MEBS600 Utility Services
Worked Example on the Design of Cold and Flush Water System

Example No.1
An office building with usable floor area 1,350m^2 is to be installed with cold and flush water systems. Sketch the schematic line diagram of the system and determine the major equipment sizing.

Other details include:
No. of floors: G/F, 1 – 40/F, R/F (with refuge floor between 20/F and 21/F)
Floor-to-floor height: 4m
1/F – 40/F will be installed with male and female toilet, no toilet at G/F and R/F

Step 1: Determine the sanitary fitments according to Building Regulations (CAP123i)
See Appendix A for Regulation 5

a) Floor area = 1350m^2
Population density = 1 person / 9m^2 (Regulation 5(5)(a))
Thus, **population per floor = 150 people**

b) Ratio of male to female = 2:1 (Regulation 5(5)(c))
Thus, male to female = 100 male: 50 female

c) Schedule of sanitary fitments (Regulation 5(1)) per floor

	Male Toilet	Female Toilet
Wash Basin	**4**	**2**
Water Closet	**4**	**3**
Urinal	**2**	**-**

Step 2: Determine the total water storage capacity and allocation of water tanks

a) Cold Water (design practice = 45L/point)
total number of water points = (4 + 2) × 40 = 240 points
total **cold water storage** = 240 points × 45L/point = **10,800L**

b) Flush Water (design practice = 45L/point)
total number of water points = (4 + 3 + 2) × 40 = 360 points
total **flush water storage** = 360 points × 45L/point = **16,200L**

c) Assume the systems will adopt a sump and pump supply with gravity feed at the roof, plus top floor booster supply
Take the roof tank : sump tank ratio = 3 : 1 (as required under the Plumbing Installation Guidelines by WSD)
Cold water
Roof tank : Sump Tank = 8,100L : 2,700L
Flush water
Roof tank : Sump Tank = 12,150L : 4,050L

Step 3: Determine the Simultaneous Demand of the various parts of the system

a) Overall Simultaneous Demand
Cold Water – No. of basins = 240 basins × 2 LU (in public use) = 480 LU
Simultaneous Demand = 4.0L/s (480 LU)
Flush Water – No. of WC = 280 WC × 2 LU = 560 LU
Simultaneous Demand for WC = 4.4L/s (560 LU)

No. of Urinals = 80 urinals × 0.004L/s = 0.32L/s
Thus, total **simultaneous demand** = (4.4 + 0.32) L/s **= 4.7 L/s**

b) Simultaneous Demand for Gravity Feed (assume top 3 floors served by top-floor booster)

Cold Water – 6 basins/floor × 37 floors = 222 basins
222 basins × 2 LU = 444 LU = **3.8 L/s**

Flush Water – 7 WCs/floor × 37 floors = 259 WCs
259 WCs × 2 LU = 518 LU = 4.1 L/s
2 urinals/floor × 37 floors = 74 urinals
74 urinals × 0.004 L/s = 0.30 L/s
Total demand = (4.1 + 0.3) = **4.4 L/s**

c) Simultaneous Demand for Top-floor Booster System

Cold Water – 6 basins/floor × 3 floors = 18 basins
18 basins × 2 LU = 36 LU = **0.63 L/s**

Flush Water – 7 WCs/floor × 3 floors = 21 WCs
21 WCs × 2 LU = 42 LU = 0.72L/s
2 urinals/floor × 3 floors = 6 urinals
6 urinals × 0.004 L/s = 0.024 L/s
Total demand = (0.72 + 0.024) = **0.74 L/s**

d) Simultaneous Demand for Tee-off at Male and Female Toilet
Assume the vertical pipe tees off to the Male and Female toilet separately

Male Toilet – **Cold Water** – 4 basins × 2 LU = 8 LU = **0.26 L/s**
Flush Water – 4WC × 2 LU + 2 urninal × 0.004L/s = **0.27 L/s**

Female Toilet – **Cold Water** – 2 basins × 0.15 L/s = **0.3 L/s** (consider not taking diversity due to small number of sanitary fitments)
Flush Water – 3WC × 2 LU = **0.22 L/s**

Step 4: Sizing the Upfeed Pump and Pipe

a) The Total Simultaneous Demand of the building has to be served by the upfeed pump when the Roof Tank capacity has been consumed.
Thus, **upfeed pump flow rate** for
Cold Water = 4.0 L/s (see Step 3 a))
Flush Water = 4.7 L/s (see Step 3 b))

b) Pipe Sizing
Consider design practice using 0.1mH loss per m pipe run for pipe sizing
Cold Water
Take **54mmØ Cu pipe**, 4.0L/s → **Loss = 0.07mH/m**, **velocity ~1.8 m/s**
Flush Water
Take **63mmØ uPVC pipe**, 4.7 L/s → **Loss = 0.11mH/m**, **velocity ~ 2.2m/s**

c) Pump head calculation
Pump head = Static head + Head Loss due to friction and fitting
Cold Water
Consider static height = 42 floors × 4m = 168m
Take pipe length = 180m (by addition the actual pipe length for horizontal run)
Equivalent length = 180m +30% (say) = 234m
Total Head Loss = 234m × 0.07mH/m = 16.6mH

Thus, **Pump Head** = 168mH (static) + 16.6mH (loss) = **185mH**

Flush Water

Consider same elevation and equivalent pipe length as the cold water

Total Head Loss = 234m × 0.11mH/m = 25.7mH

Thus, **Pump Head** = 168mH (static) + 25.7mH (loss) = **194mH**

Step 5: Sizing of the down feed pipe

The down feed pipe will be sized at different sections carrying different flow rates

One of the concepts is by using same head loss per m run of the pipe, i.e. 0.1mH/m

Cold Water

From Plumbing Engineering Services Design Guide, the water carrying capacities of individual pipe size are as follows:

Cu Pipe at head loss 0.1mH/m run

Diameter (mm)	Flow rate (L/s)	Loading Unit (LU)
54	4.9	600
42	2.4	230
35	1.45	120
28	0.8	50
22	0.38	15
15	0.13	2

The different section of the pipe along the gravity down feed can then be presented:

From (/F)	To (/F)	Loading Unit (LU)	Pipe size (mmØ)
R/F	20/F	480 to 240	54
20/F	19/F	240 to 228	54 to 42
19/F	10/F	228 to 120	42
10/F	9/F	120 to 108	42 to 35
9/F	5/F	108 to 60	35
5/F	4/F	60 to 48	35 to 28
4/F	2/F	48 to 24	28
2/F	1/F	24 to 12	28 to 22

Similar approach, the different section of the pipe for top floor intermediate booster system:

From (/F)	To (/F)	Loading Unit (LU)	Pipe size (mmØ)
R/F	40/F	36	28
40/F	39/F	24	28
39/F	38/F	12	22

The **same approach is adopted for Flush Water** pipe sizing.

Step 6: Sizing the main tee off pipe

The same approach is to size the tee-off pipe to the male and female toilets

Cold Water

Male Toilet	0.26L/s	22mmØ
Female Toilet	0.3 L/s	22mmØ
Individual basin	0.15 L/s	15mmØ

The **same approach is adopted for Flush Water** pipe sizing.

Appendix A:
Chapter 123I
Building (Standards of Sanitary Fitments, Plumbing, Drainage Works and Latrines) Regulations
Regulation 5 – Offices, industrial undertakings and other places of work

(1) Save as provided in paragraph (3), in every building used or intended to be used for the purpose of an office and in every industrial undertaking and other place of work-

(a) the number of water closet fitments and urinals provided for male persons employed or likely to be employed therein shall be not less than the number specified in Table VI;

TABLE VI

Type of fitment	No. of male persons employed or likely to be employed and No. of fitments to be provided therefor
Watercloset fitments	Less than 100, 1 such fitment for every 25 such persons, or part thereof. More than 100, 5 such fitments and 1 additional such fitment for every 50 such persons, or part thereof, over 150.
Urinals	10-50 inclusive, 1 such fitment. More than 50, 2 such fitments and 1 additional such fitment for every 50 such persons, or part thereof, over 100.

No. of Males	*1-25*	*26-50*	*51-75*	***76-100***	*101-150*	*151-200*	*201-250*	*…*
No. of Watercloset	*1*	*2*	*3*	***4***	*5*	*6*	*7*	*…*
No. of Urinals	*1(≥10)*	*1*	*2*	***2***	*3*	*3*	*4*	*…*

(b) the number of watercloset fitments provided for female persons employed or likely to be employed therein shall be not less than the number specified in Table VII; and

TABLE VII

No. of females employed or likely to be employed	No. of watercloset fitments
1-10 inclusive	1
11-25 inclusive	2
More than 25	3 and 1 additional watercloset fitment for every 25 such persons, or part thereof, over 50.

No. of Females	*1-10*	*11-25*	***26-50***	*51-75*	*76-100*	*101-125*	*126-150*	*…*
No. of Watercloset	*1*	*2*	***3***	*4*	*5*	*6*	*7*	*…*

(c) the number of lavatory basins provided for persons employed or likely to be employed therein shall not be less than the number specified in Table VIII.

TABLE VIII

No. of male persons employed or likely to be employed	No. of lavatory basins	No. of female persons employed or likely to be employed	No. of lavatory basins
Less than 100	1 for every 25 such persons, or part thereof.	Less than 100	1 for every 25 such persons, or part thereof.

More than 100	5 and 1 additional lavatory basin for every 50 such persons, or part thereof, over 150.	More than 100	5 and 1 additional lavatory basin for every 50 such persons, or part thereof, over150.

No. of Males	*1-25*	*26-50*	*51-75*	***76-100***	*101-150*	*151-200*	*201-250*	*…*
No. of Basins	*1*	*2*	*3*	***4***	*5*	*6*	*7*	*…*
No. of Females	*1-25*	***26-50***	*51-75*	*76-100*	*101-150*	*151-200*	*201-250*	*…*
No. of Basins	*1*	***2***	*3*	*4*	*5*	*6*	*7*	*…*

(2) Baths or showers shall be provided in any industrial undertaking or other place of work (other than in a building used or intended to be used for the purpose of an office) as required for the trade or industry carried on therein.

(3) Where, in any building used or intended to be used for the purpose of an office or in any industrial undertaking or other place of work, the number of persons, whether the same are or will be male persons or female persons, or both, employed or likely to be employed does not or will not exceed 10, there shall be provided not less than one watercloset fitment and one lavatory basin.

(4) In every building used or intended to be used for the purpose of an office and in every industrial undertaking and other place or work, the watercloset fitments, urinals and lavatory basins for male persons and the watercloset fitments and lavatory basins for female persons shall be provided in separate rooms exclusively for the use of male persons and female persons respectively.

(5) For the purposes of this regulation-

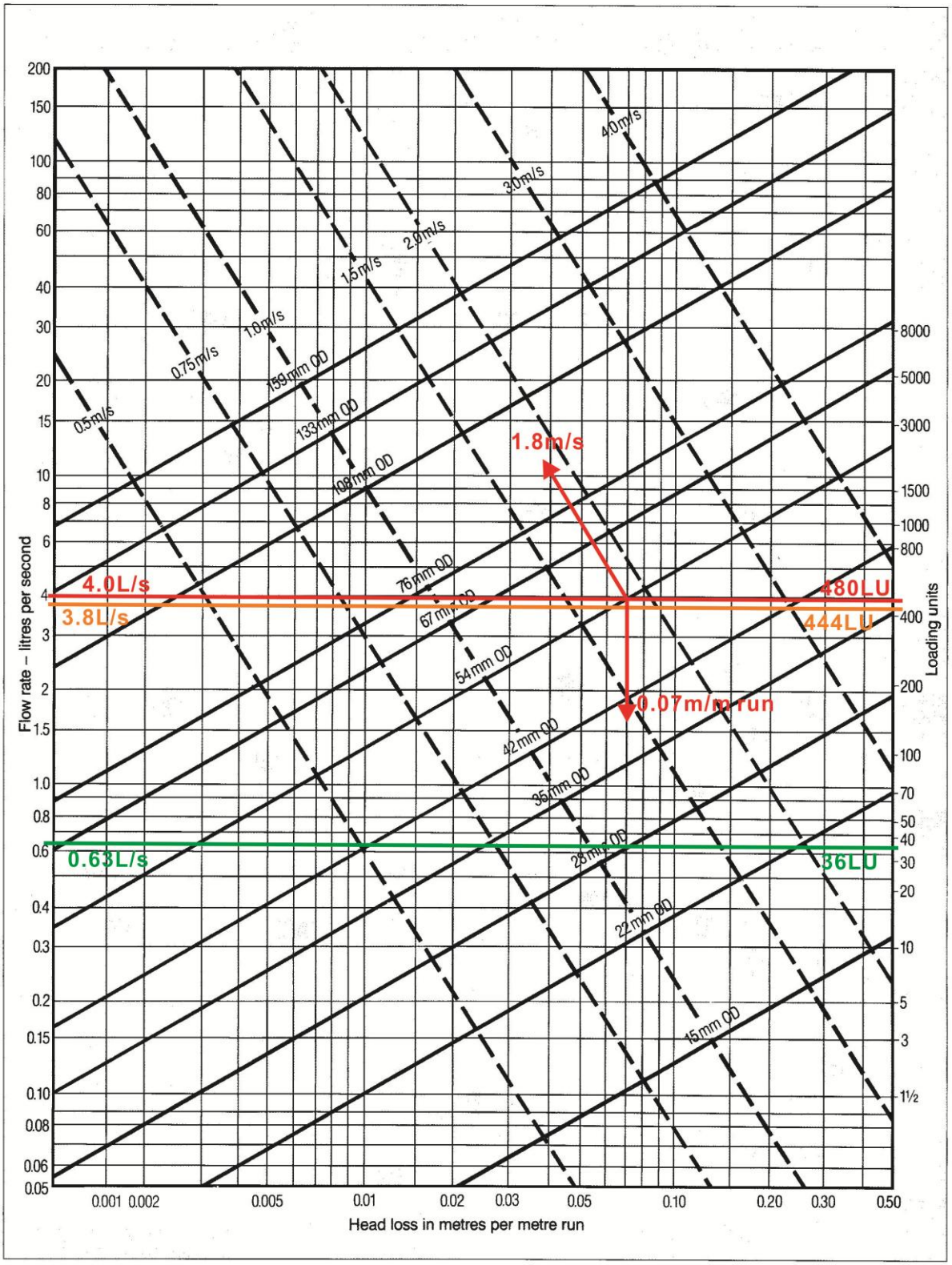
(a) the number of persons employed or likely to be employed in any building used or intended to be used for the purpose of an office or in any other place of work (other than in an industrial undertaking) shall be determined by the Building Authority, and, in the case of a building used or intended to be used for the purpose of an office, shall be so determined at the rate of **one person for every 9 square metres of usable floor space**; (L.N. 294 of 1976)

(b) the number of persons employed or likely to be employed in any industrial undertaking shall be determined by the Commissioner for Labour; and

(c) in the case of a building used or intended to be used for the purpose of an office, **the proportion of male persons to female persons employed or likely to be employed therein shall be deemed to be 2:1**, and, in any other case, shall be determined by the Building Authority or, in the case of an industrial undertaking, by the Commissioner for Labour.

Appendix B1:
Pipe Sizing Chart for Copper Pipe

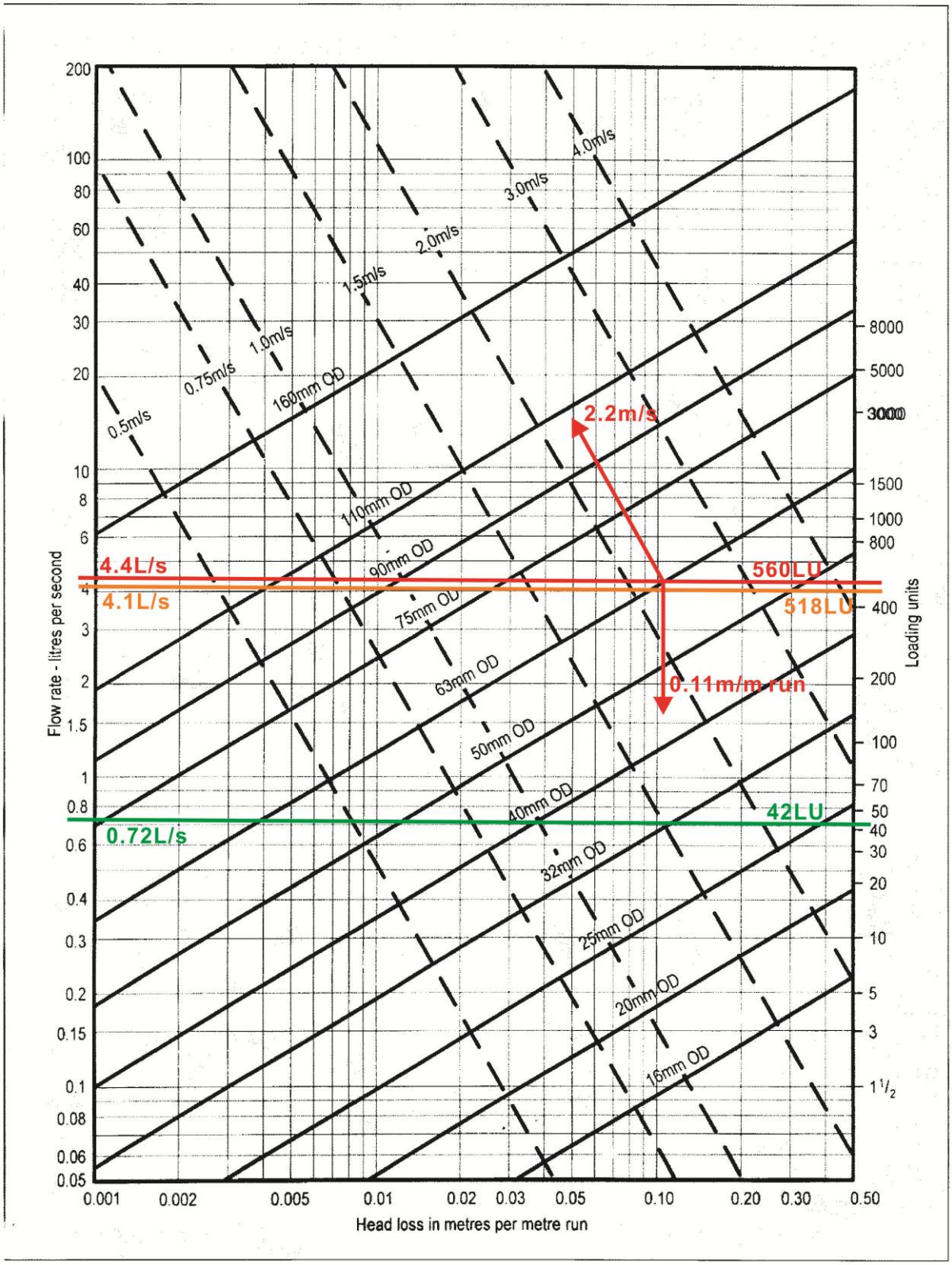
Graph 3 *Pipe sizing chart – copper and stainless steel.*



(Plumbing Engineering Services Design Guide 2002)

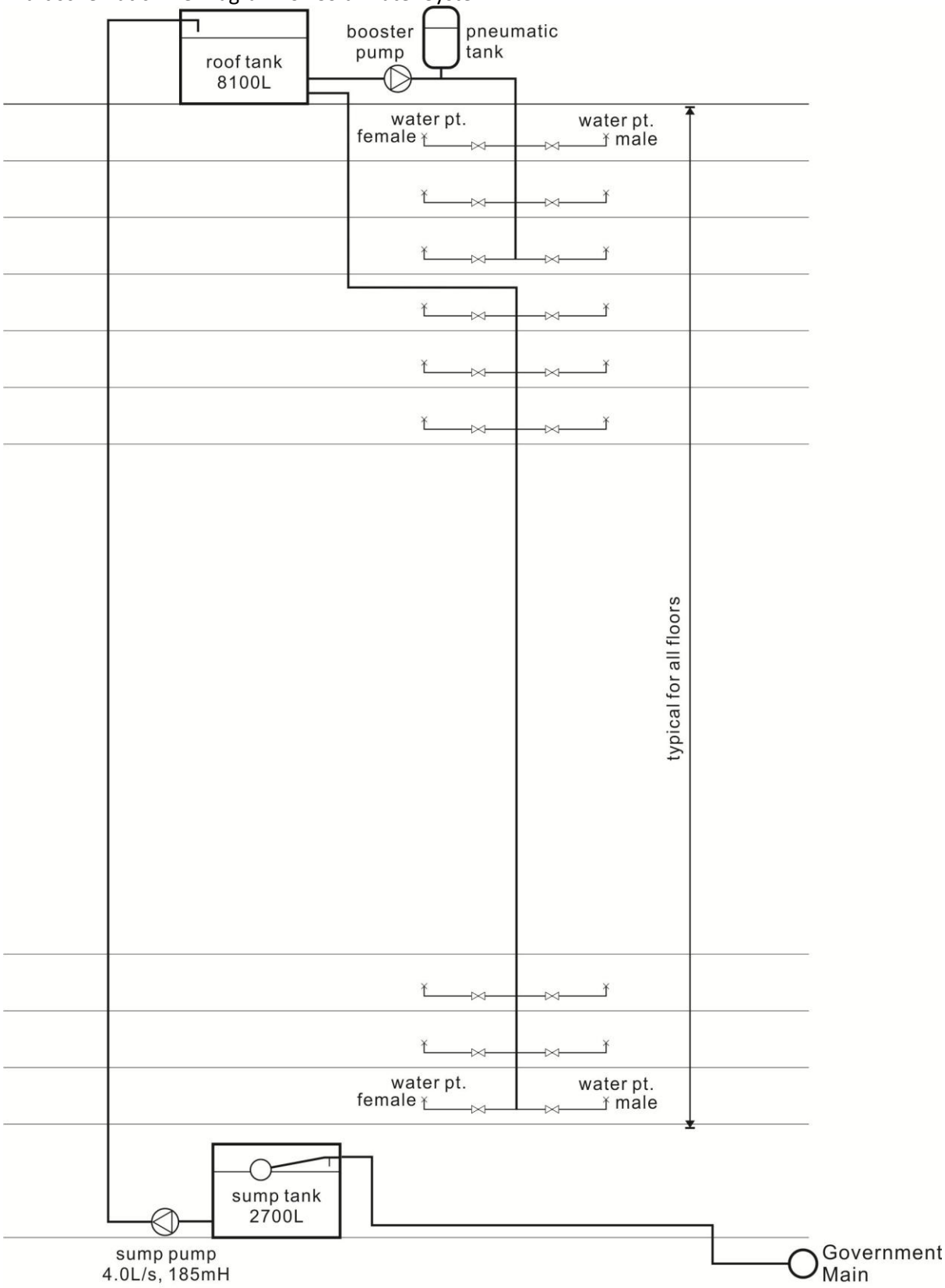
Appendix B1:
Pipe Sizing Chart for Plastic Pipe

Graph 4 *Pipe sizing chart – plastic*



(Plumbing Engineering Services Design Guide 2002)

Appendix C:
Draft schematic Line Diagram for Cold Water System



Draft Schematic Diagram for Cold Water System
(typical for flush water)