,800 × 2.4 = 25,920 [m3/day] = 0.30 [m3/sec]
③ Retention time (Reservoir) 12 [hour] or more of max. daily flow (Design Guideline)
④ Retention time (Elev. Tank) 10-30 [min] of hourly peak flow (Design Guideline)

2. Capacity of Service Reservoir
Capacity is examined taking into account of power supply condition and economic viewpoint

From hourly distribution flow pattern anaysis, approx. 5,000 m3 is required
20.0×32.0×h4.0m×2tanks, Capacity: 5,000m3

3. Capacity of Elevated Tank
Elevated tank is designed to regulate water pressure in the service areas. In general, it does no intend to regulate changing water flow since it is always kept full capacity.
Required capacity of elevated tank is between 10-30min of the hourly peak flow.
Considering unstability of power supply, etc., 30min is adopted.
Capacity = 25,920×30/1,440 = 540$m^3$

4. Raiser Pipe to Elevated Tank
Velocity 2.0 [m/sec] is assumed

A = Q ÷ V = 0.30 ÷ 2.0 = 0.150 [$m^2$]

$\phi$ = √(A×4/π) = 0.437 [m] →to be 500mm considering pipe head loss

| | | |
|---|---|---|
| Diameter | $\phi$500 | [mm] |
| No. of pipe | 1.0 | [pipe] |
| Hydraulic Gradie | 5.6 | [‰] |
| Velocity | 1.6 | [m/sec] |

## 2. Distribution Pump (Lifting Pump)

1. Discharge capacity of one pump
No. of pump 3 [unjits]

Q = Q ÷ N = 18.0 ÷ 3.0 = 6.000 [m3/min]

2. Pump Head
Pipe length of raiser pipe to elevated tank. The pipe loss is:
△h1 = I × L = 0.11 [m]

Actual head
△h2 = 525.1 − 509.7 = 15.4 [m]
(HWL of elevated tank)
(LWL of service reservoir)
Head loss around pump
△h3 = 5.00 [m]

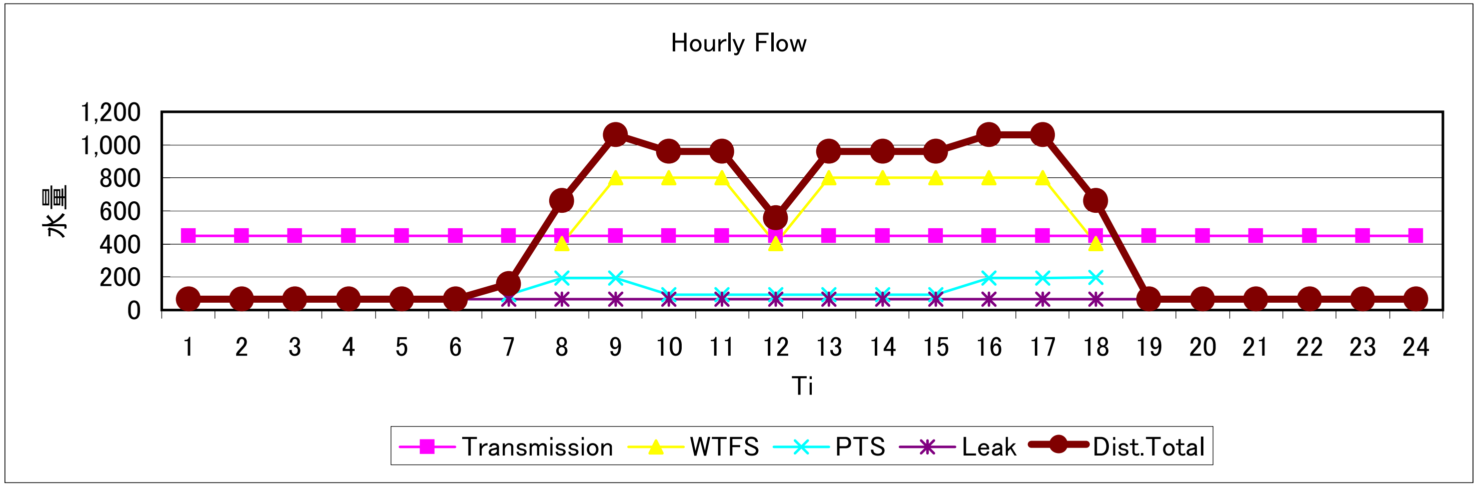
Total head required:
△H = △h1 + △h2 + △h3 = 20.51 [m]

3.Summary
Specification $\phi$200 [mm] × 6.0 [m3/min] × 21 [m] × 37 [kW
No. of pump 4 [unijt(incl. 1 standby)

Hourly Distribution Flow Analysis

| | | Unit | 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5-6 | 6-7 | 7-8 | 8-9 | 9-10 | 10-11 | 11-12 | 12-13 | 13-14 | 14-15 | 15-16 | 16-17 | 17-18 | 18-19 | 19-20 | 20-21 | 21-22 | 22-23 | 23-24 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transmission | | $m^3/h$ | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 450 | 10,800 |
| Distribution | WTFS 8箇所 | $m^3/h$ | | | | | | | | 401 | 802 | 802 | 802 | 401 | 802 | 802 | 802 | 802 | 802 | 402 | | | | | | | 7,620 |
| | PTS 120箇所 | $m^3/h$ | | | | | | | 92 | 195 | 195 | 92 | 92 | 92 | 92 | 92 | 92 | 195 | 195 | 196 | | | | | | | 1,620 |
| | Leak 15% | $m^3/h$ | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 1,560 |
| | Dist. Total | $m^3/h$ | 65 | 65 | 65 | 65 | 65 | 65 | 157 | 661 | 1,062 | 959 | 959 | 558 | 959 | 959 | 959 | 1,062 | 1,062 | 663 | 65 | 65 | 65 | 65 | 65 | 65 | 10,800 |
| Required capacity for Service Reservoir | | $m^3/h$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 211 | 612 | 509 | 509 | 108 | 509 | 509 | 509 | 612 | 612 | 213 | 0 | 0 | 0 | 0 | 0 | 0 | 4,913 |
| Hourly Factor | | $m^3/h$ | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.35 | 1.47 | 2.36 | 2.13 | 2.13 | 1.24 | 2.13 | 2.13 | 2.13 | 2.36 | 2.36 | 1.47 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | |

(N.B.) 1. Operation Hours of Water Tanker Filling Station: 7：30～17：30、assuming 50% of operating ratio during lunch time
2. Operation hours of Public Tap Stands: 6：30～18：00, assuming 50% of operating ratio during lunch time
3. Time lag caused by water flow in pipelines are not calculated by taking safer side.




From the Above analysis, Capacity of Service Reserovir is to be 5,000 m3, Hourly peak factor is to be 2.4

# IV. Distribution facility

## 3. Hydraulic Calculation on Distribution Main

1.Condition
① Dist. capacity (Max. day) Q = 10,800 = 10,800 [m3/day] = 125 [L/sec]
② Dist. capacity (hour peak) Q = 10,800 × 2.4 = 25,920 [m3/day] = 300 [L/sec]
③ HWL of Elev. Tank 525.1 [m]
④ LWL of Elev. Tank 522.5 [m]
⑤ Minimum Operating Pressure 1.5 [bar] (1.0 bar is accepted in high elevation)
⑥ Maximum Operating Pressure 5.0 [bar]
⑦ Maximum Static Pressure 7.5 [bar]

2. Water Demand
Ave. daily water consumption per one tap (water tanker filling station) 192 [m3/day-tap]
··· 8.0 [m3/hour-tap]

Water demand of public tap stands to be taken into account for hydraulic calculation
Total base demand 1620 [m3/day] / 0.85 (effective rate) / 10 hours = 203 [m3/hour]
Assuming one tap of filling station bear equal flow:
203 / 40 taps = 5.1 [m3/hour-tap] ··· 1.4 [L/sec-tap]

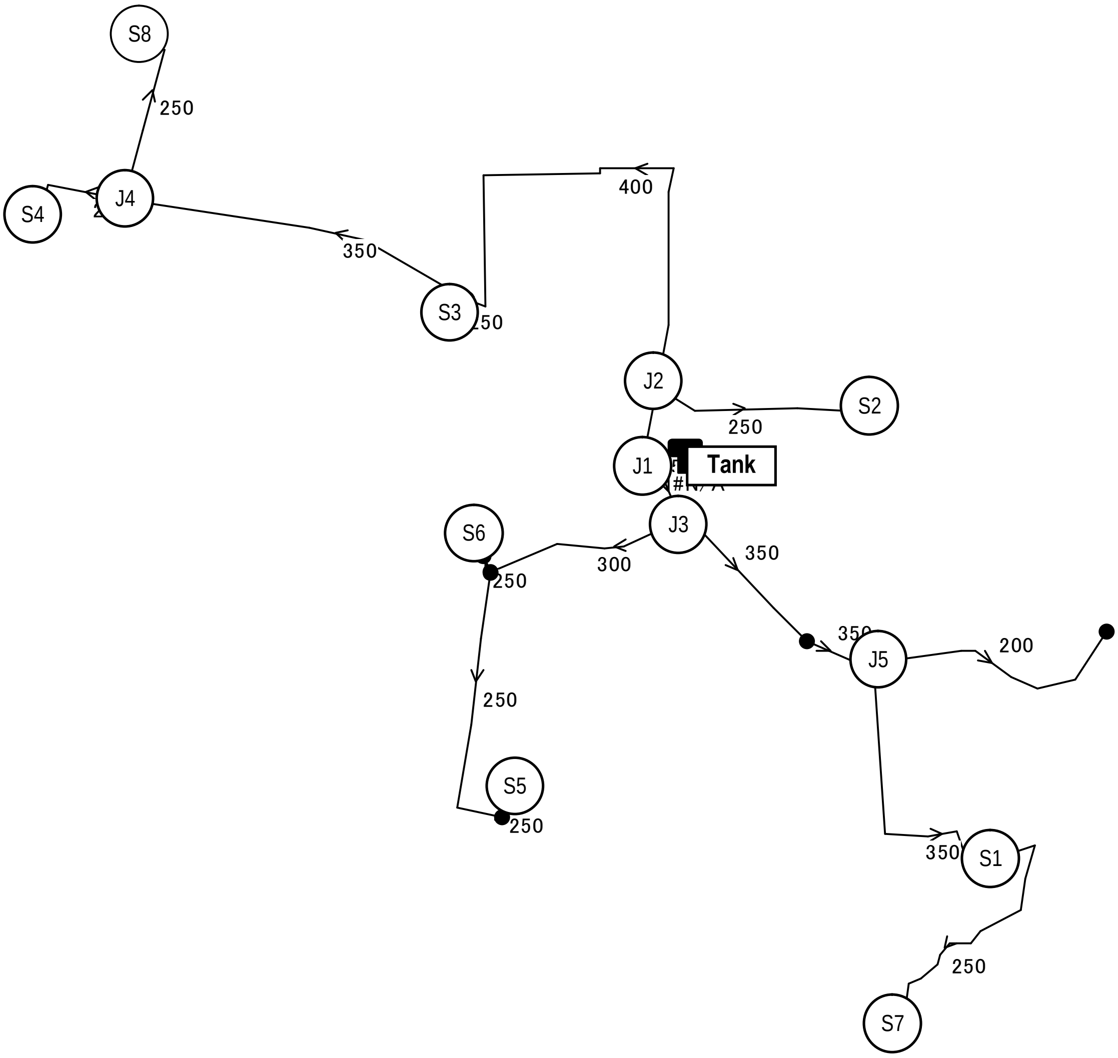
Base demand by station
For 4 taps 8.0 x 4 taps / 0.85 (effective rate) + 5.1 x 4 taps = 58.0 [m3/hour]
··· 16.1 [L/sec]
For 6 taps 8.0 x 6 taps / 0.85 (effective rate) + 5.1 x 6 taps = 87.1 [m3/hour]
··· 24.2 [L/sec]

Peak flow by station
For 4 taps: 16.1 x 2.4 = 38.64 [L/sec]
For 6 taps: 24.2 x 2.4 = 58.08 [L/sec]

Summary of Hydraulic Status at Static Flow (00:00) and Peak Demand (08:00)

| | Ground Elevation (+m) | Base Flow [Ave.] (L/sec) | Peak Flow [08:00] (L/sec) | Maximum Head [00:00] (+m) | Statistic Pressure [00:00] (+m) | Head at Peak flow [08:00] (+m) | Min. Op. Pressure [08:00] (+m) |
|---|---|---|---|---|---|---|---|
| El.Tank | 507.5 | | | 525.1 | | 525.1 | |
| St.1 | 476.0 | 24.2 | 58.08 | 525.1 | 49.1 | 508.07 | 32.1 |
| St.2 | 488.0 | 24.2 | 58.08 | 525.1 | 37.1 | 515.02 | 27.0 |
| St.3 | 489.0 | 16.1 | 38.64 | 525.1 | 36.1 | 511.61 | 22.6 |
| St.4 | 481.0 | 16.1 | 38.64 | 525.1 | 44.1 | 504.13 | 23.1 |
| St.5 | 502.0 | 16.1 | 38.64 | 525.1 | 23.1 | 511.82 | 9.8 |
| St.6 | 507.0 | 16.1 | 38.64 | 525.1 | 18.1 | 516.66 | 9.7 |
| St.7 | 465.0 | 24.2 | 58.08 | 525.1 | 60.1 | 497.34 | 32.3 |
| St.8 | 480.0 | 24.2 | 58.08 | 525.1 | 45.1 | 499.37 | 19.4 |

Hydraulic Analysis Model




Network Link at Peak Flow (08:00)

| Link ID | Start Node | End Node | Pipe Length (m) | Pipe Diameter (mm) | Peak Flow [08:00] (L/s) | Velocity at peak flow [08:00] (m/s) | Unit Head Loss [08:00] (m/km) | Pipe Head Loss [08:00] (m) |
|---|---|---|---|---|---|---|---|---|
| 1 | Tank | J1 | 230 | 500 | 386.88 | 2.0 | 6.61 | 1.52 |
| 2 | J1 | J2 | 480 | 450 | 193.44 | 1.2 | 3.06 | 1.47 |
| 3 | J2 | S2 | 1290 | 250 | 58.08 | 1.2 | 5.79 | 7.47 |
| 4 | J2 | S3 | 3450 | 400 | 135.36 | 1.1 | 2.81 | 9.69 |
| 5 | S3 | J4 | 2210 | 350 | 96.72 | 1.0 | 2.89 | 6.39 |
| 6 | J4 | S4 | 570 | 250 | 38.64 | 0.8 | 2.72 | 1.55 |
| 7 | J4 | S8 | 1100 | 250 | 58.08 | 1.2 | 5.79 | 6.37 |
| 8 | J1 | J3 | 400 | 450 | 193.44 | 1.2 | 3.06 | 1.22 |
| 9 | J3 | S6 | 1240 | 300 | 77.28 | 1.1 | 4.04 | 5.01 |
| 10 | S6 | S5 | 1740 | 250 | 38.64 | 0.8 | 2.72 | 4.73 |
| 11 | J3 | J5 | 1070 | 350 | 116.16 | 1.2 | 4.05 | 4.33 |
| 12 | J5 | S1 | 1810 | 350 | 116.16 | 1.2 | 4.05 | 7.33 |
| 13 | S1 | S7 | 1880 | 250 | 58.08 | 1.2 | 5.79 | 10.9 |

## Examination on NPSH of Pump

Net Positive Suction Head (NPSH) of the pump facilities to be designed in the Project are examined as below. As a result, it is confirmed that available suction head (NPSH available) are larger than required suction head (NPSH required).

| | | Intake pump | Backwash tank lift pump | Transmission pump | Distribution pump (Elevated tank lifting pump) |
|---|---|---|---|---|---|
| Type | | Single suction | Single suction | Single suction | Double suction |
| Discharge ($m^3$/min) | Q | 4.125 | 3 | 2.5 | 5.5 |
| Atmospheric pressure (m), 460m above sea water level | Pa | 9.78 | | | |
| Saturated vapor pressure (m) water temperature 30℃ | Hv | 0.43 | | | |
| Level of pump center (m) | | 452.9 | 459.7 | 459.7 | 506.8 |
| Lowest level of suction (m) | | 450.5 | 456 | 456 | 507.5 |
| Suction head (m) | Has | -2.4 | -3.7 | -3.7 | 0.7 |
| Pipe loss (m) | Hsl | 1 | 1 | 1 | 0.5 |
| NPSH(av) | | NPSH(av) = Pa – Hv – Has – Hsl | | | |
| | | 6.0 | 4.7 | 4.7 | 9.5 |
| Pump rotating speed (min-1) | N | 1475 | 1475 | 1475 | 1475 |
| Suction specific speed (by manufactures data) | S | 1100 | 1100 | 1100 | 1300 |
| NPSH(rq) | | NPSH(rq) = $(N \times Q^{0.5} / S)^{4/3}$ | | | |
| | | 3.8 | 3.1 | 2.7 | 2.3 |
| Judge（NPSH(av)＞NPSH(rq)） | | OK | OK | OK | OK |

# Water Hammer Analysis of Transmission Pipeline

１．Purpose : To examine water hammer caused by stop of pump operation in transmission pipeline

２．Analysis : Fluid transient phenomenon analysis program by using characteristic curve method

３．Criteria : Allowable minimum pressure -0.058842 MPa

４．Conditions

Specification of pumps

| | |
|---|---|
| (1) Type | : Single suction volute pump |
| (2) Discharge capacity | : 2.5 m3/min |
| (3) Total head | : 78m |
| (4) Diameter | : DN 150mm |
| (5) Motor | : 55kW x 415V x 50Hz x 3 phase x 4 P |
| (6) Protection grade | : IP44 |
| (7) Isolation grade | : More than type F |
| (8) Starting method | : Star-Delta |
| (9) Flange Rate | : JIS 10K or equivalent |

５．Results

As shown in Figure 1.1, column separation is expected without measures. Appropriate protective measures are required, such as:

・ Installation of air valves
・ Installation of Surge tank
・ Installation of Flywheel

Pressure gradients of the cases of air valve and surge tank are shown in Figure 1.2 and 1.3 respectively. As for flywheel installation, it is not applicable since the negative pressure is too large as seen in Figure 1.1

In case of surge tank, it is not recommendable since it costs approx. USD 230,000, which also requires cost for maintenance in future. Therefore, installation of air valves is proposed to prevent column separation.

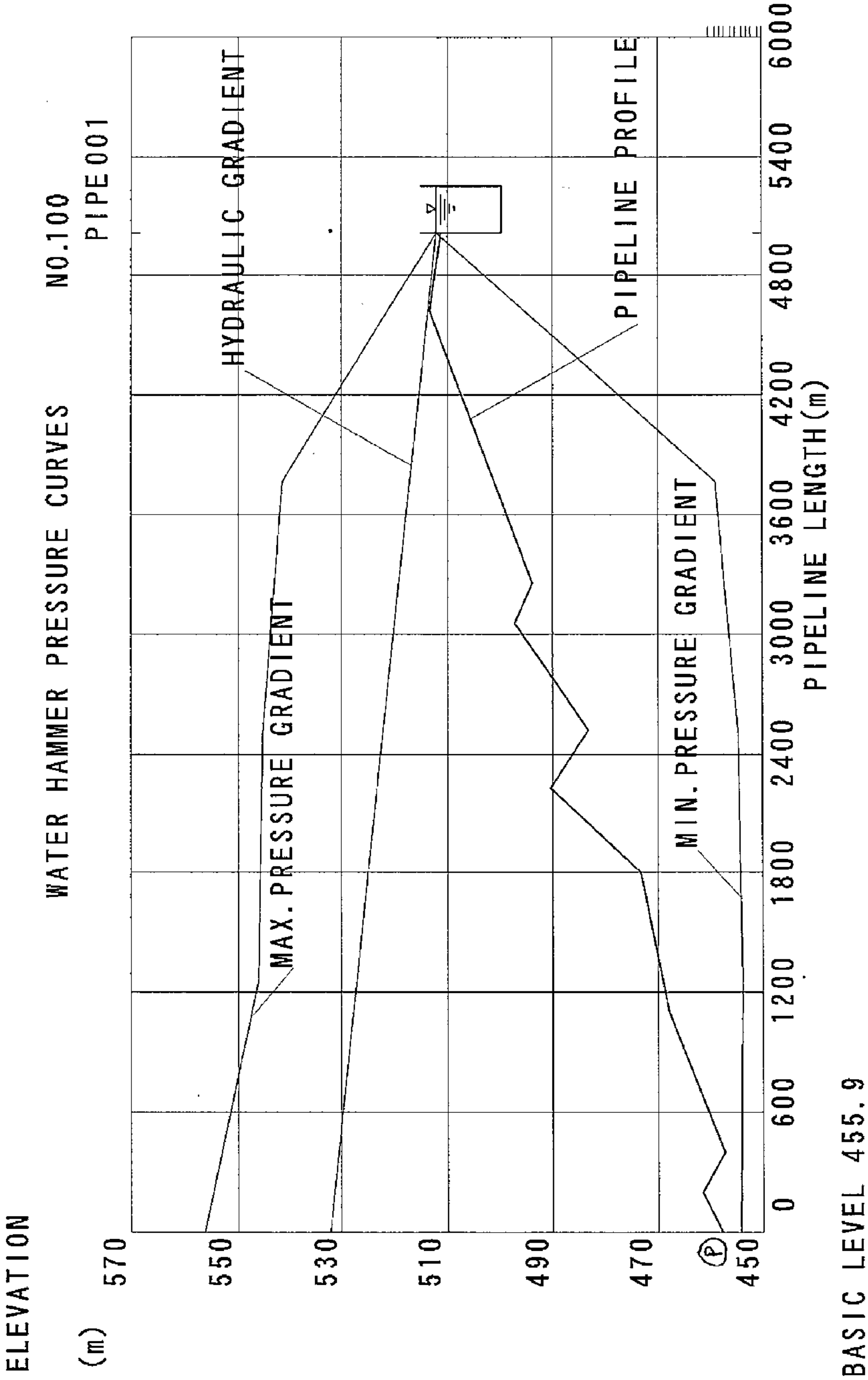



Figure 1.1 Hydraulic Grade Line without Countermeasure

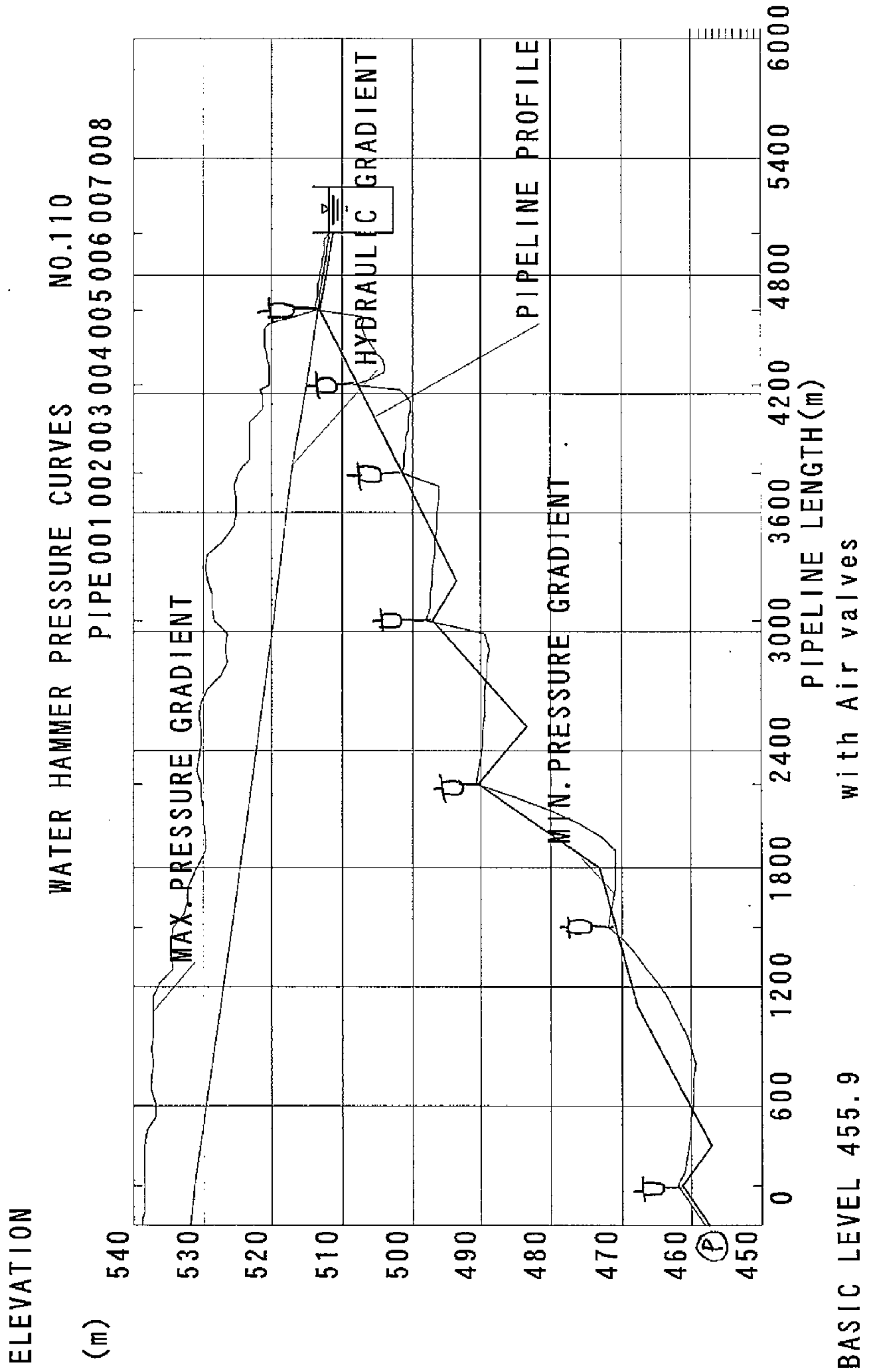



Figure 1.2 Hydraulic Grade Line After Air Valve Installation

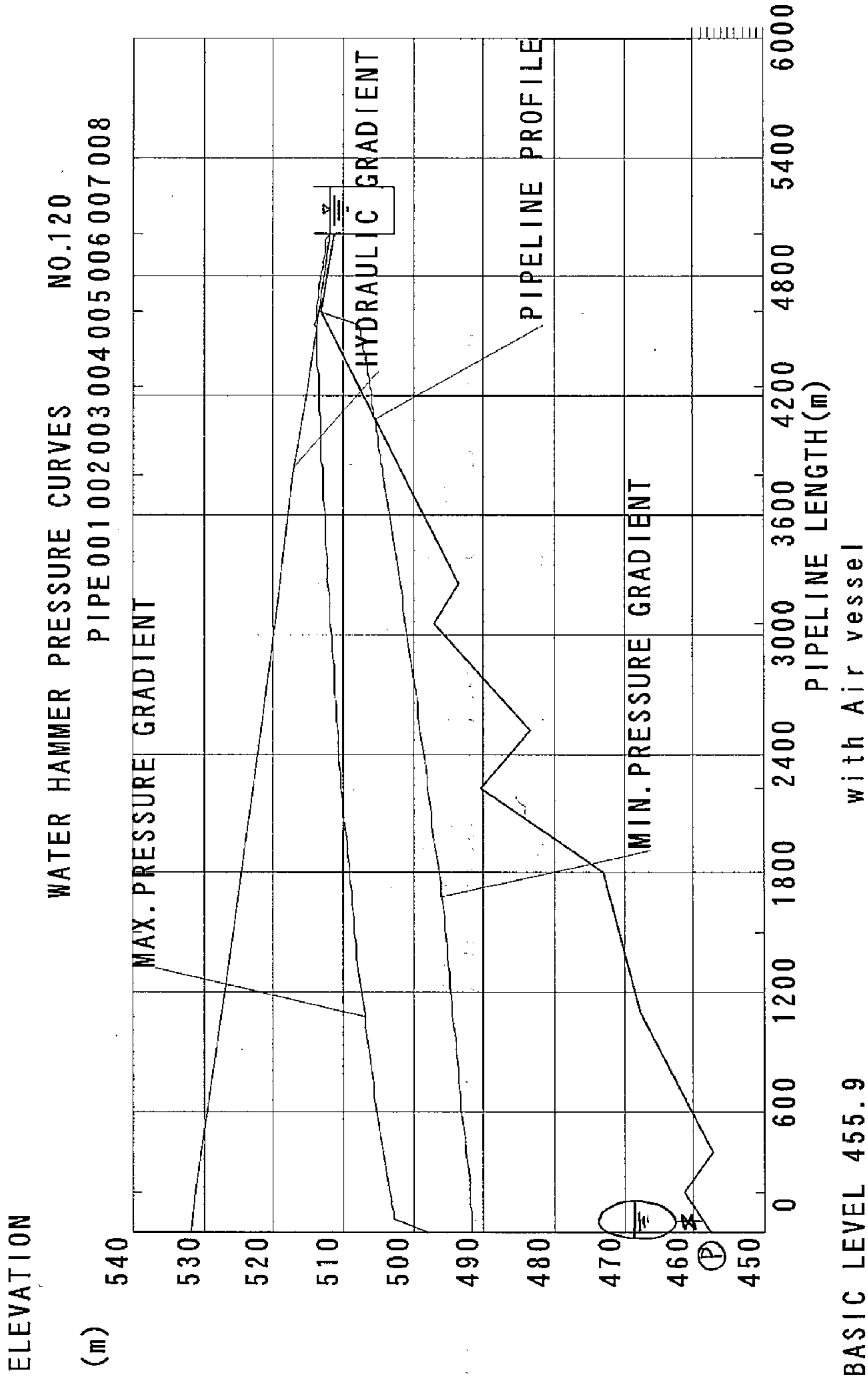



Figure 1.3 Hydraulic Grade Line After Surge Tank Installation

# Appendix-9 Operation and Maintenance Cost

## Operation and Maintenance Cost

(Cost in SDG, Price Level of July 2010)

| [A] Production Cpacity (m3/day) | [B] Revenue Water Ratio | [C] Annual Revenue Water (m3/year) | O&M Cost (SDG/year) | | | | | | | [K] O&M cost per revenue water (SDG/m3) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | [D] Personnel | [E] Electricity | [F] Chemical | [G] Spareparts | [H] Staff Training | [I] Others | [J] Total | |
| 10,800 | 80% | 3,153,600 | 1,199,160 | 755,638 | 485,713 | 56,297 | 59,958 | 127,838 | 2,684,604 | 0.85 |
| | | | (45%) | (28%) | (18%) | (2%) | (2%) | (5%) | (USD1,214,753) | (USD0.38) |

| | | |
|---|---|---|
| [A] | Production Capacity | 10,800m3/day as incremental by the Project |
| [B] | Revenue Water Ratio: | Assumed to be 80%, i.e. NRW ratio to be 20% (Physical loss: 15%, Revenue collection ratio: 95%) |
| [C] | Annual Revenue Water: | [A: Production capacity] / 1.0 (max. daily factor) x [B: Revenue water ratio]) x 365 |
| [D] | Personnel cost | Refere to attached "[D] O&M Cost: Personnel" |
| [E] | Electricity cost | Refere to attached "[E] O&M Cost: Electricity" |
| [F] | Chemical cost | Refere to attached "[F] O&M Cost: Chemical" |
| [G] | Spareparts cost | Refere to attached "[G] O&M Cost: Spare parts" |
| [H] | Staff training | 5% of [D: personnel cost] is assumed |
| [I] | Others | 5% of total of ([D]+[E]+[F]+[G]+[H]) is assumed |
| [K] | O&M cost per revenue water | [J: Total O&M cost] / [C: annual revenue water] |

## [D] O&M Cost: Personnel

| | | | Year | 2009 (Existing System) | 2015 |
|---|---|---|---|---|---|
| [1] | Production Capacity | m3/day | Existing: 7,200 m3/day, Proposed: 10,800 m3/day | 7,200 | 18,000 |
| [2] | No. House Connection | nos | 2009: actual record of UWC (CES) Juba, Same number assumed in 2015 | 2,451 | 2,451 |
| [3] | No. Non-Dom. Connect | nos | 2009: actual record of UWC (CES) Juba, Same number assumed in 2015 | 228 | 228 |
| [4] | No. Public Tap | nos | Existing:38, Proposed Tap Stands (Project): 120, Proposed Station (Project): 40 | 38 | 198 |
| [5] | Total Connection | nos | Total of [1]+[2]+[3]+[4] | 2,717 | 2,877 |
| [6] | Staff Efficiency | staff per 1000 connection | 2009: calculation [7: staff no.] / [5: connection]<br>2015: assumed to be 60 | 60 | 60 |
| [7] | Est. Total Staff No. | persons | 2009: actual number<br>2015: est. [5: connection] x [6: efficiency] / 1000 | 164 | 173 |
| [8] | No of Managers | persons | 2009: estimated from organization chart<br>2012-2015: assumed annual increase rate of 3% | 6 | 7 |
| [9] | No of Chief | persons | 2009: estimated from organization chart<br>2012-2015: assumed annual increase rate of 3% | 15 | 18 |
| [10] | No of Staff | persons | 2009: estimated from organization chart<br>2012-2015: assumed annual increase rate of 3% | 100 | 119 |
| [11] | No of Workers | persons | 2009: estimated from organization chart<br>2012-2015: [7: total] - ([8]+[9]+[10]) | 46 | 29 |
| [12] | Monthly salary (Manager) | SDG/month | 2009: average salary estimated<br>2012-2015: annual growth of 3% is assumed | 1,200 | 1,430 |
| [13] | Monthly salary (Chief) | SDG/month | 2009: average salary estimated<br>2012-2015: annual growth of 3% is assumed | 1,000 | 1,190 |
| [14] | Monthly salary (Staff) | SDG/month | 2009: average salary estimated<br>2012-2015: annual growth of 3% is assumed | 800 | 960 |
| [15] | Monthly salary (Worker) | SDG/month | 2009: average salary estimated<br>2012-2015: annual growth of 3% is assumed | 600 | 720 |
| [16] | Personnel cost (Manager) | SDG/year | [8] x [12] x 12 | 86,400 | 120,120 |
| [17] | Personnel cost (Chief) | SDG/year | [9] x [13] x 12 | 180,000 | 257,040 |
| [18] | Personnel cost (Staff) | SDG/year | [10] x [14] x 12 | 960,000 | 1,370,880 |
| [19] | Personnel cost (Worker) | SDG/year | [11] x [15] x12 | 331,200 | 250,560 |
| [20] | Personnel cost (Total in SDG) | SDG/year | Total ([16]+[17]+[18]+[19]) | 1,557,600 | 1,998,600 |
| [21] | Cost to be borne by the Project | SDG/year | [20] x 10800 / (10800+7200)<br>Assumed that personnel cost distributed in propotion to production capacity | N/A | 1,199,160 |

## [E] O&M Cost: Electricity

| | | | [1] Power output (kW) | [2] Average daily operation hours (hours/day) | [3] Power consumption (kWh) | [4] Unit power cost (SDG/kWh) | [5] Power cost (SDG) |
|---|---|---|---|---|---|---|---|
| | | | | | [1] x [2]/1.0 x 0.8 x 365 | Price as of 2009 | [3] x [4] |
| [E-1] | Intake Pump (New WTP) | Pump: 22kW x 2 = 44kW | 44 | 24 | 308,352 | 0.500 | 154,176 |
| [E-2] | Transmission Pump (New | Pump: 55kW x 2 =110kW | 110 | 24 | 770,880 | 0.500 | 385,440 |
| [E-3] | Others (New WTP) | Others: 10 % of (E-1 plus E-2), as air blower, chemical mixer, lighting, etc. | | | 107,923 | 0.500 | 53,962 |
| [E-4] | Lifting Pump (Service | Pump: 37kW x 3 = 111kW | 111 | 10 | 324,120 | 0.500 | 162,060 |
| | | | | | | Total [E] | 755,638 |

(Note) [4]: Uniti power cost as of July 2010

## [F] O&M Cost: Chemical

| | | | [1] Average daily flow (m3/day) | [2] Dosing rate (mg/L) | [3] Dosage (kg/day) | [4] Unit price (SDG/kg) | [5] Annual chemical cost (SDG) |
|---|---|---|---|---|---|---|---|
| | | | | | [1] x [2] / 1000 | | [3] x [4] x 365 |
| [F-1] | Aluminum Sulphate | Alumina conttent: est. 17% | 11,800 | 30 | 354 | 3.120 | 403,135 |
| [F-2] | Chlorine | Calcium hypochlrorite, effective Cl2: est. 65% | 10,800 | 3 | 32 | 7.070 | 82,578 |
| | | | | | | Total [F] | 485,713 |

(Note) [4]: Unit price as of July 2010

## [G] O&M Cost: Spareparts

| | | [1] Electrical & Mechanical Equipment Cost (USD) | [2] Ratio of maintenance cost | [3] Maintenance Cost (SDG) |
|---|---|---|---|---|
| | | | | [1] x [2] / 2.26 |
| [G-1] | Proposed WTP | 3,670,000 | 3% | 48,717 |
| [G-2] | Proposed Service Reservoir | 571,000 | 3% | 7,580 |
| | | | Total [G] | 56,297 |

(Note) [1]: Electrical and mechanical equipment cost, provisional estimation by the Team