SARVODAYA

RURAL TECHNICAL SERVICES

CORRESPONDENCE COURSE

ON THE

CALCULATION & DESIGN

OF

GRAVITY WATER SUPPLY SCHEMES

LANKA JATHIKA SARVODAYA SHRAMADANA SANGAMAYA (Inc.)
(An approved charity)

Sarvodaya Rural Technical Services

SUMMARY OF THE GRAVITY WATER SUPPLY DESIGN & HYDRAULIC CORRESPONDENCE COURSE

PREFACE

This summary contains all the theory and exercise lessons with respective solutions to the Gravity Water Supply Design & Hydraulic Correspondence Course implemented in 1989. This edition is intended as a practical reference book for design and calculation of Village Water Supplies in rural areas, and in particular for SRTS technicians, who have followed this course.

Sri Lanka, August 1989
Heini Pfiffner
Technical Advisor SRTS

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ABBREVIATIONS

HBG = Handbook of Gravity-Flow Water Systems (Thomas D. Jordan Jnr.)
MST = Manual of Standardization VWS (Sarvodaya Rural Technical Services)
WHO = Worlds Health Organization
HGL = Hydraulic Grade Line

Q = Flow
L = Distance
H = Head, Height
Ø = (Pipe) Diameter
Qmin. = Minimum Flow
Qmax. = Maximum Flow
Qreq. = Required Flow (Design Flow)
l/sec. = Litre per Second
l/min. = Litre per Minute
l/day = Litre per Day
m/sec. = Meter per Second (Velocity)

FORMS:

Form A = Preliminary Survey (Form A - F available in MST)
Form B = Spring Measurements
Form C = Friction Losses in PVC Pipes
Form D = Hydraulic Profile
Form E = Symbols for Situation Plan
Form F = Headloss throgh Orifice
Form G = Hydraulic Calculation Variants
Form H = Survey (Situation & Hydraulic)
Form I = Technical Information (I/a)
Technical Information (I/b)

SARVODAYA RURAL TECHNICAL SERVICES

STANDARD PLANS / REVISED 1988

(Type A : Entrance door, steel)

(Type B : Manhole, concrete)

SILTBOX	
Volume 3001- 8001 (Type A)	S - 01
Volume 3001- 8001 (Type B)	S - 02
Volume 10001-20001 (Type A) With valve chamber	S - 03
Volume 10001-20001 (Type B)	S - 04
Volume 3001- 8001 (Type A) With valve chamber	S - 05
CHAMBER	
Valve 60cm x 45cm	C - 01
Valve 60cm x 100cm	C - 02
Pressure Break / Collection	C - 03
Distribution	C - 04
TANK	
Volume 2M2 / 3M2 / 4M2 / 5M2 (Type A)	T - 01
Volume 2M2 / 3M2 / 4M2 / 5M2 (Type B)	T - 02
Volume 6.5M2 / 8M2 / 10M2 / 12M2 (Type A)	T - 03
Volume 6.5M2 / 8M2 / 10M2 / 12M2 (Type B)	T - 04
Volume 2M2 - 15M2 (Ferro-cement) Drawing 1	T - 05
Volume 2M2 - 15M2 (Ferro-cement) Drawing 2	T - 06
VARIOUS	
Attached tap(s)	V - 01
Stand-pipe "86"	V - 02
Stand-pipe "88"	V - 03

Form A:

PRELIMINARY SURVEY FOR VILLAGE WATER SUPPLIES

Name of village: ....

Divisional Centre responsible: ....

District/Electorate/Area: ....

Population: ....

Infrastructure: ....

Sarvodaya activities/previous shramadana work: ....

....

Present water condition: ....

Type of sources available: ....

Altitude source:................................Altitude consumers: ....

Protection zone for springs: ....

....

Yield of springs: S 1 :............................ S 2 :.....................................

S 3 :......................... S 4 :.....................................

Months of dry season: ....

Name and address of contact person: ....

....

Remarks: ....

....

....

Name of Surveyor:...................... Date:......................

Overleaf: Handsketch about the project area and the sources

Form B

බී. ආකෘති පත්‍රය.

SPRING MEASUREMENTS / ජල උල්පත් ධාරිතාව මැනීම

Name of village: ....
(ගමේ නම)

District:................................ Divisional Centre :..................................
(දිස්ත්‍රික්කය) ප්‍රාදේශීය මධ්‍යස්ථාන

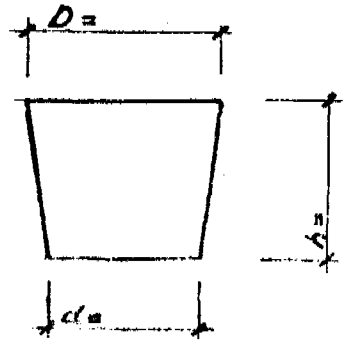
Date, when measured ජලය මැනීය සිදුකල දිනය	Spring 1 1 වෙනි උල්පත Location: .... (පිහිටීම)	Spring 2 2 වෙනි උල්පත	Spring 3 3 වෙනි උල්පත	Spring 4 4 වෙනි උල්පත

Remarks : Use for all measurements the same bucket. Measure the spring at least every week once at the same spot. Write in the list above the time it takes to fill the bucket. Write beside the volume of the bucket or give its dimensions.

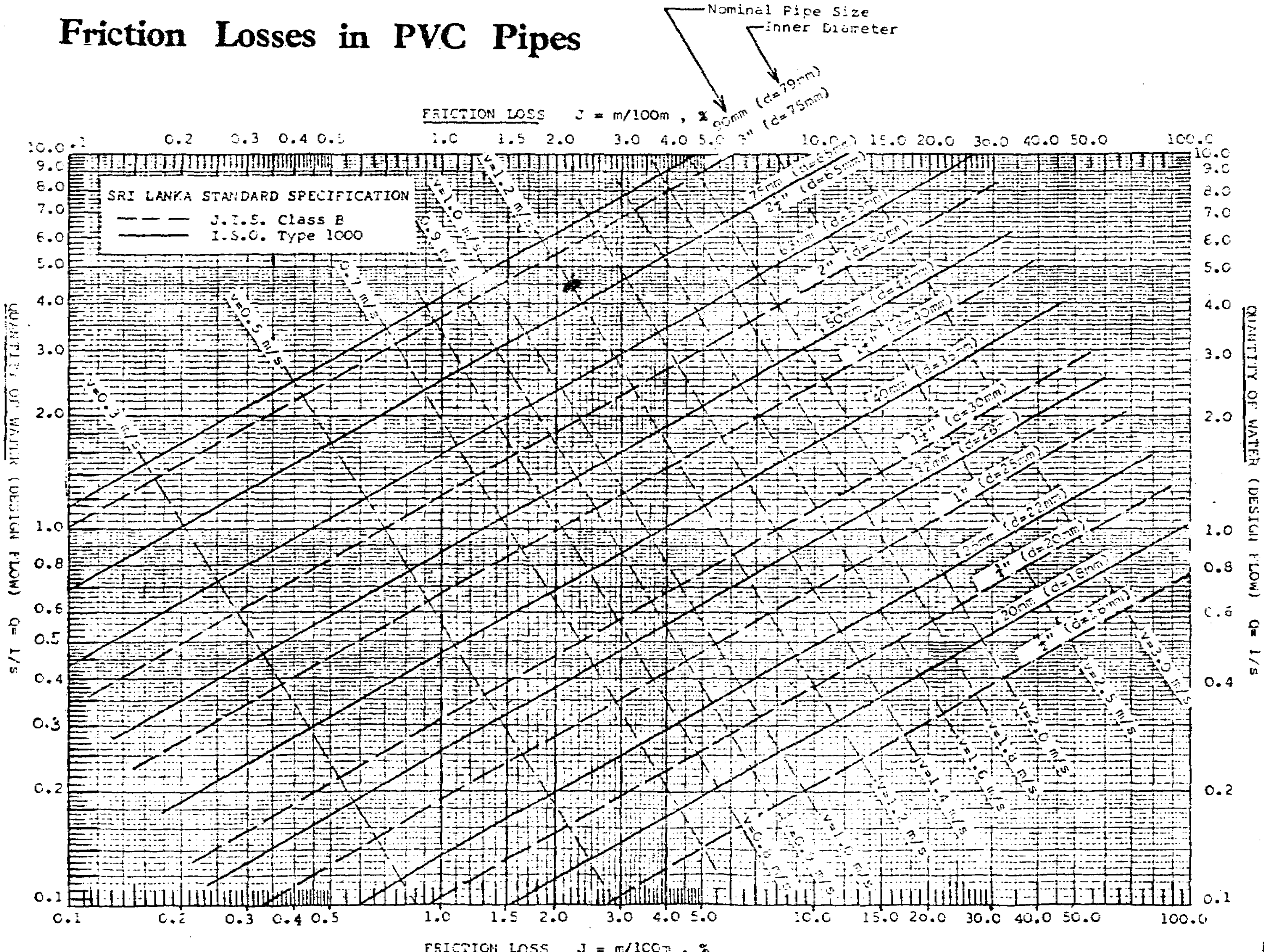
සටහන්: සියලුම මැනීම් කටයුතු සඳහා එකම භාජනයක් පාවිච්චි කරන්න. අඩුම වශයෙන් සතියකට එක් වරක්වත් ජලය මැනීම සිදු කරන්න. භාජනය වතුරින් පිරීමට ගත වූ කාලය තීරුවල අදාළ උල්පත් අංක යටතේ සටහන් කරන්න. භාජනයෙහි ජලය රඳන ප්‍රමාණය හෝ භාජනයෙහි දිග පළල රූප සටහනේ සටහන් කරන්න.

Volume .... Liters/ ලීටර්

(ප්‍රමාණය) .... Gallons ගැලුම්



Friction Losses in PVC Pipes



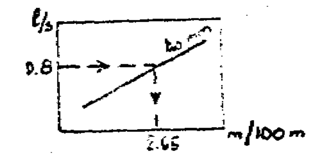
How to Read the Drawing :

Example:

Design Flow = 0.8 l/s
Pipe Length = 120m
Selected Pipe = 40mm (ISO)

Friction Loss = ?

From Drawing:



Result:

Fr. Loss: 2.65m/100m
Total Loss: 120m x $\frac{2.65m}{100m}$ = 3.1m

FORM C

Oct. 1983 / US

Pipe Roughness k=0.01 mm
Water at 10°C (50F)

FORM D

HYDRAULIC CALCULATION
AND PROFILE

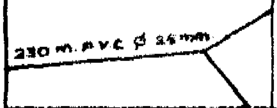
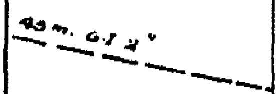
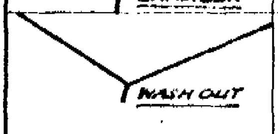
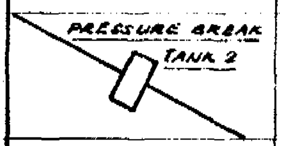
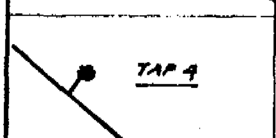
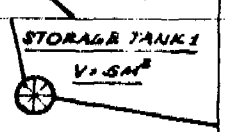
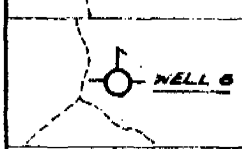
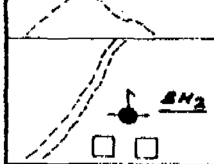
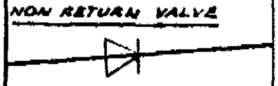
VILLAGE:.....................
....
SURVEYED BY:...............
....
DATE:......................
CHECKED BY:................

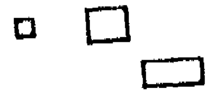
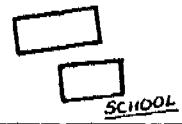
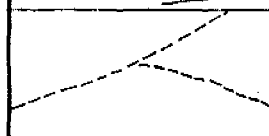
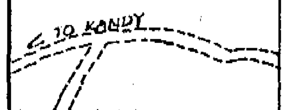
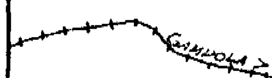
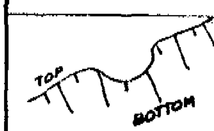
SCALE VERTICAL 1: 00
SCALE HORIZONT 1: 000

PIPELINE:
FROM: TO:
....
....
....

POINT No.		
DISTANCE BETWEEN POINTS		
REDUCED LEVEL	m	
STATIC PRESSURE HEAD	m	
DESIGNFLOW	l/sec	
PIPE SIZE (Type I.S.O.1000)		
FRICTION FACTOR	m/100	
FRICTION HEAD	m	
FRICTION CHAINAGE	m	
DYNAMIC HEAD	m	

SYMBOLS FOR DRAWINGS

SYMBOL	USED FOR
	PIPE LINE (SUPPLY , DISTRIBUTION)
	EXISTING PIPE LINE
	SPRING WITH PROTECTION ZONE
	SILT BOX
	VALVE CHAMBER
	WASH OUT WITH PLUG
	PRESSURE BREAK TANK
	WASH PLACE
	STAND PIPE
	STORAGE TANK
	WELL
	WELL WITH HAND PUMP
	BORE HOLE WITH HAND PUMP
	NON RETURN VALVE

SYMBOL	USED FOR
	HOUSES
	IMPORTANT BUILDINGS
	FOOT PATH
	ROAD
	RAILWAY LINE
	PADDY FIELD
	RIVERS
	FOREST
	TEMPLE
	CLIFF, STEEP SLOPE
	BRIDGE , CULVERT
	TEA LAND

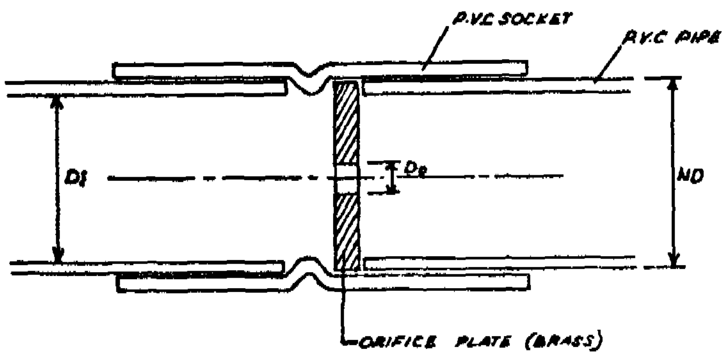
F ආකෘති පත්‍රය.
Form F

ජල නලයක් තුළ ඇති රන්ද්‍රයක් මගින් වන හිසෙහි හානිය.

Headloss through an Orifice in a Pipe

කරාමයක් තුළ අධික ජල හිසක් බල පවත්වන විට රන්ද්‍ර තහඩුවක් භාවිතයෙන් එනම් කරාමයක ජලය ලබාදෙන නලය තුළට පිත්තල වලින් තැනූ තහඩුවක් ඇතුල් කිරීමෙන් ඉතාමත් පහසුවෙන් ජලය ගලා යාම හසුරාලිය හැක.

A simple way of regulating the flow at tapstands in case of excessive hydraulic head is through the installation of an orifice plate, i.e. a plate made from brass, into the pipe leading to the tap.



රන්ද්‍රයේ විශ්කම්භය
D_o = ORIFICE DIAMETER

පී.වී.සී. නලයේ විශ්කම්භය
ND = NOMINAL DIAMETER OF P.V.C PIPE

පී.වී.සී. නලයේ ඇතුළත විශ්කම්භය
D_i = INTERNAL DIAMETER OF P.V.C PIPE

රන්ද්‍රයක් මගින් වන හිසෙහි හානිය නලයේ විශ්කම්භය රන්ද්‍රයේ ප්‍රමාණය සහ නලය තුළ ජලය ගලන වේගය මත රඳා පවතී.

The headloss through an orifice is dependent on the pipe diameter, size of orifice, and the flowrate through the pipe.

මි-මී 20ට සිට මි. මී. 25 දක්වා නාමික විශ්කම්භ ඇති නල සඳහා සහ තත්පරයකට ලීටර් 0.2ක සැළසුම් ගැලීමක් සඳහා (ස.ගැ.කා.සේ. යෝජනා ක්‍රමවල ඇති කරාමයක ප්‍රමිති සැළසුම් ගැලීම) පහත සඳහන් ආසන්න හිසෙහි හානින් ලබා ගත හැක.

For a design flow of 0.2 1/sec (standard design flow for a tap in SRTS projects), and for **nominal pipe diameters of 20 to 25 mm, the following approximate headlosses may be obtained:**

රන්ද්‍රයේ විශ්කම්භය D_0 (මි.මී.) **Orifice Diameter Do (mm)**	රන්ද්‍ර තුළින් හිසෙහි හානිය (මී) **Headloss through Orifice (m)**
3.5	**59**
4.0	**34**
4.5	**21**
5.0	**13.5**
5.5	**9**
6.0	**6.5**

HYDRAULIC CALCULATIONS — VARIANTS

FORM G

V.W.S. of: Date: Sheet:

Point NO	Distance l m	Static head m	Pipe ø mm	Tap NO	Flow rate l/s	Friction loss rate %	Friction loss m	Friction chainage	Dynamic pressure head	Remarks

FORM H

Village:..............................District:......................

Project No.:...........Surveyor:....................Date:............

Points (from–to)	Angles: horizontal	Angles: vertical	Distance	Remarks	Calculations: D_h	Calculations: D_v	Reduced level: Pt.	Reduced level: level

TECHNICAL INFORMATION (GWS only) FORM I /a

Name of Project :...

District :..............

Population :.........

...............:.........

...............:.........

...............:.........

...............:.........

Sources:	Dry Season:	Wet Season:
Spring	1/sec	1/sec
Spring	1/sec	1/sec
Spring	1/sec	1/sec
	1/sec	1/sec
Total Yield:	1/sec	1/sec

WATER DEMAND

.... x 45 1/day/consumer =...........

.... x 10 1/day/student =...........

....=...........

Total excl. Growthfactor =........... x ....Growthfactor =..........1/day

WATER BALANCE DRY SEASON

Total yield .....1/sec x 60 x 60 x 24 hrs =...........

Water demand incl. Growthfactor =...........

Estimated overflow / shortage =...........1/day

WATER BALANCE WET SEASON

Total yield .....1/sec x 60 x 60 x 24 hrs =...........

Water demand incl. Growthfactor =...........

Estimated overflow / shortage =...........1/day

SEDIMENTATION CHAMBER (Siltbox)

	Siltbox 1	Siltbox 2
Inlet Qmax wet season (1/sec x 60 x 20)	.......1/20min.	.......1/20min.
Inlet Qmin dry season (1/sec x 60 x 20)	.......1/20min.	.......1/20min.
Outlet Qmax of Designflow (1/sec x 60 x 20)	.......1/20min.	.......1/20min.
Volume chosen	 L	 L

DESIGN FLOWS

		(Qreq)	(Qmax)
Mainline Siltbox - St. Tank 1	= 1/day / 86400 sec.	= 1/sec	.....1/sec
Mainline Siltbox - St. Tank 2	= 1/day / 86400 sec.	= 1/sec	.....1/sec
Mainline Siltbox - Distr. Chamber	= 1/day / 86400 sec	= 1/sec	.....1/sec
....	= 1/day / 86400 sec	= 1/sec	.....1/sec
....	= 1/day / 86400 sec	= 1/sec	.....1/sec

TECHNICAL INFORMATION (GWS only) FORM I /b

DISTRIBUTION SYSTEM	Tank 1	Tank 2	Tank 3	Tank 4
Water Demand l/day (incl.Growthfac.)				
Distribution Ratio (Parts)				
Pipe Ø for Distribution (Chamber)				
Inlet Qmin l/sec (Dry Season)				
Inlet Qmax l/sec (Ref. Designflow)				

STORAGE TANK CALCULATION (For additional tanks use backside)

TANK NO: 1	INLET ....l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	....	30	....	....	....
8.30-11.30am	3	....	10	....	....	....
11.30- 1.30pm	2	....	15	....	....	....
1.30- 4.00pm	2.5	....	10	....	....	....
4.00- 7.00pm	3	....	30	....	....	....
7.00- 5.30am	10.5	....	5	....	....	....
Daily yield	=	....		....	= Daily demand	Overflow
Storage Capacity (min.).........L = ...M3 Tank size chosen =....M3						
Tank is filled within ....hrs. (must be less than 10 hrs)						

FLOWDIAGRAM (Handsketch)

Prepared by :..............

Date :..............

Tech. Advisor:..............

Signature :..............

TANK NO: 2	INLET....l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	....	30	....	....	....
8.30-11.30am	3	....	10	....	....	....
11.30- 1.30pm	2	....	15	....	....	....
1.30- 4.00pm	2.5	....	10	....	....	....
4.00- 7.00pm	3	....	30	....	....	....
7.00- 5.30am	10.5	....	5	....	....	....
Daily yield =		....		....	= Daily demand	Overflow
Storage Capacity (min.).........L = ...M3 Tank size chosen =....M3						

TANK NO: 3	INLET....l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	....	30	....	....	....
8.30-11.30am	3	....	10	....	....	....
11.30- 1.30pm	2	....	15	....	....	....
1.30- 4.00pm	2.5	....	10	....	....	....
4.00- 7.00pm	3	....	30	....	....	....
7.00- 5.30am	10.5	....	5	....	....	....
Daily yield =		....		....	= Daily demand	Overflow
Storage Capacity (min.).........L = ...M3 Tank size chosen =....M3						

TANK NO: 4	INLET....l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	....	30	....	....	....
8.30-11.30am	3	....	10	....	....	....
11.30- 1.30pm	2	....	15	....	....	....
1.30- 4.00pm	2.5	....	10	....	....	....
4.00- 7.00pm	3	....	30	....	....	....
7.00- 5.30am	10.5	....	5	....	....	....
Daily yield =		....		....	= Daily demand	Overflow
Storage Capacity (min.).........L = ...M3 Tank size chosen =....M3						

Tank 2 is filled within........................hrs (must be less than 10 hrs)

Tank 3 is filled within........................hrs (must be less than 10 hrs)

Tank 4 is filled within........................hrs (must be less than 10 hrs)

LESSON NO 1 : Chapter 1 : Intake of Spring
Chapter 2 : Dimensioning of Sedimentation Chamber

Chapter 1 : Intake of Spring

Refer to: HBC page -99- 11.1. Introduction
11.2. Site Locations
MST page -9- 2.2. Spring Measurements
2.3. Quality Test of Springs
3.2. Spring Catchments

Example 1.1.

Qmax = 1.5 l/sec (Spring flow during rainy season)
Qmin = 0.85 l/sec (Spring flow during dry season)
L = 25m (Distance from spring to siltbox)
H = 0.7m (Head; hight between outlet spring and inlet siltbox)
Ø = 50mm (Outlet pipe springcatchment to siltbox)
Qreq = 1.0 l/sec (Required design flow)

Question:

Is the selected pipe Ø of 50mm sufficient?
Do we need an overflow pipe at the catchment?

First Reach:

$$\text{Headloss: } \frac{0.7m}{25m} \times 100 = \underline{\underline{2.8m/100m}} \text{ or } \underline{\underline{2.8\%}}$$

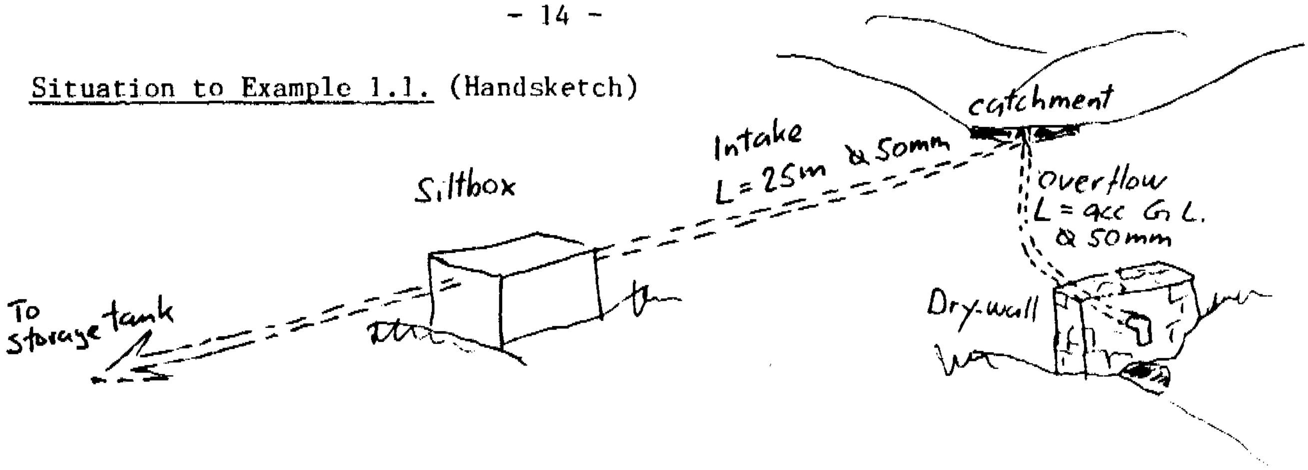
Second Reach:

Refer to table "Friction Losses in PVC Pipes" (Form C)
Accordingly to this table Qmax = 1.55 l/sec

Conclusion:

The minimum pipe Ø should never be smaller than 50mm.
Selected pipe Ø of 50mm is sufficient because Qmax = 1.55 l/sec compared to Qreq = 1.0 l/sec.
One overflow pipe of Ø 50mm is needed.

Situation to Example 1.1. (Handsketch)



Exercise 1

Design the Intake and Overflowpipe according to the following informations: Spring flow during rainy season = 2 l/sec. Spring flow during dry season = 1 l/sec. Distance spring to siltbox = 20m ; H = 0.4m

Designflow = 1.4 l/sec. (Refer to example 1.1.)

Use this space for calculation etc.

EXERCISE 1 (Solution)

Headloss: $\frac{0.4m}{20m}$ x 100 = 2m/100m or 2%

Qmax: Ø 50mm = 1.3 l/sec < Qreq

Ø 63mm = 2.3 l/sec > Qreq

Conclution: For Intake 1 x Ø 63mm or 2 x Ø 50mm

For overflow springcatchment min. 1 x Ø 50mm

or better 1 x Ø 63mm

Chapter 2 : Dimensioning of Sedimentation Chamber (Siltbox)

Refer to : HBG page -102-104- 11.6. Sedimentation
11.7. Service Pipes
-114-115- 12.1. Introduction
12.2. Settling Velocities
12.3. Detention Time
MST page -9- 3.3. Siltbox

Example 2.1.

Spring Flow: (Inlet)

Qmax = 0.45 l/sec or 27 l/min

Qmin = 0.25 l/sec or 15 l/min

Design Flow (Outlet)

Qreq. = 0.30 l/sec

Question:

What is the required volume of the siltbox to allow a minimum retention time of 20 minutes? Selected pipe Ø for the outlet is Ø 25mm with a maximum possible flow of 0.4 l/sec. (During rainy season only).

First Reach:

Qmax from spring during rainy season (Intake)
= 0.45 l/sec x 60 = 27 l/min x 20 = 540 l/20minutes

Second Reach:

Qmax for outlet pipe Ø 25mm
= 0.40 l/sec x 60 = 24 l/min x 20 = 480 l/20minutes

Third Reach:

Overflow at siltbox (during rainy season only)
= 540 l - 480 l = 60 l/20minutes or 3 l/min

Conclution:

Siltbox with volume of min 480 l is needed.
Take standard plan of Siltbox V = 500 l

Exercise 2

What is the required volume of the Siltbox?

The following informations are given:

Retention time	= 20 minutes
Spring flow Qmax	= 0.21 l/sec
Qmin	= 0.16 l/sec
Design flow Qreq	= 0.20 l/sec
Outlet siltbox	= PVC Ø 25mm; Qmax = 0.3 l/sec

Use this space for calculation etc.

EXERCISE 2 (Solution)

Spring flow Qmax = 0.21 l/sec x 60 x 20 = 252 l/20minutes

Minimum volume of siltbox = 252 l / take standardplan V = 300 L

Exercise 3

What is the required volume of the Siltbox, and what is the expected overflow during rainy season at the Siltbox ?

The following informations are given:

Retention time	= 20 minutes
Spring flow Qmax	= 1.60 l/sec
Qmin	= 1.00 l/sec
Design flow Qreq	= 0.80 l/sec
Qmax	= 1.00 l/sec

Use this space for calculation etc.

EXERCISE 3 (Solution)

Spring flow (rainy season) Qmax = 1.6 l/sec x 60 x 20 = 1920 l/20minutes

Designflow (outletpipe) Qmax = 1.0 l/sec x 60 x 20 = 1200 l/20minutes

Overflow at siltbox (during rainy season only) = 720 l/20minutes

Minimum volume of siltbox = 1200 L / ev. better 1500L

LESSON NO 2 : Chapter 3 : Design Period, Population, Water Demand
Chapter 4 : Design Flow of Mainline Siltbox - Storagetank

Chapter 3 : Design Period, Population, Water Demand

Refer to: HBG page -27-29- 4.1. Introduction
4.2. Design Period
4.3. Population Forecast
4.4. Water Demand
MST page -9- 3.1. Water Consumption

Example 3.1.

Calculate the Water Demand for a village with the following information:

Population = 450 people
School = 200 day-students
Daily Consum. = 45 l per person (Possible due to good spring available)
Spring Flow = 25 l/min during dry season

Note: For the increase of population and consumption which is about 35% increase over a period of 20 years, as well leakage and wastage of water which is about 10%, it is advisable to take a GROWTHFACTOR of 1.1 - 1.5 to consider the future water demand.

First Reach:

Daily Water Demand

450 x 45 l/day/consumer.................. = 20250
200 x 10 l/day/student................... = 2000
22250 l/day

Second Reach:

Design of future Water Demand

Growthfactor 1.5 x 22250................. = 33375 l/day

Third Reach:

Water Balance (during dry season)

Spring yield, 25 l/min................... = 36000 l/day
Estimated consumption incl. future consum. = 33375 l/day
Estimated overflow....................... = 2625 l/day

Exercise 4

Calculate the Water Demand as well Water Balance during dry and rainy season for a village with the following informations:

Population	= 150 people
Spring Flow	= 0.12 l/sec during rainy season
	0.06 l/sec during dry season
Growthfactor	= 1.3 (This factor of 1.3 includes in this example the increase of consumption only, assuming there is no increase of population.

Use this space for calculation etc.

EXERCISE 4 (Solution)

Daily water demand incl. future demand:

150 x 45 l/day = 6750 l/day x 1.3 growthfactor	= 8775 l/day
Water balance: (rainy season)	
Spring yield: 0.12 l/sec x 86400 sec.	= 10368 l/day
Consumption incl. future demand	= 8775 l/day
Estimated overflow	= 1593 l/day
Water balance: (dry season)	
Spring yield: 0.06 l/sec x 86400sec	= 5184 l/sec
Consumption incl. future demand	= 8775 l/day
Estimated shortage	= -3591 l/day

Conclution: During rainy season sufficient water available, see overflow. During dry season in future shortage of 3591 l/day possible.

Therefore: Rainy season 45 l/day/person / dry seson about 35 l/day/person or less, if the population increase.

Chapter 4 : Design Flow of Mainline Siltbox - Storagetank

The Design Flow is calculated by dividing the total consumption per day (Water Demand incl. ev. Growthfactor) by 86400 seconds.

$$\text{DESIGN FLOW} \quad \text{Qreq (1/sec)} = \frac{\text{Water Demand per Day (1)}}{\text{86400 (seconds)}}$$

Example 4.1.

We want to know the Design Flow based on the informations given in example 3.1. As there is a sufficient spring yield available as well an estimated overflow during dry season, we can take the estimated Future Water Demand incl. Growthfactor for the calculation of the Design Flow.

$$\text{Design Flow Qreq} = \frac{33375 \text{ 1}}{86400 \text{ sec}} = \underline{\underline{0.386 \text{ 1/sec}}}$$

Question:

What is the required pipe Ø for the mainline siltbox to storagetank assuming the following informations are given:

L = 400m (Distance siltbox - storagetank)

H = 40m (Head; hight between siltbox - storagetank)

Qreq = 0.386 1/sec

First Reach:

$$\text{Headloss: } \frac{40\text{m}}{400\text{m}} \times 100 = \underline{\underline{10\text{m}/100\text{m or } 10\%}}$$

Second Reach:

Refer to table "Friction Losses in PVC Pipes" (Form C)

Accordingly to this table:

Headloss (Frictionloss) 10%, PVC Ø 20mm Qmax = 0.29 1/sec (to small Ø)

10%, PVC Ø 25mm Qmax = 0.49 1/sec (suitable Ø)

Conclusion:

To guarantee the required Design Flow of Qreq = 0.386 1/sec, we have to select PVC pipe Ø 25mm with approximately Qmax = 0.49 1/sec.

Exercise 5

Calculate the Design Flow and required pipe Ø for the pipeline siltbox to storagetank. What is the maximum flow (Qmax) of the selected pipe?
The following informations are given:

Daily Water Demand		= 22000 l/day (incl. future demand)
Siltbox	H	= 135m
Storagetank	H	= 100m
Distance Siltb.- Tank		= 700m

EXERCISE 5 (Solution)

Designflow : $\frac{22000\ l}{86400\ sec} = \underline{\underline{0.25\ l/sec}}$

Headloss: $\frac{35m}{700m} \times 100 = \underline{\underline{5m/100m\ or\ 5\%}}$

Proposed pipe Ø : Ø 20mm Qmax = 0.19 l/sec → not sufficient.
Ø 25mm Qmax = 0.33 l/sec → O.K.

Exercise 6

The following information is given:

Village population		= 300 people
Growthfactor		= 1,4
Spring flow		= 0.22 l/sec during rainy season
		0.17 l/sec during dry season
Siltbox	H	= 121m
Storagetank	H	= 100m
Distance	L	= 300m (Siltbox to Storagetank)

Calculate: Water Demand, Water Balance dry season and rainy season, Design Flow (Qreq), Pipe Ø Siltbox to Storagetank, Design Flow (Qmax) and required Volume of Siltbox.

EXERCISE 6 (Solution)

Daily water demand incl. future demand:

300 x 45 l/day = 13500 l/day x 1.4 growthfactor = 18900 l/day

Water balanc: (rainy season)

Spring yield: 0.22 l/sec x 60 x 60 x 24	= 19008 l/day
Water demand incl. future demand	= 18900 l/day
Estimated overflow	= 108 l/day

Water balance: (dry season)

Spring yield: 0.17 l/sec x 60 x 60 x 24	= 14688 l/day
Water demand	= 18900 l/day
Shortage in future (after 20 years)	= -4212 l/day

Designflow: $\frac{18900 \text{ L}}{86400 \text{ sec}}$ = 0.218 l/sec

Headloss : $\frac{21\text{m}}{300\text{m}}$ x 100 = 7m/100m or 7%

Mainline Siltbox - Tank = Ø 20mm = Q_{max} = 0.24 l/sec

Siltbox: 0.22 l/sec x 60 x 20 = 264 l/20minutes take Plan V = 300 L

LESSON NO 3 : Chapter 5 : Capacity Design of Storage Tanks
Chapter 6 : Distribution Ratio

Chapter 5 : Capacity Design of Storage Tanks

Refer to: HBG page -124-126- 14.1. Introduction
14.2. Necessity for a Reservoir
14.3. Capacity
MST page -11- 3.4. Storage Tank

Consumptionpattern

The consumptionpattern shown in the HBG page -126- are based upon direct observation of typical villages in Nepal. Although no actual fieldstudies have been done in Sri Lanka to determine the pattern of consumption during the day. SRTS for the purpose of design assumes, that the consumptionpattern over the day will roughly be like indicated below:

SRTS Consumptionpattern

Hours of the day		Percentage of daily consumtion		
5.30 am - 8.30 am =	3 hrs	30%	of total daily	water need
8.30 am - 11.30 am =	3 hrs	10%	-"-	-"-
11.30 am - 1.30 pm =	2 hrs	15%	-"-	-"-
1.30 pm - 4.00 pm =	2.5 hrs	10%	-"-	-"-
4.00 pm - 7.00 pm =	3 hrs	30%	-"-	-"-
7.00 pm - 5.30 am =	10.5 hrs	5%	-"-	-"-
	24 hrs	100%		

Example 5.1.

The project population of a village is 350 people.
Safe yield of the source is 0.25 l/sec. (during dry season)
The total daily water demand including growthfactor is 20000 l/day.
Calculate the required storage capacity, by using the assumed SRTS - consumptionpattern.

PERIOD	INLET		DEMAND		DIFFERENCE	WATER LEVEL
	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	2700	30	6000	- 3300	- 3300
8.30-11.30am	3	2700	10	2000	+ 700	- 2600
11.30- 1.30pm	2	1800	15	3000	- 1200	- 3800
1.30- 4.00pm	2.5	2250	10	2000	+ 250	- 3550
4.00- 7.00pm	3	2700	30	6000	- 3300	- 6850)[3]
7.00- 5.30am	10.5	9450	5	1000	+ 8450	+ 1600)[4]
Daily spring yield =		21'600)[1]		20'000)[2] = Daily demand		Overflow
Storage Capacity (min.) 6850 L		=		6.85 M3	Tank size chosen = 7 M3	

)[1] = Daily spring yield (0.251/sec x 60 x 60 x 24 = 21600 L

)[2] = Daily water demand incl. growthfactor (20000 L)

)[3] = The maximum shortfall during the day (-6850 L)

)[4] = Overflow early morning (1600 L)

Conclusion: The required storage capacity is 6850 L. (The maximum shortfall during the day). This volume is rounded off to the next available standard-plan, lets say recommended volume is 7000 L / 7 m3

After calculating the required storage capacity always check whether the recommended tank(s) will be filled up during the night within 8 hours.

Check: Spring yield 0.25 1/sec x 60 x 60 x 8hrs = 7200 L

Recommended volume of tank = 7000 L = O.K.

Exercise 7 (Solution)

Calculate the required storage capacity for the village descriped in example 3.1. (one tank only)

PERIOD	INLET 25 1/min.		DEMAND		DIFFERENCE	WATER LEVEL
	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	4'500	30	10'012.5	- 5'512.5	- 5'512.5
8.30-11.30am	3	4'500	10	3'337.5	+ 1'162.5	- 4'350
11.30- 1.30pm	2	3'000	15	5'006.25	- 2'006.25	- 6'356.25
1.30- 4.00pm	2.5	3'750	10	3'337.5	+ 412.5	- 5'943.75
4.00- 7.00pm	3	4'500	30	10'012.5	- 5'512.5	- 11'456.25
7.00- 5.30am	10.5	15'750	5	[illegible]	[illegible]	+ 2'625
Daily spring yield =		36'000		Daily demand		Overflow
Storage Capacity (min.) 11'456 L		=		11.45 M3	Tank size chosen = 12 M3	

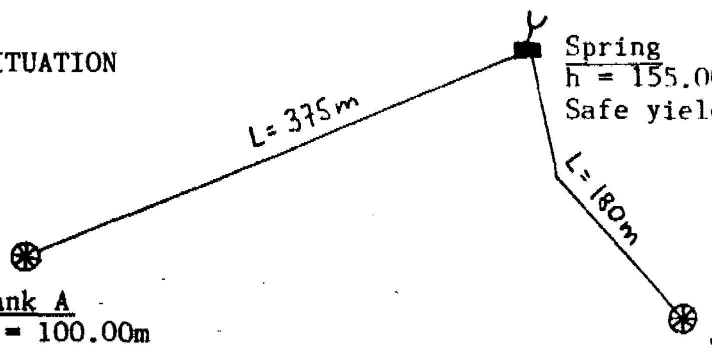
Check: Spring flow 25 1/min. x 60 x 8 hrs. = 1200 1 = Tank size 12000 1 = O.K.

Chapter 6 : Distribution Ratio

If a GWS scheme needs more than one storage tank, it is necessary to allocate the accurate number of consumers benefiting of each tank. Thereafter by knowing the daily water demand of beneficiaries for each tank, the Distribution - Ratio can be calculated as shown in the following example.

Example 6.1.

SITUATION



Spring
h = 155.00m (siltbox)
Safe yield: 0.35 l/sec

Tank A
h = 100.00m

Tank B
h = 85.00m

Consumer: (Tank A)

150 people	= 10125 l/day
300 day-students	= 4500 l/day
Total	= 14625 l/day*

Consumer: (Tank B)

80 people	= 5400 l/day
Total	= 5400 l/day*

* = Total Daily Water Demand incl. Growthfactor.

Distribution Ratio:

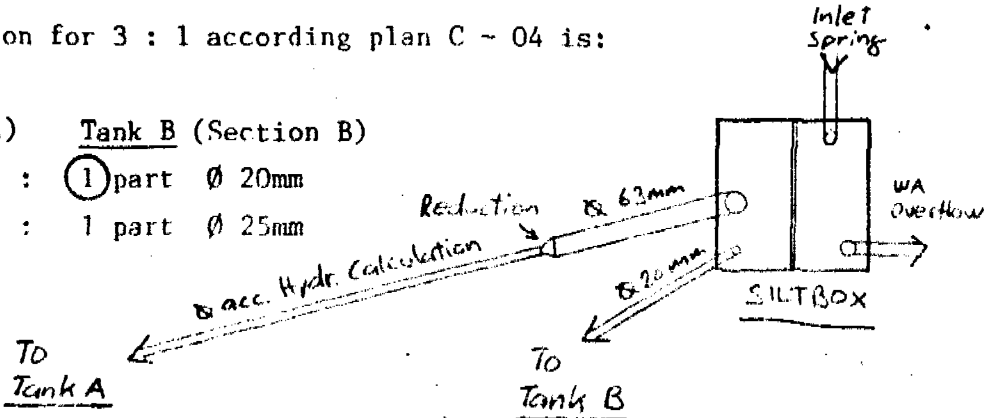
$$\frac{\text{Tank A}}{\text{Tank B}} = \frac{14625\ \text{l/day}}{5400\ \text{l/day}} = \frac{2.7}{1} = \frac{3}{1}$$

Conclusion:

As there is sufficient water available we can use instead 2.7 : 1 the ratio 3 : 1 which makes it possible to use standardplan C - 04.

Recommended distribution for 3 : 1 according plan C - 04 is:

For: Tank A (Section A) : Tank B (Section B)
(3) parts Ø 63mm : (1) part Ø 20mm
or: 3 parts Ø 75mm : 1 part Ø 25mm



Exercise 8

What is the required pipe Ø ; Qreq and Qmax for Section A (spring - tank L=375m) and Section B (spring - tank L=180m).
Refer to example 6.1.

EXERCISE 8 (Solution)

Section B : (safe yield) = $\frac{0.35\ l/sec}{4}$ = 0.0875 l/sec (Designflow = 0.0625 l/sec)

Section A : (safe yield) = $\frac{0.35\ l/sec\ x\ 3}{4}$ = 0.2625 l/sec (Designflow = 0.1692 l/sec)

Section A : Designflow = $\frac{14625\ l/day}{86400\ sec}$ = 0.1692 l/sec

Section B : Designflow = $\frac{5400\ l/sec}{86400\ sec}$ = 0.0625 l/sec

Required pipe Ø for section A:

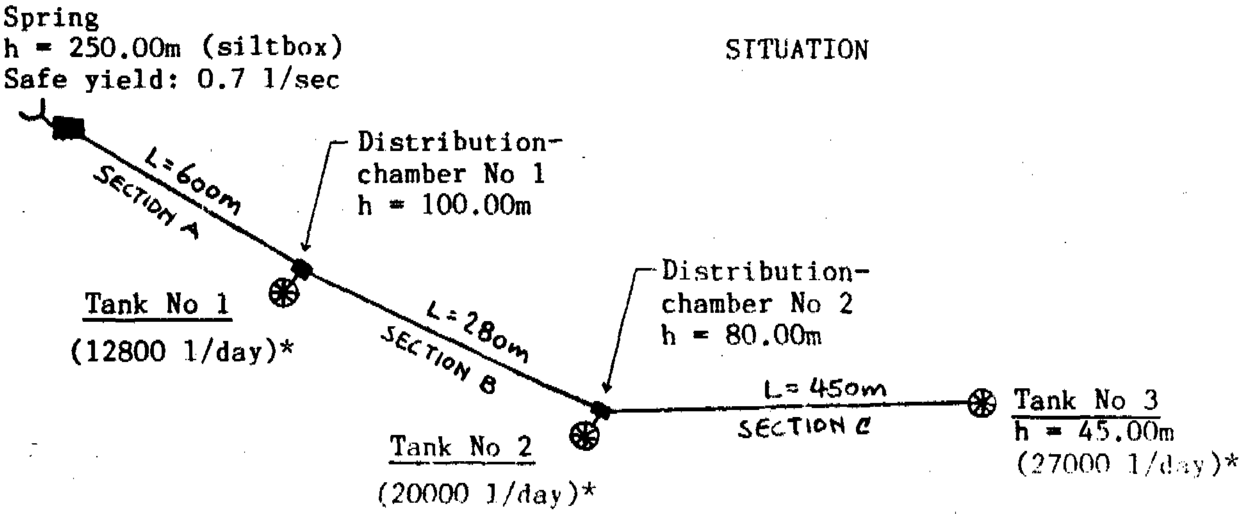
Headloss: $\frac{55m}{375m}$ x 100 = 14.66 m/100m   Ø 20mm Qmax = 0.35 l/sec (Qsafe= 0.2625)

Required pipe Ø for section B:

Headloss: $\frac{70m}{180m}$ x 100 = 38.88 m/100m   Ø 20mm Qmax = 0.58 l/sec (Qsafe= 0.08)

Exercise 9

Calculate the Distribution - Ratio as well the required pipe Ø ; Qreq and Qmax for each section. (A, B and C).



)* = Daily Water Demand incl. Growthfactor.

(Use back-side of this page for calculation etc.)

EXERCISE 9 (Solution)

Distribution system:	TANK 1	TANK 2	TANK 3
Water demand l/day :	12800 l/day	20000 l/day	27000 l/day
Distribution ratio:	$\frac{12800}{12800} = 1$	$\frac{20000}{12800} = 1.56$	$\frac{27000}{12800} = 2.1$
Pipe Ø for distribution:	1 Part = Ø 20mm	1 1/2 Parts = Ø 32mm	2 Parts = Ø 40mm
Inlet Qmin (l/sec) :	0.1555	0.2333	0.3111

→ (0.7 l/sec = safe yield)

Section A:

Headloss: $\frac{150m}{600m} \times 100 = 25\%$

Selected pipe Ø : 25mm Qmax = 0.8 l/sec Qreq = 0.7 l/sec → 4.5 Parts

Section B:

Headloss: $\frac{20m}{280m} \times 100 = 7.14\%$

Selected pipe Ø : 25mm Qmax = 0.4 l/sec (not sufficient) Qreq = 0.5444 l/sec (0.3111 + 0.2333)

32mm Qmax = 0.8 l/sec O.K. 2 Parts + 1.5 Parts

better combination of pipe sizes:

assumed Qmax = 0.6 l/sec

$$\frac{100 \times 15 - (4.5\% \times 280m)}{14.5\% - 4.5\%} = \begin{matrix} 24m \ Ø \ 25mm \\ 256m \ Ø \ 32mm \end{matrix}$$

Qmax = 0.6 l/sec (Head 5m)

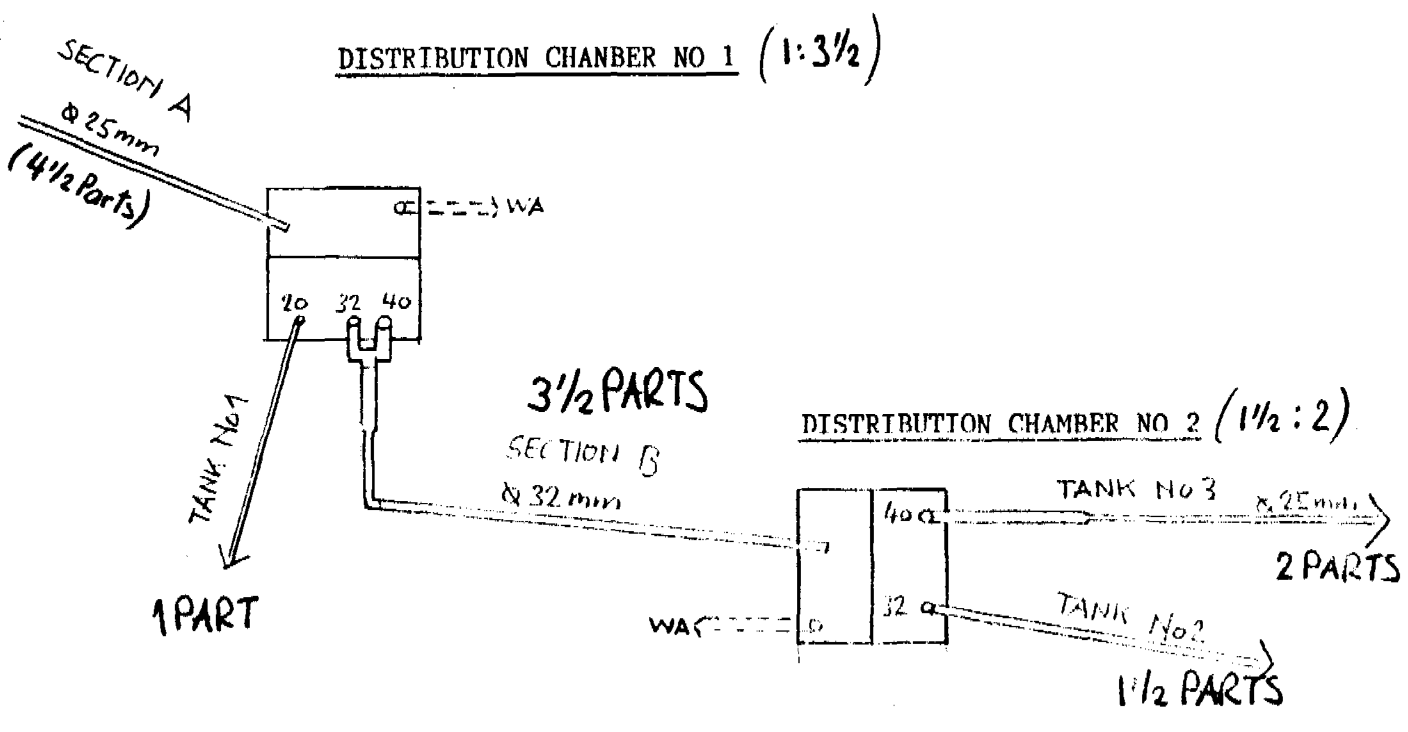
Section C:

Headloss: $\frac{35m}{450m} \times 100 = 7.77\%$

Selected pipe Ø : 25mm Qmax = 0.42 l/sec Qreq = 0.3111 l/sec → 2 Parts

EXERCISE 9 (Ratio for Distribution Chamber)

(Solution) Sketch in addition to solution of exercise 9



LESSON NO 4 : Chapter 7 : Topographic Surveying
Chapter 8 : Flow Rate, Pipeline Design

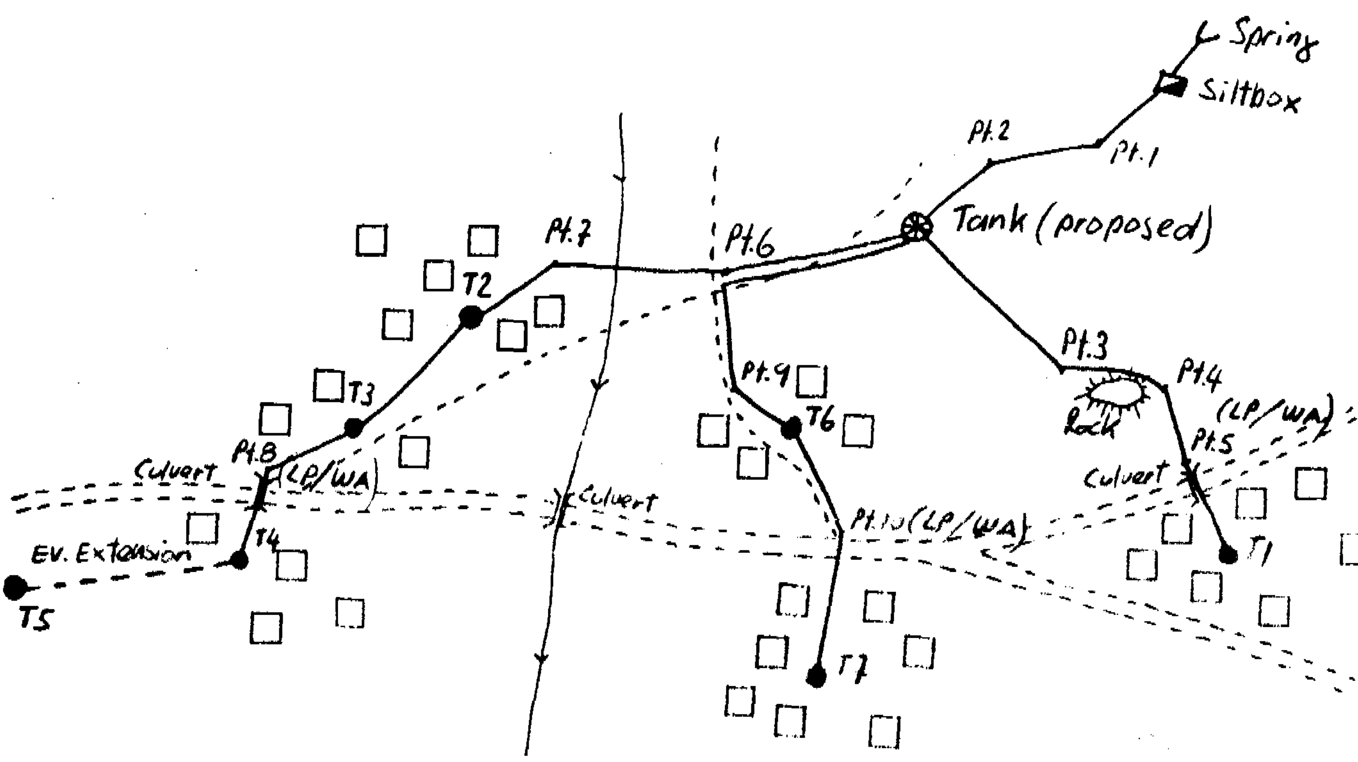
Chapter 7 : Topographic Surveying

Refer to: HBG page -16-26- 3.1. Introduction
3.3. Barometric Altimeter
3.4. Abney Level (Clinometer)
3.8. Surveying with the Abney (Clinometer)

As it commonly happens within SRTS the topographic survey is divided up in two separate surveys. One for the so called "Situation - Survey" and the other one for the "Hydraulic - Survey". The situation survey indicates all the important marks as roads, rivers, houses etc. The hydraulic survey indicates the alignment of the pipeline from the source to the storage tank and the distribution to the standposts. These two surveys are needed to draw the final situation plan, normaly to scale 1:5000. Beside using the standard form H for surveying, it is advisable to maintain at the same time a freehandsketch of the plan, to mark all survey points or other important fix-points.

Example 7.1.

Sketch of Hydraulic Survey (By using a copy of the previous made situation plan, scale 1:5000).



Chapter 8 : Flow Rate & Pipeline Design

Refer to: HBG page -58-73- For introduction and general information.
MST page -11- 3.5. Distribution System
3.6. Piping

Flow Rate

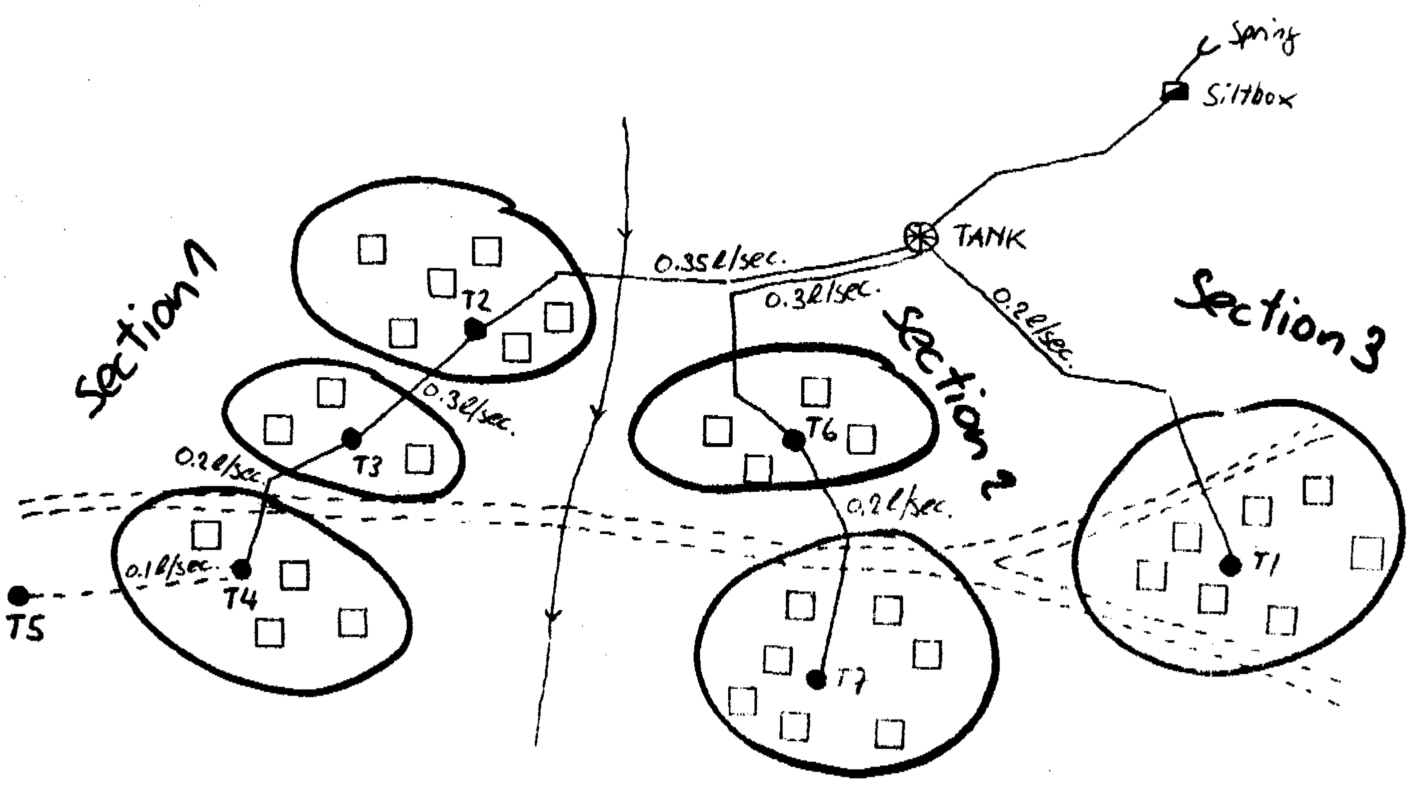
The required flow rate depends on the number of consumer at each tap. The minimum flow rate for one tap is 0.10 l/sec. (0.05 l/sec.). If many consumer are expected at the same tap, the flow rate has to be increased to 0.2 l/sec.

In general use the following recommended flow rates:

1 Tap minimum flow	= 0.10 l/sec		
2	-"-	= 0.20 l/sec	
3	-"-	= 0.30 l/sec	
4	-"-	= 0.35 l/sec	
5	-"-	= 0.40 l/sec	
6	-"-	= 0.45 l/sec	For every extra tap add 0.05 l/sec

Example 8.1.

Sketch of Flow Rate Design (Refer as well to example 7.1.)



Pipeline Design

Refer to: MST page -13- 3.7. Hydraulic Calculation

To work out the most suitable dimension of a pipeline section, it is advisable to use standard Form G as a worksheet first. Later on the final design is transfered to Form D, the Hydraulic Profile. The hydraulic profile creates a visual, easy to understand picture of the topographic elevation along the pipeline. It is not a worksheet, but the presentation with lots of information of the final pipeline design. Therefore it should be carefully laid out and kept clean. (Not too many eraser traces.)

Note: Form G does not replace Form D. The Hydraulic Profile remains always necessary for all Gravity Water Supplies.

Example 8.1.

Explains how to work out the most suitable pipeline design for section 2 by using stanard Form G (Hydraulic Calculation Variants).

Refer also to sketch of example 8.1.

Distance:

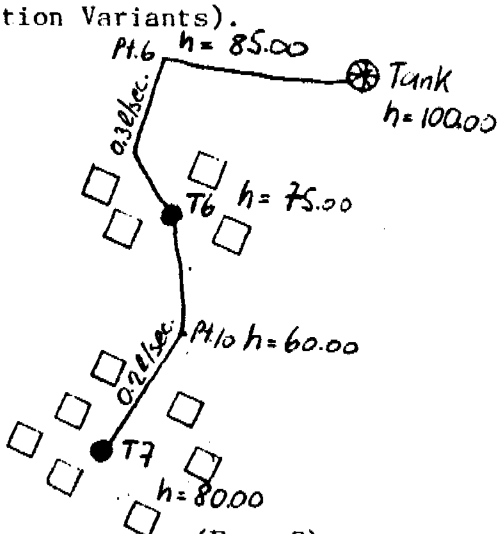
Tank - Tap 6 = 220m

Tap 6- Pt.10 = 50m

Pt.10- Tap 7 = 80m

Tank - Pt. 6 = 100m

Key Plan of Section 2



Hydraulic Calculations - Variants (Form G)

Point NO	Distance l m	Static head m	Pipe ø mm	Tap NO	Flow rate l/s	Friction loss rate m/100m	Friction loss m	Friction chainage	Dynamic pressure head	Remarks
Tank/T6	220	25	25	2	0.3	4.25	9.35	9.35	15.65	O.K.
T6/T7	130	20	20	1	0.2	5.25	6.82	16.17	3.83	not sufficient! min. 5.00
Second Assumption:										
Tank/T6	220	25	25	2	0.3	4.25	9.35	9.35	15.65	O.K.
T6/T7	130	20	25	1	0.2	2.0	2.60	11.95	8.05	O.K.

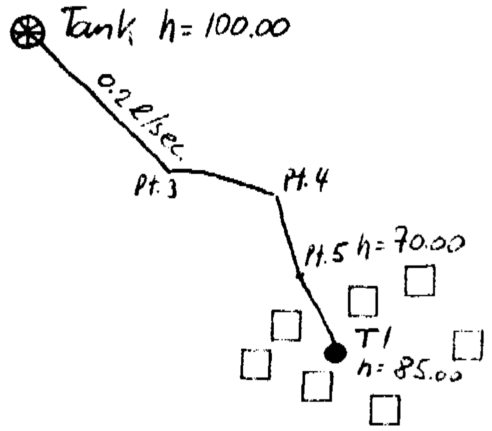
Exercise 10

Pipeline Design of Section 3. (Refer also to sketch of example 8.1.)

Distance:

Tank - Pt.5 = 185m

Pt.5 - Tap 1 = 70m



Key Plan of Section 3

Exercise 11

Pipeline Design of Section 1. (Refer also to sketch of example 8.1.)

Distance:

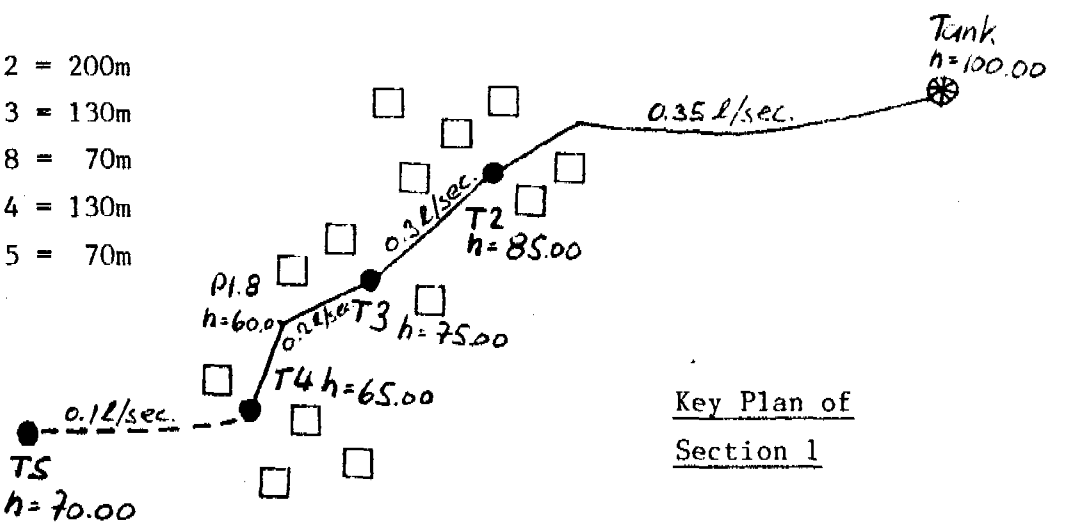
Tank - Tap 2 = 200m

Tap 2 - Tap 3 = 130m

Tap 3 - Pt. 8 = 70m

Pt. 8 - Tap 4 = 130m

Tap 4 - Tap 5 = 70m



Key Plan of Section 1

Question to Exercise 10 and 11

Work out the most suitable pipeline design for section 1 and 3. Use enclosed Hydraulic Calculations - Variants Form G.

In addition to Exercise 10 make use of the Formula "Combination Pipe Sizes" as descriped in the HBG on page -71-72- to guarantee a Residual Head or Dynamic Pressure Head of 5m at Tap 1. (H = 15.00-5.00 = 10.00m)

We will finalize the Hydraulic Profile for the sections 1-3 during the Intermediate Seminar. Please send your Calculations - Variants in advance.

Point NO	Distance l m	Static head m	Pipe ø mm	Tap NO	Flow rate l/s	Friction loss rate	Friction loss m	Friction chainage	Dynamic pressure head	Remarks
	Exercise 10 (Section 3) Solution									
Tank/T1	255	15	20	1	0.2	5.25		13.38	1.62	not sufficient
Tank/T1	255	15	(25)	1	0.2	2.05	4.61	4.61	10.39	O.K.
	Exercise 11 (Section 1) Solution									
Tank/T2	200	15	(32)	4	0.35	1.75	3.5	3.5	11.5	O.K.
T2/T3	130	25	(25)	3	0.3	4.25	5.52	9.02	15.98	O.K.
T3/T4	200	35	25	2	0.2	2.0	4.00	13.02	21.98	
T4/T5	70	30	20	1	0.1	1.5	1.05	14.07	15.93	
T3/T4	200	35	(20)	2	0.2	5.25	10.50	19.52	15.48	O.K.
T4/T5	70	30	(20)	1	0.1	1.5	1.05	20.57	9.43	O.K.
Tank/T2	200	15	25	4	0.35	5.5	11.00	11.00	4.00	not sufficient

<u>Task in addition to Exercise 10</u> (Solution)

Used formula "Combination Pipe Sizes" as descriped in HBG page -71-72-

H = desired headloss, 15m - 5m = <u>10m</u>

L = total pipelength, <u>255m</u>

X = small size pipelength, ? (m)

Fl = frictionl. factor large pipe, Ø 25mm = <u>2%</u>

Fs = frictionl. factor small pipe, Ø 20mm = <u>5.3%</u>

$$X = \frac{100H - (Fl \times L)}{Fs - Fl} = \frac{100 \times 10 - (2 \times 255)}{5.3 - 2} = \frac{490}{3.3} = \underline{148m\ Ø\ 20mm}$$

<u>Conclution:</u>

107m pipe Ø 25mm

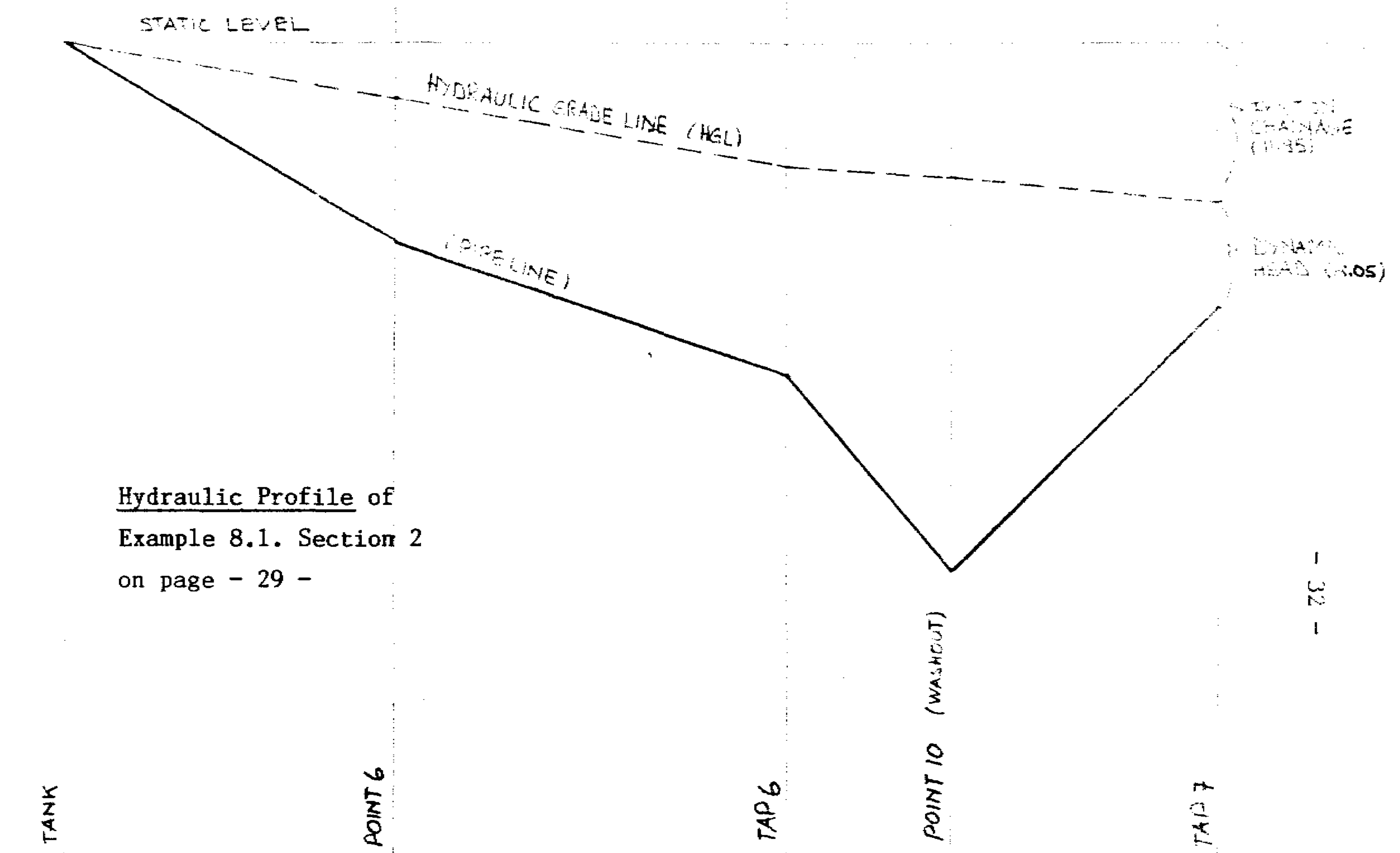
148m pipe Ø 20mm

HYDRAULIC WORK COURSE
INTERMEDIATE SEMINAR

HYDRAULIC PROFILE

SCALE VERTICAL: 1:500
SCALE HORIZONTAL: 1:2000

DATE: 20.07.89 H.M.



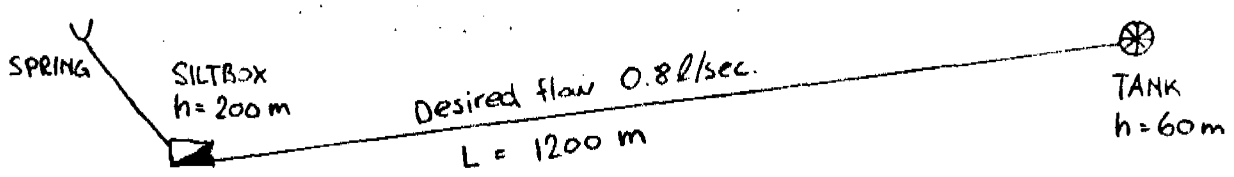
Hydraulic Profile of
Example 8.1. Section 2
on page - 29 -

Point Nº		T		Pt.6		T6		Pt.10		T7
Distance between points	m		100		120		50		80	
Reduced level	m	100.00		85.00		75.00		60.00		80.00
Static pressure head	m	0.00		15.00		25.00		40.00		20.00
Design flow	l/sec.		0.3		0.3		0.2		0.2	
Pipe size (Type ISO 1000)			Ø 25mm		Ø 25mm		Ø 25mm		Ø 25mm	
Friction factor	m/100m		4.25		4.25		2.00		2.00	
Friction head	m		4.25		5.10		1.00		1.60	
Friction chainage	m			4.25		9.35		10.35		11.95
Dynamic head	m			10.75		15.65		29.65		8.05

LESSON NO 5 : Exercise 12 : Combination of pipe sizes
Diagrammatical and arithmetical method
Exercise 13 : Pipeline Design and Hydraulic Profile

Exercise 12

Calculate the length and diameter of the smaller-sized pipe and larger-sized pipe to guarantee a desired natural maximum flow of 0.8 l/sec.



For diagrammatical method use Vertical Scale 1:1000 / Horizontal Scale 1:5000.
For arithmetical method use Formula *HBG* page -72- / -203-

Use this space for calculation (arithmetical method)

Exercise 12 (Solution)

1. Reach: Maximum head loss $\frac{200m - 60m}{1200m} \times 100 = \underline{11.66\%}$

2. Reach: Refer to friction loss table.
   By frictionloss 11.66% .... Ø 25mm = 0.52 l/sec. (Qmax)
   .... Ø 32mm = 1.00 l/sec. (Qmax)

3. Reach: Combination of pipe size Ø 25mm & Ø 32mm possible.
   Refer to formula page - 31 - or HBG page - 72 -

L = 1200m
X = ?
Fs = Ø 25mm; 24%
Fl = Ø 32mm; 7.5%
H = 140m

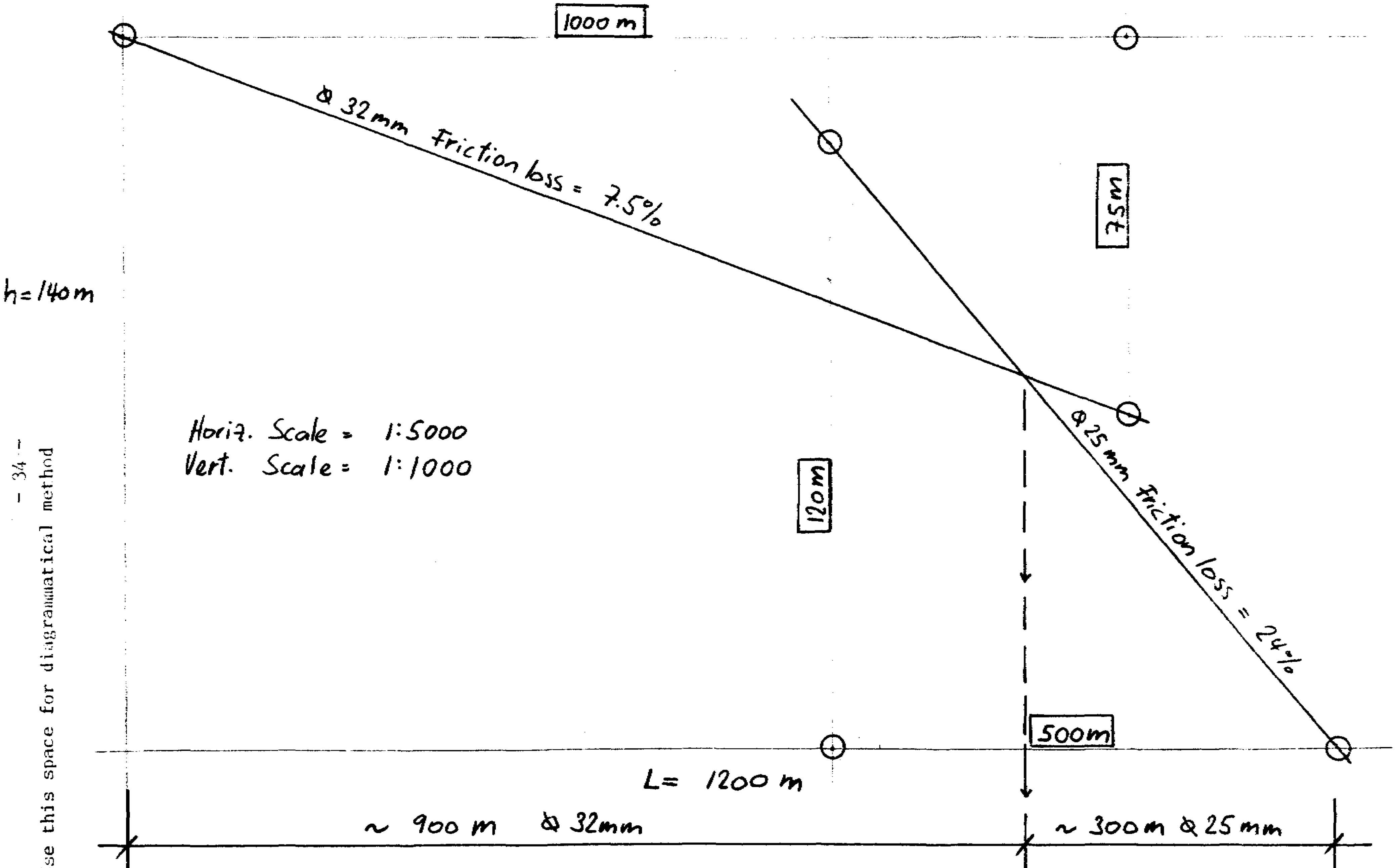
$$X = \frac{100 \times 140 - (7.5 \times 1200)}{24 - 7.5} = \frac{5000}{16.5} = \underline{303m}$$

Conclution:

303m pipe Ø 25mm

897m pipe Ø 32mm

Use this space for diagrammatical method



Exercise 13

Work out the most suitable pipeline design by using Hydraulic Calculation - Variants, Form G, based on the following survey data.

In addition prepare the Hydraulic Profile by using Vertical Scale 1:500 and Horizontal Scale 1:5000.

Section:	Elevation:	Distance:
Tank	100 m	
Tank - Tap 1		200 m
Tap 1	80 m	
Tap 1 - Tap 2		180 m
Tap 2	70 m	
Tap 2 - Tap 3		220 m
Tap 3	50 m	
Tap 3 - Tap 4		150 m
Tap 4	60 m	
Tap 4 - Tap 5		300 m
Tap 5	70 m	

HYDRAULIC CALCULATIONS - VARIANTS FORM G

Point NO	Distance l m	Static head m	Pipe ø mm	Tap NO	Flow rate l/s	Friction loss rate m/100m	Friction loss m	Friction chainage	Dynamic pressure head	Remarks
Tank/T1	200	20	(32)	5	0.4	2.2	4.4	4.4	15.60	O.K
T1/T2	180	30	25	4	0.35	5.4	9.72	14.12	15.88	
T2/T3	220	50	25	3	0.3	4.2	9.24	23.36	26.64	
T3/T4	150	40	25	2	0.2	2.0	3.0	26.36	13.64	
T4/T5	300	30	20	1	0.1	1.5	4.5	30.86	-0.86	< min 5.00
T1/T2	180	30	(32)	4	0.35	1.75	3.15	7.55	22.45	O.K.
T2/T3	220	50	(25)	3	0.3	4.2	9.24	16.79	33.21	O.K.
T3/T4	150	40	(25)	2	0.2	2.0	3.0	19.79	20.21	O.K.
T4/T5	300	30	(20)	1	0.1	1.5	4.5	24.29	5.71	O.K.

FORM D

HYDRAULIC CALCULATION
AND PROFILE

Exercise 13
HYDRAULIC CORR. COURSE

SURVEYED BY:...............

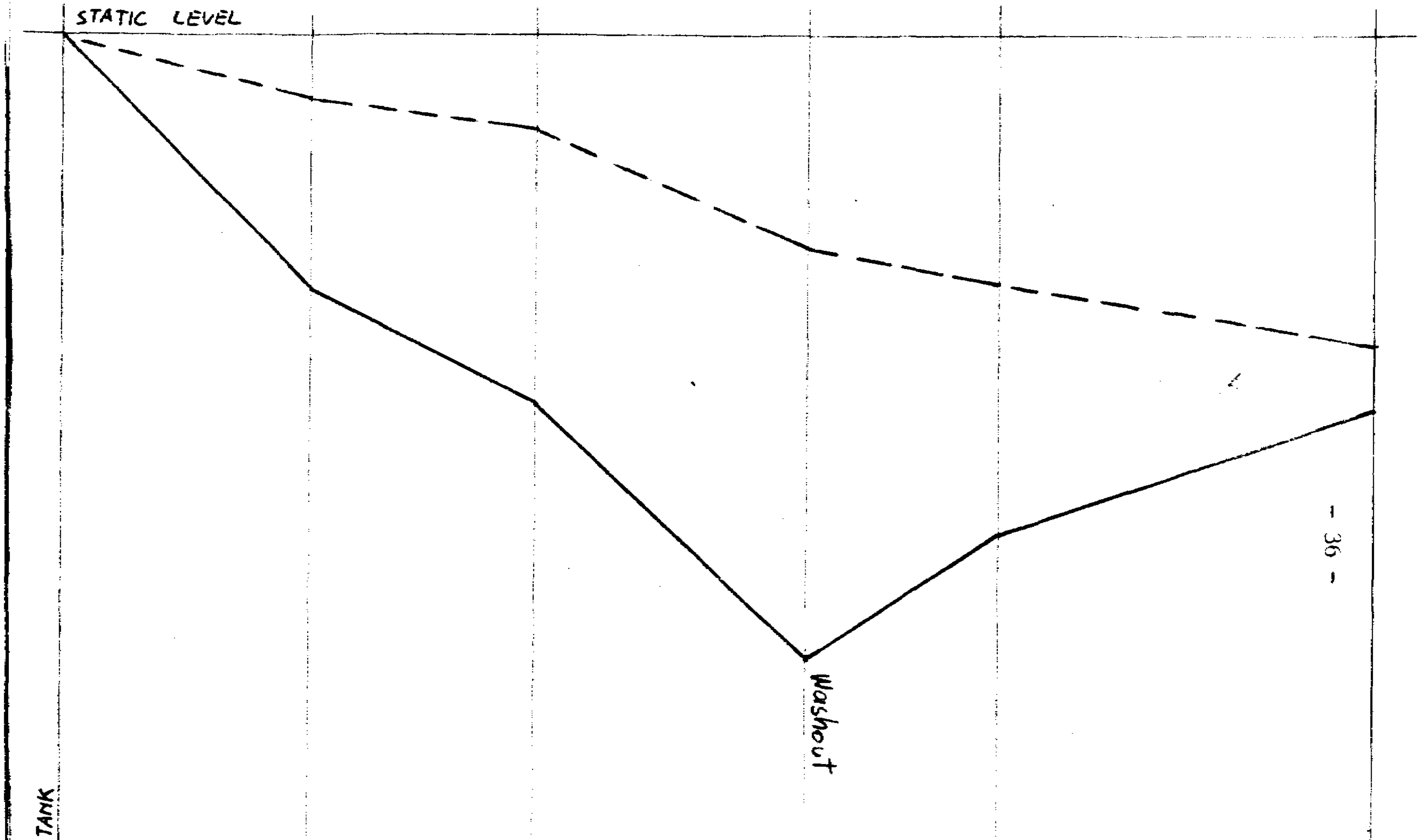
....

DATE:......................

....

SCALE VERTICAL 1:500
SCALE HORIZONT. 1:5000

PIPELINE:
FROM: TO:
Tank - Tap 5



POINT No.				T 1		T 2		T 3		T 4		T 5
DISTANCE BETWEEN POINTS			200		180		220		150		300	
REDUCED LEVEL	m	100		80		70		50		60		70
STATIC PRESSURE HEAD	m			20		30		50		40		30
DESIGNFLOW	l/sec		0.4		0.35		0.3		0.2		0.1	
PIPE SIZE (Type I.S.O.1000)			⌀ 32		⌀ 32		⌀ 25		⌀ 25		⌀ 20	
FRICTION FACTOR	m/100		2.2		1.75		4.20		2.0		1.5	
FRICTION HEAD	m		4.4		3.15		9.24		3.0		4.5	
FRICTION CHAINAGE	m			4.40		7.55		16.79		19.79		24.29
DYNAMIC HEAD	m			15.60		22.45		33.21		20.21		5.71

LESSON NO 6 : Exercise 14 : Technical Information, Standard-form I/a & I/b
Exercise 15 : Flow-rates

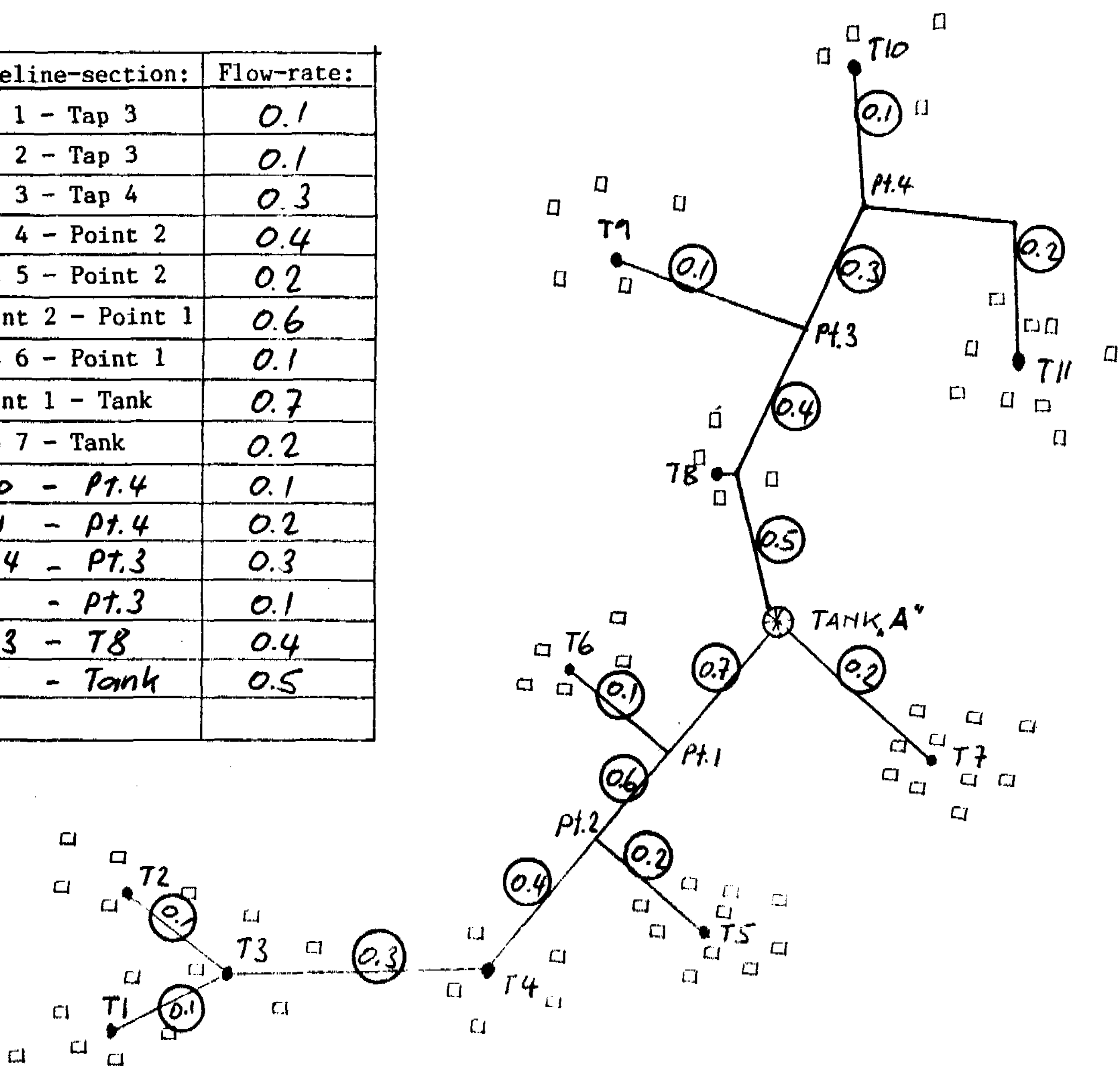
Exercise 14 / a

Calculate all technical informations required for the GWS scheme represented with enclosed Situation Plan, by using new introduced Standard-form I/a & I/b. For the flowdiagram use the space provided on form I/b.

Exercise 15 / a

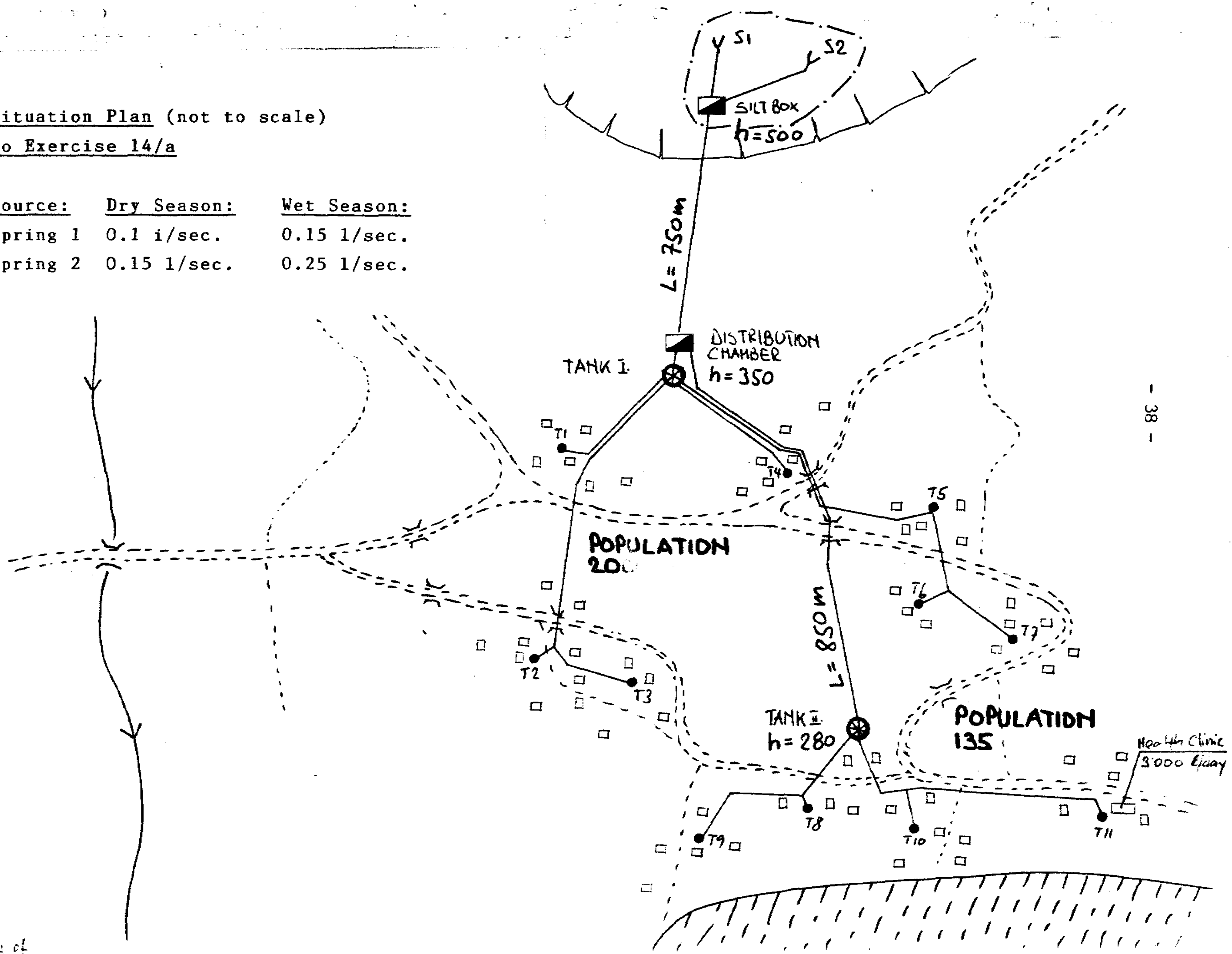
Calculate and indicate in the table provided minimum Flow-rates required for each pipe-section.

Pipeline-section:	Flow-rate:
Tap 1 - Tap 3	0.1
Tap 2 - Tap 3	0.1
Tap 3 - Tap 4	0.3
Tap 4 - Point 2	0.4
Tap 5 - Point 2	0.2
Point 2 - Point 1	0.6
Tap 6 - Point 1	0.1
Point 1 - Tank	0.7
Tap 7 - Tank	0.2
T10 - Pt.4	0.1
T11 - Pt.4	0.2
Pt.4 - Pt.3	0.3
T9 - Pt.3	0.1
Pt.3 - T8	0.4
T8 - Tank	0.5



Situation Plan (not to scale)
to Exercise 14/a

Source:	Dry Season:	Wet Season:
Spring 1	0.1 i/sec.	0.15 1/sec.
Spring 2	0.15 1/sec.	0.25 1/sec.



TECHNICAL INFORMATION (GWS only) FORM I /a

Name of Project : Exercise 14/a

District :

Population : 335

Sources:	Dry Season:	Wet Season:
Spring 1	0.10 1/sec	0.15 1/sec
Spring 2	0.15 1/sec	0.25 1/sec
Spring	1/sec	1/sec
	1/sec	1/sec
Total Yield:	0.25 1/sec	0.40 1/sec

WATER DEMAND

335 x 45 1/day/consumer = 15'075

.... x 10 1/day/student = ...

Health Clinic = 3'000

Total excl. Growthfactor = 18'075 x 1.3 Growthfactor = 23'497.5 1/day

WATER BALANCE DRY SEASON

Total yield 0.25 1/sec x 60 x 60 x 24 hrs = 21'600

Water demand incl. Growthfactor = 23'497.5

Estimated ~~overflow~~ / shortage = -1'897.5 1/day

WATER BALANCE WET SEASON

Total yield 0.40 1/sec x 60 x 60 x 24 hrs = 34'560

Water demand incl. Growthfactor = 23'497.5

Estimated overflow / ~~shortage~~ = 11'062.5 1/day

SEDIMENTATION CHAMBER (Siltbox)

	Siltbox 1	Siltbox 2
(0.4) Inlet Qmax wet season (1/sec x 60 x 20)	480 1/20min.	.......1/20min.
(0.25) Inlet Qmin dry season (1/sec x 60 x 20)	300 1/20min.	.......1/20min.
(0.37) Outlet Qmax of Designflow (1/sec x 60 x 20)	444 1/20min.	.......1/20min.
Volume chosen	500 L	 L

DESIGN FLOWS		(Qreq)	(Qmax)
Mainline Siltbox - St. Tank 1	= 1/day / 86400 sec.	= 1/sec	1/sec
Mainline Siltbox - St. Tank 2	= 1/day / 86400 sec.	= 1/sec	1/sec
Mainline Siltbox - Distr. Chamber	= 23'500 1/day / 86400 sec	= 0.271 1/sec	0.37 1/sec (⌀ 20mm)
Distr. Chamber - Tank I.	= 11'700 1/day / 86400 sec	= 0.135 1/sec	~ 0.60 1/sec (⌀ 20mm)
Distr. Chamber - Tank II.	= 11'797 1/day / 86400 sec	= 0.136 1/sec	0.22 1/sec (⌀ 20mm)

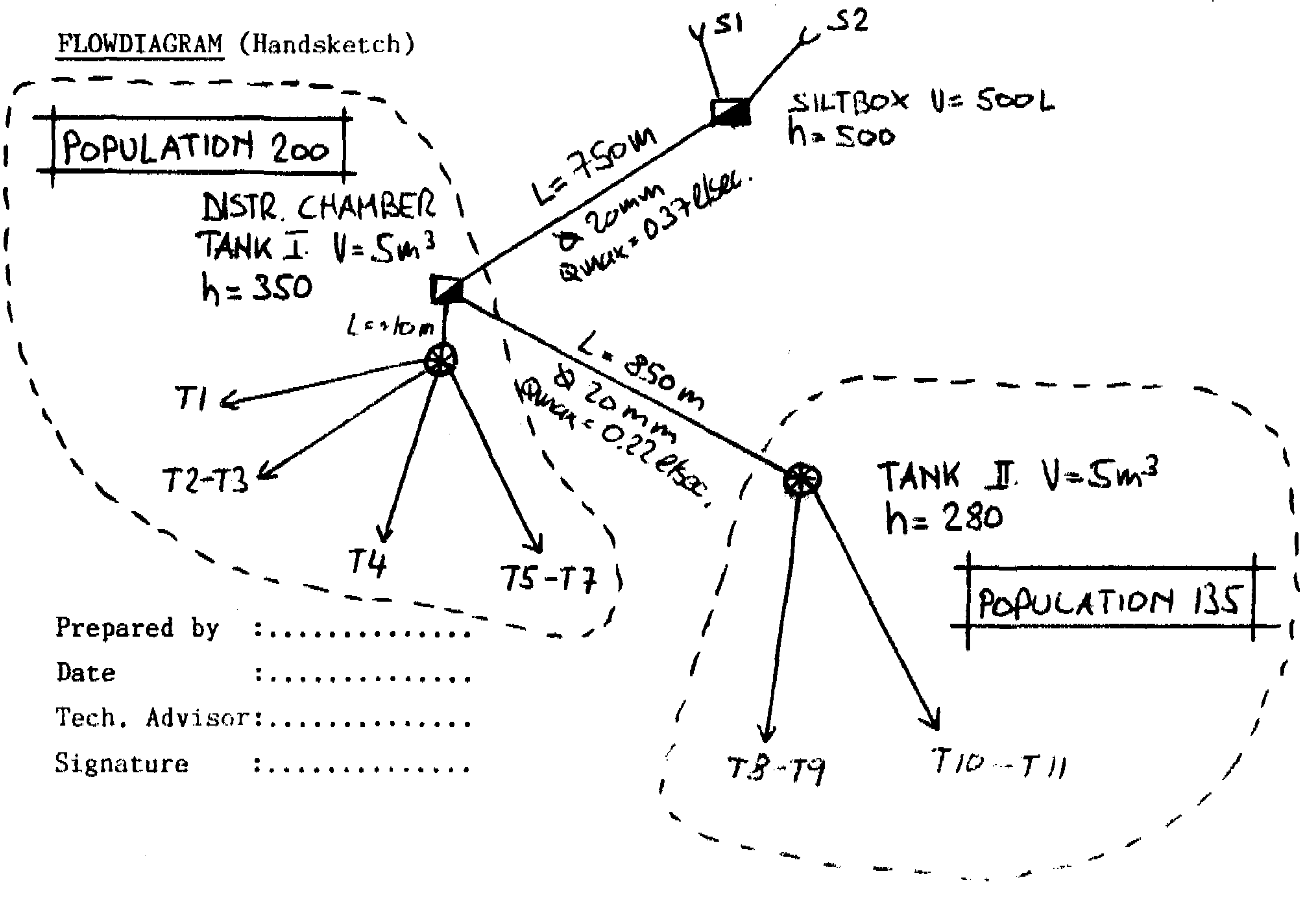
TECHNICAL INFORMATION (GWS only) FORM I /b

DISTRIBUTION SYSTEM	Tank 1	Tank 2	Tank 3	Tank 4
Water Demand l/day (incl.Growthfac.)	11'700	11'797.5		
Distribution Ratio (Parts)	1	1		
Pipe Ø for Distribution (Chamber)	25mm	25mm → (after red. to 20mm)		
Inlet Qmin l/sec (Dry Season)	0.125	0.125		
Inlet Qmax l/sec (Ref. Designflow)	~0.60	0.22		

STORAGE TANK CALCULATION (For additional tanks use backside)

TANK NO: 1+2	INLET 0.125 l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	1350	30	3510	- 2160	- 2160
8.30-11.30am	3	1350	10	1170	+ 180	- 1980
11.30- 1.30pm	2	900	15	1755	- 855	- 2835
1.30- 4.00pm	2.5	1125	10	1170	- 45	- 2880
4.00- 7.00pm	3	1350	30	3510	- 2160	- 5040
7.00- 5.30am	10.5	4725	5	585	+ 4140	- 900
Daily yield	=	10'800		11'700	= Daily demand	Overflow
Storage Capacity (min.) 5040 L = 5.04 M3 Tank size chosen = 5 M3						
Tank is filled within ~ 11 hrs. (must be less than 10 hrs)						

FLOWDIAGRAM (Handsketch)



Prepared by :..............

Date :..............

Tech. Advisor:..............

Signature :..............

LESSON NO 6 : Exercise 14 : Technical Information, Standard-form I/a & I/b
Exercise 15 : Flow-rates

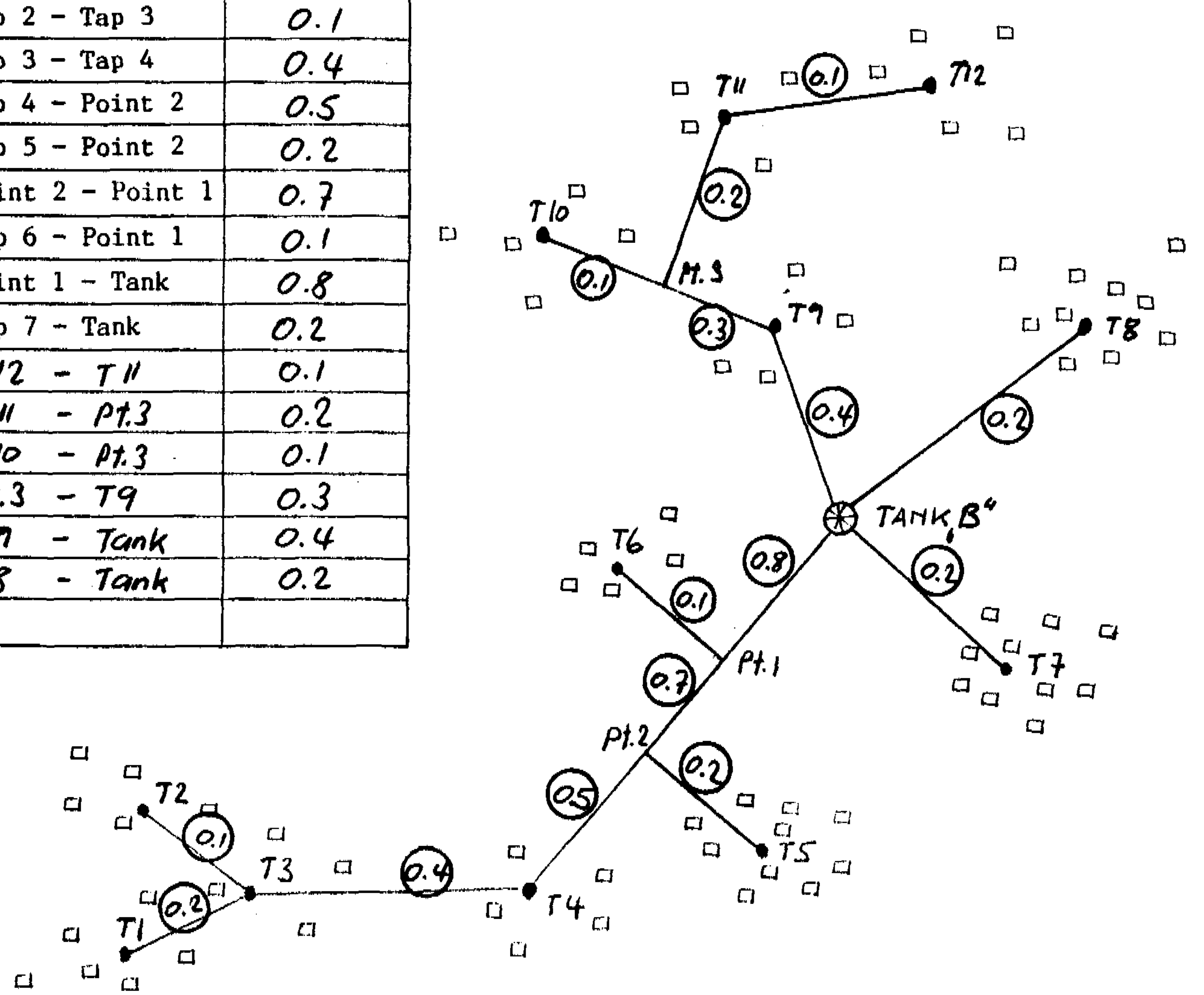
Exercise 14 / b

Calculate all technical informations required for the GWS scheme represented with enclosed Situation Plan, by using new introduced Standard-form I/a & I/b. For the flowdiagram use the space provided on form I/b.

Exercise 15 / b

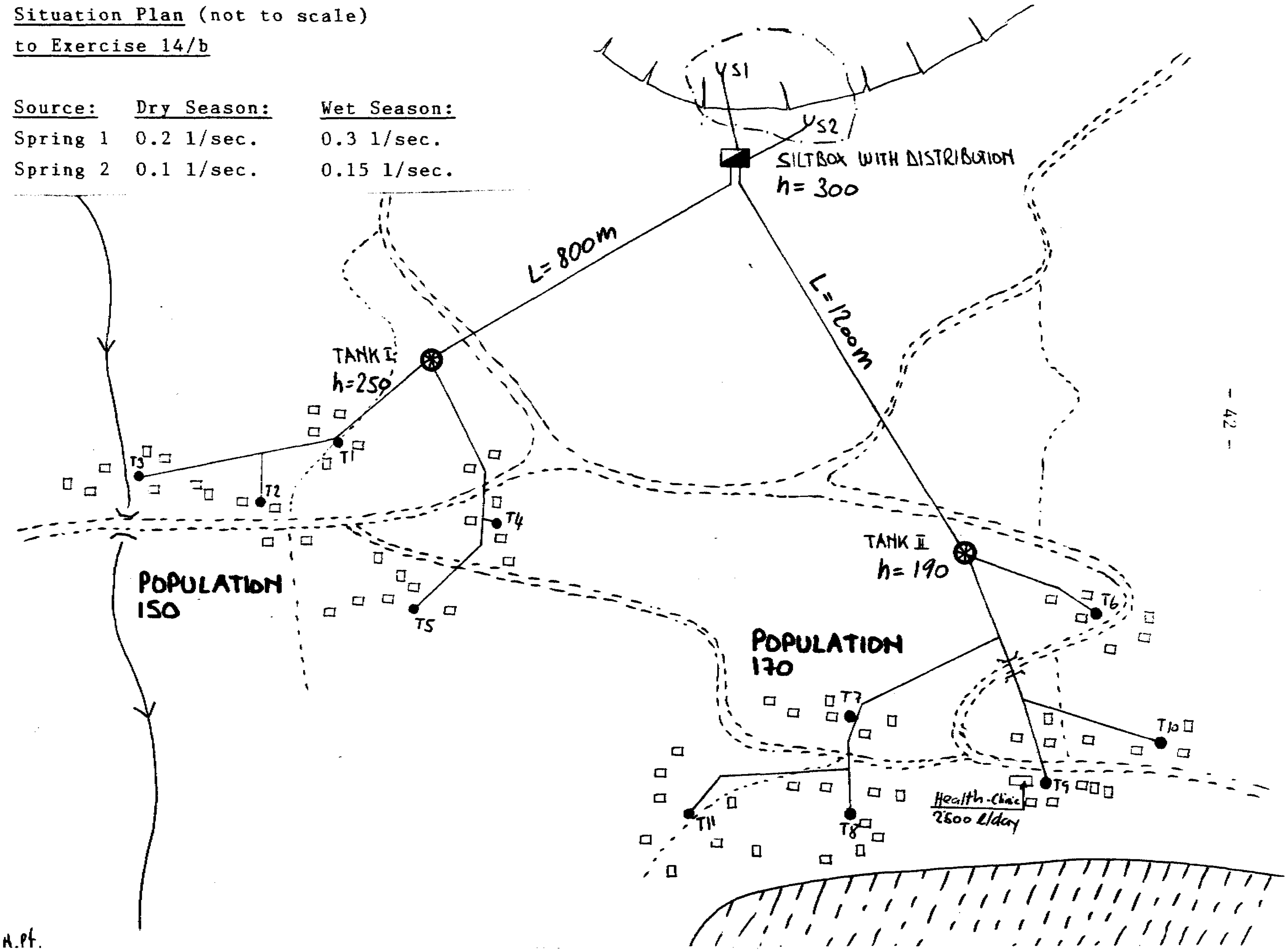
Calculate and indicate in the table provided minimum Flow-rates required for each pipe-section.

Pipeline-section:	Flow-rate:
Tap 1 - Tap 3	0.2
Tap 2 - Tap 3	0.1
Tap 3 - Tap 4	0.4
Tap 4 - Point 2	0.5
Tap 5 - Point 2	0.2
Point 2 - Point 1	0.7
Tap 6 - Point 1	0.1
Point 1 - Tank	0.8
Tap 7 - Tank	0.2
T12 - T11	0.1
T11 - Pt.3	0.2
T10 - Pt.3	0.1
Pt.3 - T9	0.3
T9 - Tank	0.4
T8 - Tank	0.2



Situation Plan (not to scale)
to Exercise 14/b

Source:	Dry Season:	Wet Season:
Spring 1	0.2 l/sec.	0.3 l/sec.
Spring 2	0.1 l/sec.	0.15 l/sec.



12.06.89 H.Pf.

TECHNICAL INFORMATION (GWS only) FORM I /a

Name of Project : Exercise 14 /b

District :..............

Population : 320

Sources:	Dry Season:	Wet Season:
Spring 1	0.2 l/sec	0.3 l/sec
Spring 2	0.1 l/sec	0.15 l/sec
Spring	l/sec	l/sec
	l/sec	l/sec
Total Yield:	0.3 l/sec	0.45 l/sec

WATER DEMAND

320 x 45 l/day/consumer = 14·400

.... x 10 l/day/student = ...

Health - clinic = 2·500

Total excl. Growthfactor = 16·900 x 1.2 Growthfactor = 20·280 l/day

WATER BALANCE DRY SEASON

Total yield 0.3 l/sec x 60 x 60 x 24 hrs = 25·920

Water demand incl. Growthfactor = 20·280

Estimated overflow / ~~shortage~~ = 5·640 l/day

WATER BALANCE WET SEASON

Total yield 0.45 l/sec x 60 x 60 x 24 hrs = 38·880

Water demand incl. Growthfactor = 20·280

Estimated overflow / ~~shortage~~ = 18·600 l/day

SEDIMENTATION CHAMBER (Siltbox)

		Siltbox 1	Siltbox 2
(0.45) Inlet Qmax wet season	(l/sec x 60 x 20)	540 l/20min.	.......l/20min.
(0.3) Inlet Qmin dry season	(l/sec x 60 x 20)	360 l/20min.	.......l/20min.
Outlet Qmax of Designflow (0.19 + 0.24)	(l/sec x 60 x 20)	516 l/20min.	.......l/20min.
Volume chosen	min.	500 L	 L

DESIGN FLOWS

		(Qreq)	(Qmax)
Mainline Siltbox - St. Tank 1	= 8·100 l/day / 86400 sec.	= 0.09 l/sec	0.19 l/sec — 0.19 : Ø20, 0.36 : Ø25
Mainline Siltbox - St. Tank 2	= 12·180 l/day / 86400 sec.	= 0.14 l/sec	0.24 l/sec Ø20
Mainline Siltbox - Distr. Chamber	= l/day / 86400 sec	= .....l/sec	.....l/sec
....	= l/day / 86400 sec	= .....l/sec	.....l/sec
....	= l/day / 86400 sec	= .....l/sec	.....l/sec

TECHNICAL INFORMATION (GWS only) FORM I /b

DISTRIBUTION SYSTEM	Tank 1	Tank 2	Tank 3	Tank 4
Water Demand l/day (incl.Growthfac.)	8'100	12'180		
Distribution Ratio (Parts)	2	3		
Pipe Ø for Distribution (Chamber) (Siltbox)	20mm	32mm →	(after red.	acc. Hydl. cal)
Inlet Qmin l/sec (Dry Season)	0.12	0.18		
Inlet Qmax l/sec (Ref. Designflow)	0.19	0.24		

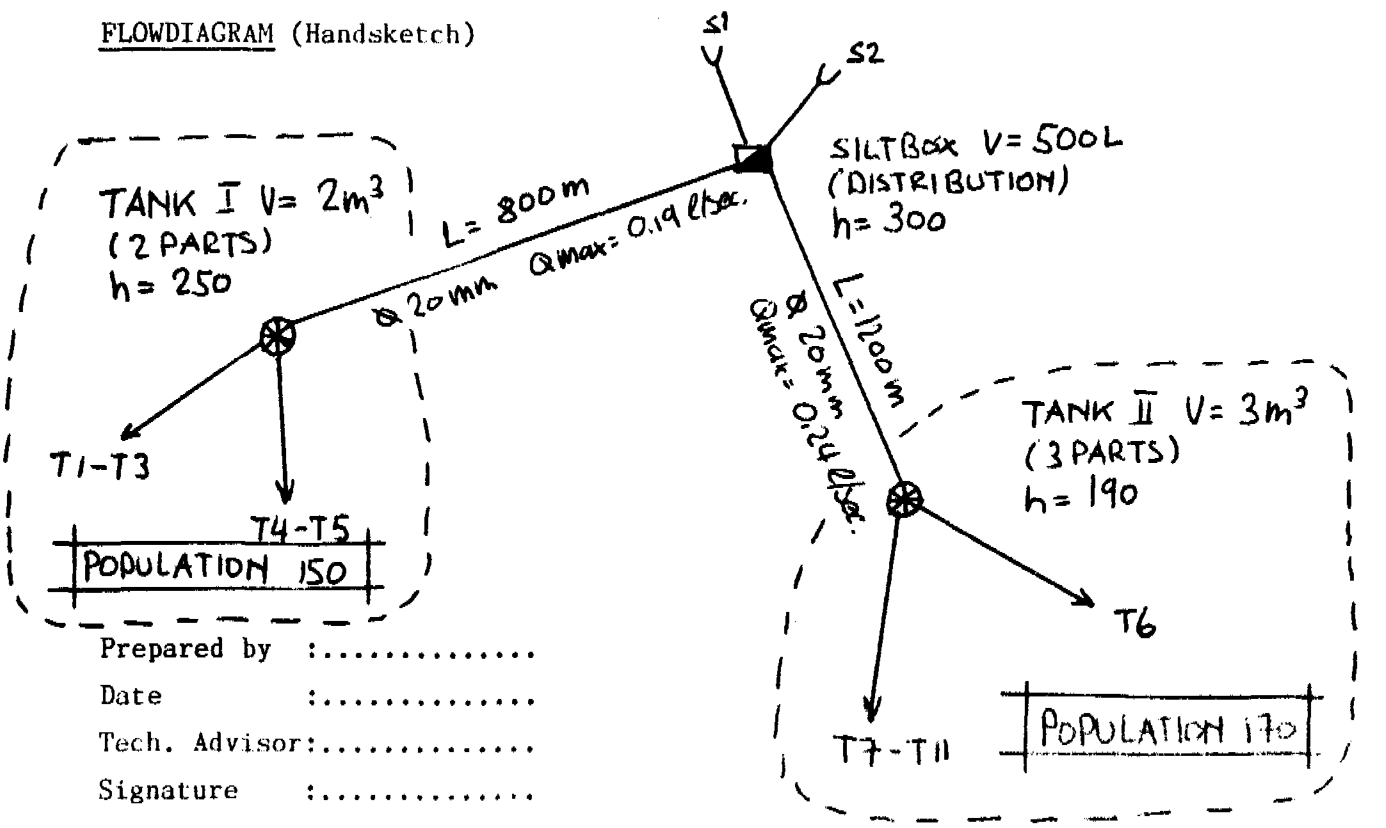
STORAGE TANK CALCULATION (For additional tanks use backside)

TANK NO: 1	INLET 0.12 l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	1296	30	2430	- 1134	- 1134
8.30-11.30am	3	1296	10	810	+ 486	- 648
11.30- 1.30pm	2	864	15	1215	- 351	- 999
1.30- 4.00pm	2.5	1080	10	810	+ 270	- 729
4.00- 7.00pm	3	1296	30	2430	- 1134	- 1863
7.00- 5.30am	10.5	4536	5	406	+ 4131	+ 2268
Daily yield	=	10'368		8'100	= Daily demand	Overflow

Storage Capacity (min.) 1863 L = 1.9 M3 Tank size chosen = 2 M3

Tank is filled within ~4.5 hrs. (must be less than 10 hrs)

FLOWDIAGRAM (Handsketch)



Prepared by :..............

Date :..............

Tech. Advisor:..............

Signature :..............

TANK NO: 2	INLET 0.18 l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	1944	30	3654	- 1710	- 1710
8.30-11.30am	3	1944	10	1218	+ 726	- 984
11.30- 1.30pm	2	1296	15	1827	- 531	-1515
1.30- 4.00pm	2.5	1620	10	1218	+ 402	-1113
4.00- 7.00pm	3	1944	30	3654	-1710	-2823
7.00- 5.30am	10.5	6804	5	609	+6195	+3372
Daily yield =		15552		12180	= Daily demand	Overflow
Storage Capacity (min.) 2823 L = 2.8 M3 Tank size chosen = 3 M3						

TANK NO: 3	INLET....l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	....	30	....	....	....
8.30-11.30am	3	....	10	....	....	....
11.30- 1.30pm	2	....	15	....	....	....
1.30- 4.00pm	2.5	....	10	....	....	....
4.00- 7.00pm	3	....	30	....	....	....
7.00- 5.30am	10.5	....	5	....	....	....
Daily yield =		....		....	= Daily demand	Overflow
Storage Capacity (min.).........L = ...M3 Tank size chosen =...M3						

TANK NO: 4	INLET....l/sec		DEMAND		DIFFERENCE	WATER LEVEL
PERIOD	hrs:	liters:	%:	liters:	+ / -	liters:
5.30- 8.30am	3	....	30	....	....	....
8.30-11.30am	3	....	10	....	....	....
11.30- 1.30pm	2	....	15	....	....	....
1.30- 4.00pm	2.5	....	10	....	....	....
4.00- 7.00pm	3	....	30	....	....	....
7.00- 5.30am	10.5	....	5	....	....	....
Daily yield =		....		....	= Daily demand	Overflow
Storage Capacity (min.).........L = ...M3 Tank size chosen =...M3						

Tank 2 is filled within ~ 4.5 hrs (must be less than 10 hrs)

Tank 3 is filled within........................hrs (must be less than 10 hrs)

Tank 4 is filled within........................hrs (must be less than 10 hrs)

Hydraulic Correspondence Course FINAL TEST Name:.....................

1) The minimum pipe Ø used for the construction of spring catchments is:
   Ø 32mm   Ø 40mm   Ø 50mm   Ø 63mm

2) The minimum gradient of the pipeline from the spring catchment to the siltbox is:
   0.5%   1.0%   1.5%   2%   3%   5%

3) The volume of the siltbox should allow a minimum retention time of:
   30 minutes   20 miniutes   15 minutes

4) The permitted maximum static pressure at a tap is:
   100m   80m   60m   50m   40m

5) The maximum static pressure in PVC pipes (pipelines) should not exeed:
   100m   80m   60m   50m   40m

6) Taps are distributed in the village, that nobody has to walk more than:
   50m   100m   150m   300m

7) After calculating the required storage tank capacity we check how many hours during the night are needed to fill the tank. After how many hours should the tank be filled:
   6 hours   8 hours -- 10 hours   12 hours

8) Calculate design flow, required pipe Ø for the pipeline siltbox to storagetank. What is the maximum flow (Qmax) of the selected pipe ?

Daily water demand		=	30240 l/day
Siltbox	H	=	160m
Tank	H	=	100m
Distance	L	=	950m

Use this space for the calculation:

Solution:

Design Flow: $\frac{30240}{86400} = \underline{0.35\ l/sec.}$

Head Loss: $\frac{60}{950} \times 100 = \underline{6.31\%}$

Proposed pipe Ø : 25mm ; Qmax.= 0.36 - 0.38 l/sec.

HYDRAULIC COMP. COURSE FINAL TEST

Name: ....

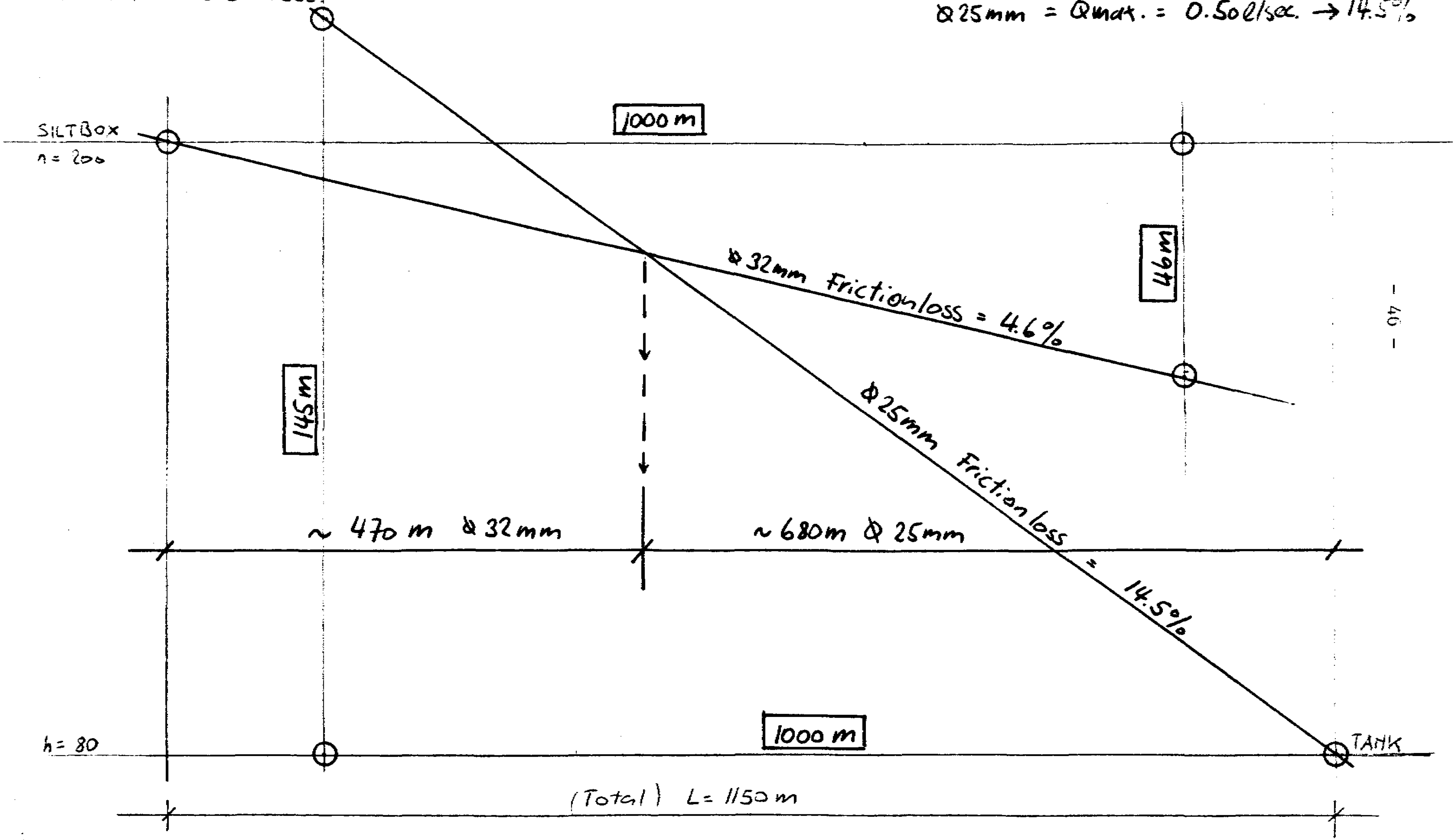
Combination of Pipe sizes:

Siltbox = h 200m
Tank = h 80m
L = 1150 m
Desired flow = 0.6 l/sec.

Horizontal Scale: 1:5000
Vertical Scale: 1:1000

Frictionloss fact.

Ø32mm = Qmax. = 0.96 l/sec. → 4.6%
Ø25mm = Qmax. = 0.50 l/sec. → 14.5%



V.W.S. of: Date: Sheet:

Hydr. Corr. Course 89 FINAL TEST Name: . . . .

Point NO	Distance l m	Static head m	Pipe ø mm	Tap NO	Flow rate l/s	Friction loss rate	Friction loss m	Friction chainage	Dynamic pressure head	Remarks
Tank/Pt8	150	35	25	4	0.6	14.5	21.75	21.75	13.25	
Pt8/T3	90	60	25	3	0.5	10.0	9.00	30.75	29.25	
T3/T2	220	43	25	2	0.4	7.0	15.40	46.15	-3.15	not possible
Second	Assumption:									
Tank/Pt8	150	35	32	4	0.6	4.5	6.75	6.75	28.25	O.K.
Pt.8/T3	90	60	25	3	0.5	10.0	9.00	15.75	44.25	O.K. (low point)
T3/T2	220	43	25	2	0.4	7.0	15.40	31.15	11.85	O.K. (high point)
T2/T1	150	55	20	1	0.2	5.25	7.87	39.00	16.00	O.K.
Pt.8/T4	80	20	20	1	0.1	1.5	1.20	7.95	12.05	O.K. (high point)

Pipeline section (not to scale)