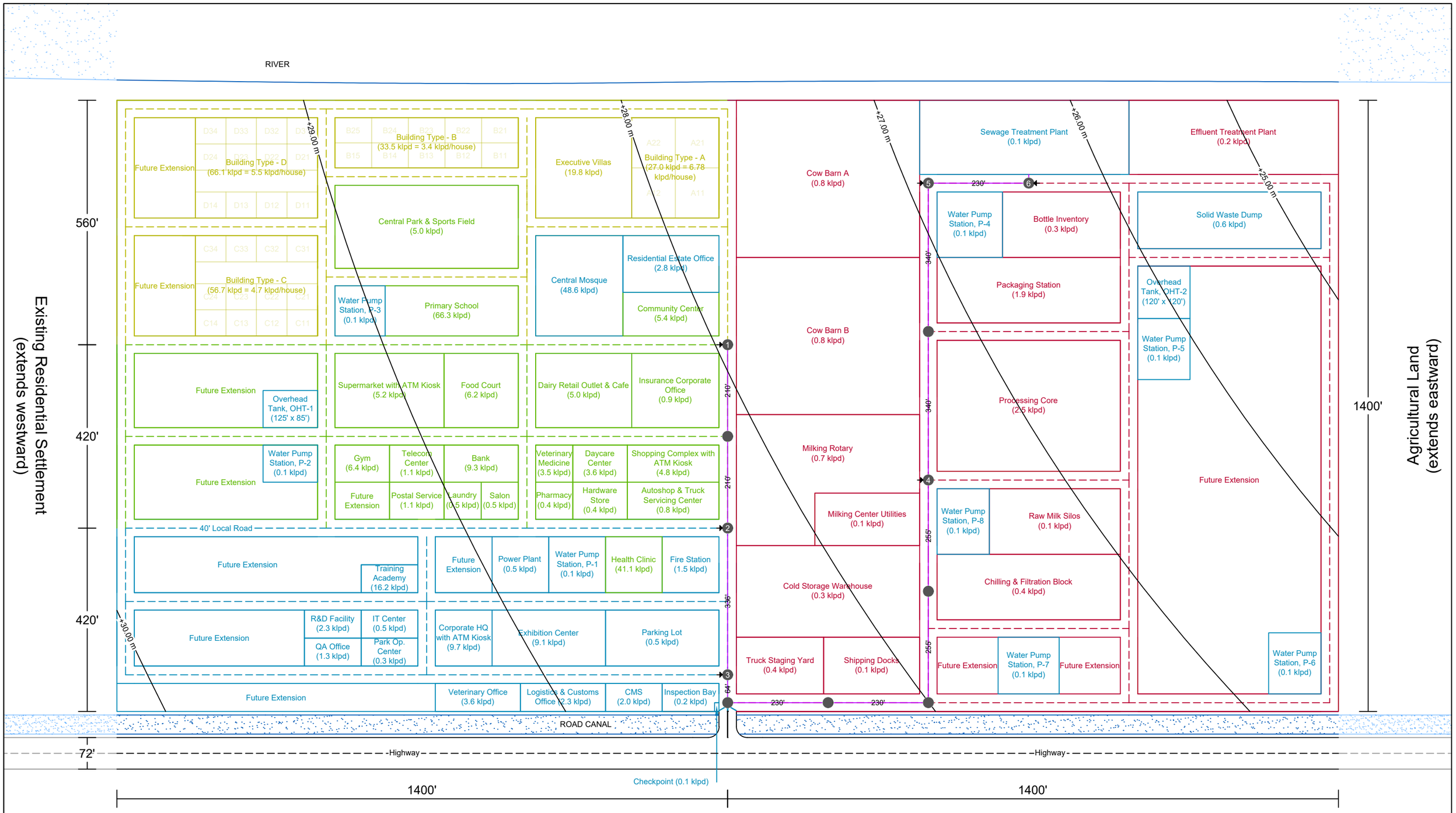


DRAWING COMPONENT

DAIRY FARM INDUSTRIAL PARK

DATE	SCALE
2026-09-19	1:2500

PARAMETERS

DEPARTMENT: ENVIRONMENTAL, WATER RESOURCES, AND COASTAL ENGINEERING
COURSE: ENVIRONMENTAL ENGINEERING DESIGN SESSIONAL (EWCE 432)
GROUP NO.: 03
PARK TYPE: DAIRY FARM
TOTAL FOOTPRINT: 90 ACRES

LEGENDS

- Administrative Wing
- Commercial Wing
- Residential Wing
- Industrial Wing
- River / Lake / Road Canals
- Road
- Trunk Sewer
- Manhole

RESIDENTIAL SCHEDULE

Villa	Residence of Senior Executives (220' x 230')
A	Division Head Quarters (100' x 115')
B	Department Manager & Doctor Quarters (84' x 57.5')
C	Technical Staff & Supervisor Quarters (70' x 60')
D	Operator, Clerk, and Laborer Quarters (70' x 60')

Wastewater Conveyance System (Trunk Sewer)

Introduction

The following report designs the trunk sewer network of the wastewater conveyance system for our dairy farm industrial village.

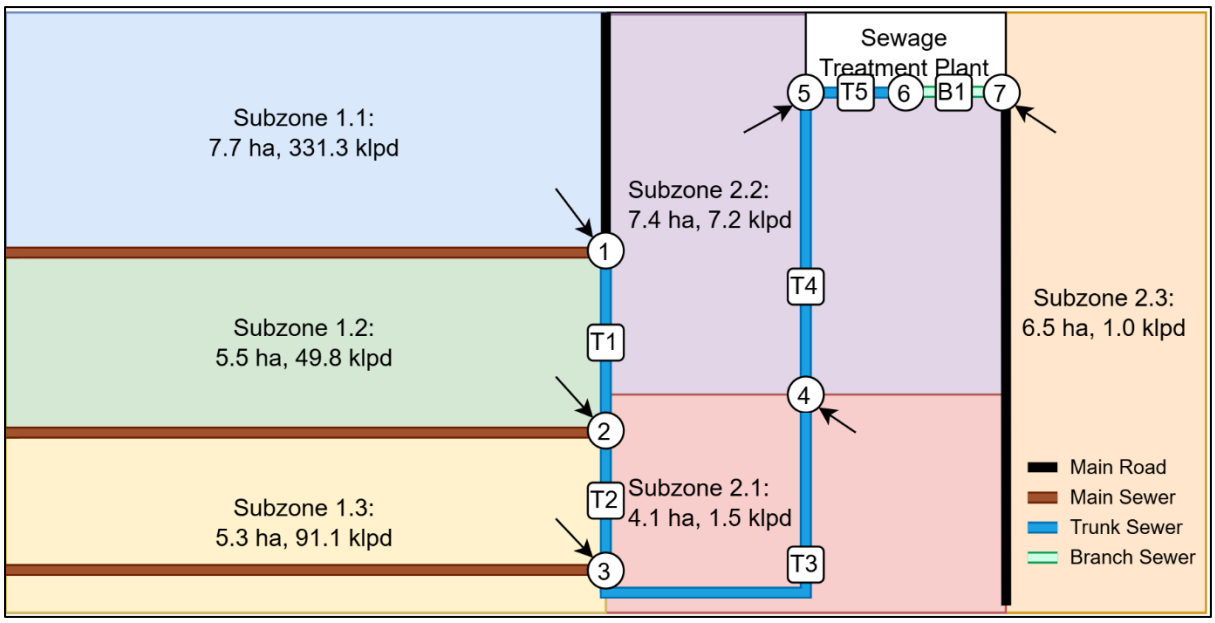


Figure 1 Layout of trunk sewer alignment and tributary subzones

Considerations:

- Four categories of direct wastewater sources considered are: residential, commercial, industrial, and institutional. Additionally, sufficient infiltration inflow is also considered.
- Wastewater and infiltration from residential subzone (subzone 1.1) enter the trunk sewer at the upper end of pipe T1 via main sewers.
- Similarly, wastewater and infiltration from subzone 1.2, 1.3, 2.1, and 2.2 enters the trunk sewer at the upper end of pipe T2, T3, T4, and T5 respectively.
- Wastewater and infiltration from subzone 2.3 are very low and thus this volume is conveyed via a branch sewer directly into the STP entrance node. This branch pipe is omitted from design as we are only interested in trunk sewer design here.

Assumptions:

- Average wastewater generated based on source category and water supply:

Category	Percent Wastewater
Industrial	90.0%
Institutional	80.0%
Commercial	80.0%
Residential	80.0%

- Peak factors considered:

Category	Peak Factor
Industrial	2.1
Institutional	4
Commercial	1.8

Note: Peak factors for residential zone are determined from graph "Peaking Factor for Residential Wastewater Flows". Equation of the curve: $PF = 2.228 \times Q^{-0.07333}$ with an upper and lower limit of 3.34 and 1.98.

- Manning's $n = 0.013$.
- Minimum velocity, $v_{min} = 2$ ft/s or $v_{min} = 0.6$ m/s
- Maximum velocity, $v_{max} = 10$ ft/s or $v_{max} = 3$ m/s

Methodology:

Determination of pipe flow:

1. Trunk sewer network is prepared on the industrial village layout.
2. Nodes are determined based on where main sewer or branch sewer joins the trunk sewer.
3. Each of the two zones is further subdivided into multiple subzones where each subzone contributes to the trunk sewer via a node (wastewater/infiltration inflow is conveyed via either main sewer or branch sewer).
4. All facilities in a particular subzone are categorized as either "Residential", "Industrial", "Institutional", or "Commercial".
5. Total water supply, followed by average wastewater flow, peak factor, and peak flow is determined for each category under each subzone. Peak factor is obtained from above mentioned graph or using its curve equation.

$$AverageWastewaterFlow = AverageWaterSupply \times PercentWastewater$$

$$PeakFlow = PeakFactor \times AverageWastewaterFlow$$

6. Total peak wastewater flow is the summation of all peak flows within the subzone.

$$TotalPeakWastewaterFlow = \sum WW_{peak}$$

7. Infiltration allowance per unit area (ha) is determined from the graph "Average infiltration rate allowance for new sewers" or using its curve equation of $II = 26.593 \times A^{-0.300}$ with maximum value of 8.75.
8. Infiltration inflow for a particular subzone is the multiplication of earlier determined infiltration allowance and subzone area in hectares.
$$InfiltrationInflow = InfiltrationAllowance \times Area$$
9. Cumulative wastewater flow is determined as the flow carried by each segment of the trunk sewer.
For a particular pipe, cumulative flow is the summation of flow from feeder pipe, connecting subzone's wastewater inflow and infiltration inflow.

Determination of pipe size:

1. Flow (Q) through each pipe is considered as determined by earlier steps.
2. Initial slope (S) is assumed for each pipe to be the minimum slope required (0.033) for minimum pipe diameter (200 mm) for gravity flow.
3. Pipe diameter (D_{calc}) is calculated from the equation:
$$Q = \frac{1}{n}\frac{\pi D^2}{4} \times \left(\frac{D}{4}\right)^{2/3} \sqrt{S} \qquad (1)$$
4. Calculated diameter is rounded to the next available pipe size from the table "Gravity Sewer Minimum Pipe Slopes".
5. Corresponding slope is obtained from the same table and check against the initially assumed slope. Steps 3 and 4 are repeated with the new slope until both slopes are same.
6. Discharge at full depth (Q_{full}) is determined by using equation (1).
7. Flow velocity at full depth is determined as:
$$V = \frac{1}{n}\left(\frac{D}{4}\right)^{2/3} \sqrt{S}$$
8. The term Q/Q_{full} is determined and correspondingly, V/V_{full} and d/D is determined using graph "Hydraulic elements for circular sewers for sewers flowing partly full".
9. Partly full flow velocity V is determined by multiplying V/V_{full} with previously determined V_{full}.
10. Determined V is checked against V_{min} and V_{max}.

Trunk sewer longitudinal profile:

1. Length of each pipe (in meters) is determined from layout.
2. Total elevation fall across the pipe length is determined as:
$$Fall = Slope \times Length$$
3. Invert drop is determined as the difference between the diameter of previous pipe and current pipe.

4. Ground elevation at the two ends of the pipe (designated by *upper* and *lower*) is determined from available contour lines of the village.
5. Initial sewer invert elevation (upper end) is determined ensuring a cover of 2 m:
$$Elv = GroundElv - Cover - PipeThickness - PipeDiameter$$
6. Subsequent invert elevation is determined by subtracting fall in sewer from upper invert elevation.
7. Cover above pipe is calculated as:
$$Cover = GroundElv - InvertElv + PipeDiameter + PipeThickness$$

Manhole placement:

1. Since all pipes are of diameter 48" or smaller, manhole is provided at:
    a. Change in direction
    b. Change in slope
    c. Change in size
    d. And at intervals not greater than 350 ft
2. Manholes at nodal positions are named as MH-*N* where *N* is the node number.
3. Intermediate manholes are named as MH-*NA* where *N* remain the node number but *A* is the alphabetic index of the node within the pipe.

Sample Calculation

Pipe T1:

Determination of wastewater flow:

Category	Facilities	Water Supply (klpd)
Residential	Building Type – Villa	19.8
	Building Type – A	27
	Building Type – B	33.5
	Building Type – C	56.8
	Building Type – D	66.1
Industrial	N/A	0
Institutional	Central Mosque	48.6
	School	66.3
Commercial	Community Center	5.4
	Residential Estate Office	2.8
	Water Pump Station	0.1
	Central Park & Sports Field	5

Total water supply on:

- Residential facilities: $19.8 + 27 + 33.5 + 56.8 + 66.1 = 203.2$ klpd
- Industrial facilities: 0 klpd
- Institutional facilities: $48.6 + 66.3 = 114.9$ klpd
- Commercial facilities: $5.4 + 2.8 + 0.1 + 5 = 13.3$ klpd

Wastewater flows from:

- Residential facilities: $203.2 \times 0.8 = 162.56\ klpd$
  $= 162.56/86400$ cumec
  $= 0.001881$ cumec
- Industrial facilities: $0 \times 0.9 = 0$ klpd $= 0$ cumec
- Institutional facilities: $114.9 \times 0.8 = 91.92$ klpd $= 0.001064$ cumec
- Commercial facilities: $13.3 \times 0.8 = 10.64$ klpd $= 0.000123$ cumec

Peak factor for residential flow: $2.228 \times 0.001881^{-0.07333} \leq 3.34$
$= 3.53 \leq 3.34 = 3.34$

Peak flows:

- Residential facilities: $162.56 \times 3.34 = 542.95$ klpd
- Industrial facilities: $0 \times 2.1 = 0$ klpd
- Institutional facilities: $91.92 \times 4 = 367.68$ klpd
- Commercial facilities: $10.64 \times 1.8 = 19.15$ klpd

Total peak wastewater flow: $542.95 + 0 + 367.68 + 19.15 = 929.78$ klpd

Determination of infiltration flow:

- Subzone: 1.1
- Area: 7.7 ha
- Infiltration allowance: $26.593 \times 7.7^{-0.300} \leq 8.75$
  $= 14.42 \leq 8.75 = 8.75$
- Infiltration flow: $8.75 \times 7.7 = 67.38$ klpd

Determination of cumulative flows:

- Feeder flow: 0 klpd [first node]
- Entering wastewater flow: 929.78 klpd
- Entering infiltration flow: 67.38 klpd
- Total entering flow: $929.78 + 67.38 = 997.16$ klpd
- Cumulative flow: $997.16 + 0 = 997.16\ klpd = 0.0115\ cumec$

Determination of pipe diameter:

- Flow: 0.0115 cumec
- Assumed slope, S: 0.0033
- Calculated diameter: $0.0115 = \frac{1}{0.013}\frac{\pi D_{calc}^2}{4}\left(\frac{D_{calc}}{4}\right)^{2/3}\sqrt{0.0033}$
  $\Longrightarrow D_{calc} = 0.166$ m
- Actual diameter: 0.200 m
- Corrected slope: 0.0033
- Discharge, Q_{full}: $\frac{1}{0.013}\frac{\pi \times 0.2^2}{4}\left(\frac{0.2}{4}\right)^{2/3}\sqrt{0.0033} = 0.0189$ cumec
- Velocity, V_{full}: $\frac{1}{0.013}\left(\frac{0.2}{4}\right)^{2/3}\sqrt{0.0033} = 0.5997$ m/s
- Q/Q_{full}: $0.0115/0.0189 = 0.6122$
- V/V_{full}: 1.06
- d/D: 0.57
- Velocity, v: $1.06 \times 0.5997 = 0.64$ m/s [$0.64 \geq 0.60 \therefore$ OK]

Pipe profile:

- Length: 128.0 m
- Slope: 0.0033
- Diameter: 200 mm
- Fall in sewer: $128.0 \times 0.0033 = 0.422$ m
- Invert drop: 0 mm [no feeder pipe to compare]
- Ground elevation (upper): 28 m
- Ground elevation (lower): 28.3 m [direction towards ground elevation]
- Invert elevation (upper): $28 - 2 - 0.05 - 0.2 = 25.75$ m
- Invert elevation (lower): $25.75 - 0.422 = 25.33$ m
- Cover (upper): $28 - (25.75 + 0.2 + 0.05) = 2.00$ m
- Cover (lower): $28.3 - (25.33 + 0.2 + 0.05) = 2.72$ m

Determination of Wastewater Flow

Pipe	From	To	Category	Facilities	Water Supply (klpd)	Wastewater Flow (klpd)	Wastewater Flow (m^3/s)	Peak Factor	Peak Flow (klpd)	Total Peak Flow (klpd)
T1	1	2	Residential	Building Type - A Building Type - Villa Building Type - B Building Type - C Building Type - D	203.20	162.56	0.001881	3.34	542.95	929.78
			Institutional	Central Mosque School	114.90	91.92	0.001064	4.00	367.68	
			Commercial	Community Center Residential Estate Office Water Pump Station Central Park & Sports Field	13.30	10.64	0.000123	1.80	19.15	

Pipe	From	To	Category	Facilities	Water Supply (klpd)	Wastewater Flow (klpd)	Wastewater Flow (m^3/s)	Peak Factor	Peak Flow (klpd)	Total Peak Flow (klpd)
T2	2	3	Commercial	Insurance Corporate Office Dairy Retail Outlet & Café Shopping Complex Autoshop & Truck Servicing Center Daycare Center Hardware Store Veterinary Medicine Pharmacy Salon Laundry Bank Telecom Center Postal Services Gym Water Pump Station Food Court Supermarket	49.80	39.84	0.000461	1.80	71.71	71.71
T3	3	4	Institutional	Exhibition Center Training Academy	25.30	20.24	0.000234	4.00	80.96	176.00

Pipe	From	To	Category	Facilities	Water Supply (klpd)	Wastewater Flow (klpd)	Wastewater Flow (m^3/s)	Peak Factor	Peak Flow (klpd)	Total Peak Flow (klpd)
			Commercial	Security Checkpoint Inspection Bay CMS Logistics & Customs Office Veterinary Office Parking Lot Corporate HQ IT Center Park Op. Center R&D Facility QA Office Fire Station Health Clinic Water Pump Station Power Plant	66.00	52.80	0.000611	1.80	95.04	
T4	4	5	Industrial	Truck Staging Yard Shipping Docks Cold Storage Warehouse Chilling & Filtration Block Milking Center Utilities Water Pump Station Raw Milk Silos	1.50	1.35	0.000016	2.10	2.84	2.98

Pipe	From	To	Category	Facilities	Water Supply (klpd)	Wastewater Flow (klpd)	Wastewater Flow (m^3/s)	Peak Factor	Peak Flow (klpd)	Total Peak Flow (klpd)
			Commercial	Water Pump Station	0.10	0.08	0.000001	1.80	0.14	
T5	5	6	Industrial	Milking Rotary Processing Core Cow Barn B Packaging Station Bottle Inventory Cow Barn A	7.00	6.30	0.000073	2.10	13.23	13.37
			Commercial	Water Pump Station	0.10	0.08	0.000001	1.80	0.14	
B1	7	6	Industrial	Effluent Treatment Plant	0.20	0.18	0.000002	2.10	0.38	1.67
			Commercial	Water Pump Station Water Pump Station Solid Waste Dump Sewage Treatment Plant	0.90	0.72	0.000008	1.80	1.30	

Determination of Infiltration Flow

Pipe	From	To	Subzone	Area (ha)	Infiltration Allowance (m^3/ha-d)	Infiltration (m^3/d)
T1	1	2	1.1	7.7	8.75	67.375
T2	2	3	1.2	5.5	8.75	48.125
T3	3	4	1.3	5.3	8.75	46.375
T4	4	5	2.1	1.5	8.75	13.125
T5	5	6	2.2	7.4	8.75	64.75
B1	7	6	2.3	6.5	8.75	56.875

Determination of Cumulative Flow

Pipe	Feeder	Feeder Flow (klpd)	Entering Wastewater Flow (klpd)	Entering Infiltration Flow (klpd)	Total Entering Flow (klpd)	Cumulative Flow (klpd)	Cumulative Flow (cumec)
T1	None	0.00	929.78	67.38	997.16	997.16	0.0115
T2	T1	997.16	71.71	48.13	119.84	1116.99	0.0129
T3	T2	1116.99	176.00	46.38	222.38	1339.37	0.0155
T4	T3	1339.37	2.98	13.13	16.10	1355.47	0.0157
T5	T4	1355.47	13.37	64.75	78.12	1433.60	0.0166
B1	None	0.00	1.67	56.88	58.55	58.55	0.0007

Note: Cumulative wastewater flow from the adjacent East subzone of the STP is very low as calculated above. Thus, installation of dedicated trunk sewer is not deemed practical (to ensure self-cleansing velocity). Instead, a branch sewer (*B1*) conveys the wastewater directly into STP's entrance node.

Determination of Pipe Diameter

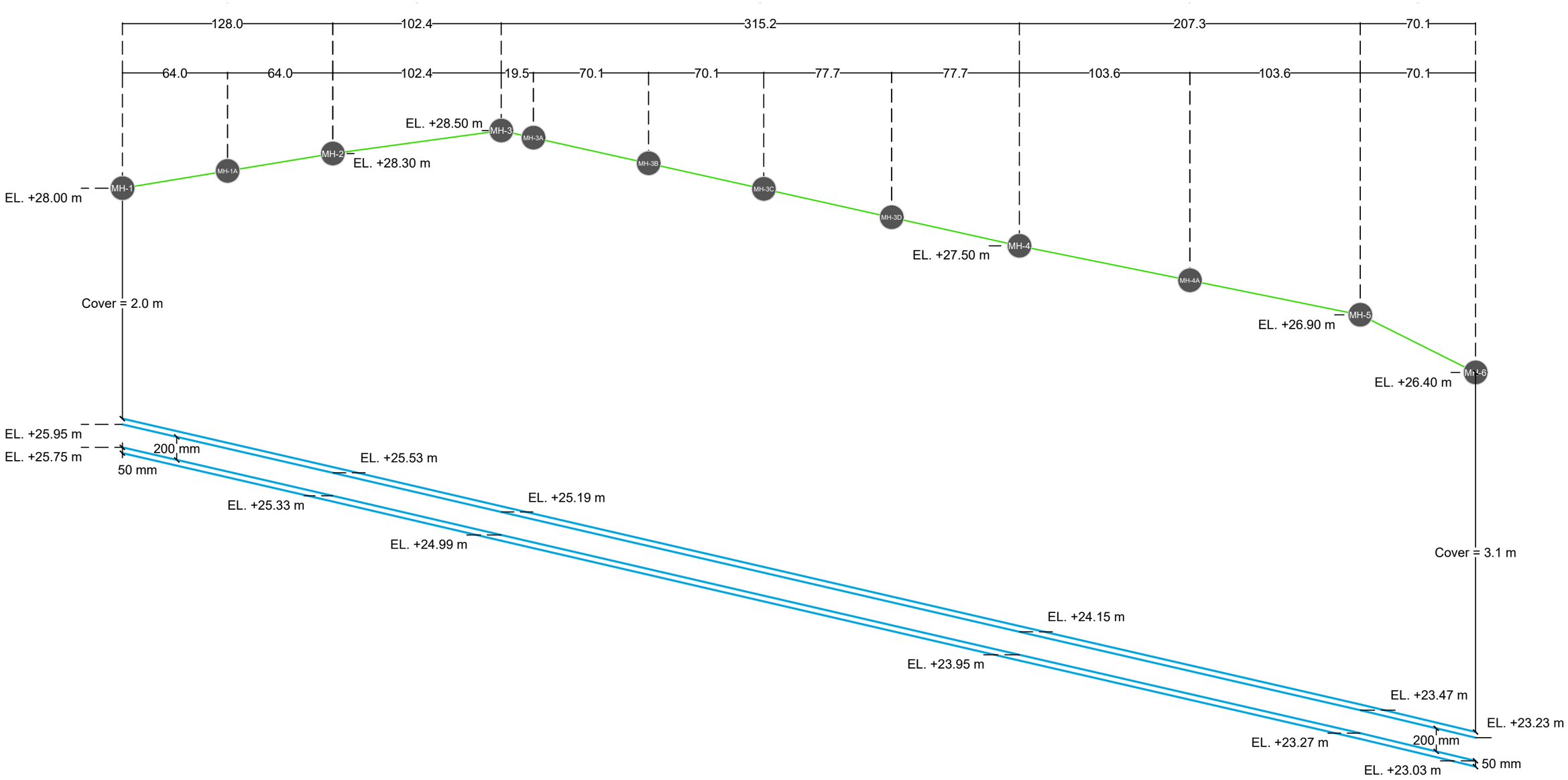
Pipe	Flow (cumec)	Assumed S	D_{calc} (m)	D_{actual} (m)	Corrected S	Q_{full} (cumec)	V_{full} (m/s)	Q/Q_{full}	V/V_{full}	d/D	V_{actual} (m/s)	Status
T1	0.0115	0.0033	0.166	0.200	0.0033	0.0189	0.5997	0.6122	1.0600	0.5700	0.64	OK
T2	0.0129	0.0033	0.174	0.200	0.0033	0.0189	0.5997	0.6858	1.0800	0.6100	0.65	OK
T3	0.0155	0.0033	0.186	0.200	0.0033	0.0189	0.5997	0.8223	1.1200	0.7000	0.67	OK
T4	0.0157	0.0033	0.187	0.200	0.0033	0.0189	0.5997	0.8322	1.1300	0.7100	0.68	OK
T5	0.0166	0.0033	0.191	0.200	0.0033	0.0189	0.5997	0.8802	1.1350	0.7400	0.68	OK

Trunk Sewer Profile

Pipe	Length (ft)	Length (m)	Slope (m/m)	Diamter (mm)	Fall in Sewer (m)	Invert Drop (m)	Ground Elevation: Upper (m)	Ground Elevation: Lower (m)	Sewer Invert Elevation: Upper (m)	Sewer Invert Elevation: Lower (m)	Cover Above Pipe: Upper (m)	Cover Above Pipe: Lower (m)
T1	420	128.0	0.0033	200	0.422	0	28	28.3	25.75	25.33	2.00	2.72
T2	336	102.4	0.0033	200	0.338	0	28.3	28.5	25.33	24.99	2.72	3.26
T3	1034	315.2	0.0033	200	1.040	0	28.5	27.5	24.99	23.95	3.26	3.30
T4	680	207.3	0.0033	200	0.684	0	27.5	26.9	23.95	23.27	3.30	3.38
T5	230	70.1	0.0033	200	0.231	0	26.9	26.4	23.27	23.03	3.38	3.12

Manhole Placement

Manhole ID	Location	Distance from Upper End of Pipe (m)	Diameter (m)
MH-1	1	0.0	1.5
MH-1A	1–2	64.0	1.5
MH-2	2	64.0	1.5
MH-3	3	102.4	1.5
MH-3A	3–4	19.5	1.5
MH-3B	3–4	70.1	1.5
MH-3C	3–4	70.1	1.5
MH-3D	3–4	77.7	1.5
MH-4	4	77.7	1.5
MH-4A	4–5	103.6	1.5
MH-5	5	103.6	1.5
MH-6	6	70.1	1.5



DRAWING COMPONENT

Trunk Sewer Longitudinal Profile

DATE	SCALE	VERTICAL EXAGGERATION
2026-09-23	**1:2500**	**70x**

PARAMETERS

DEPARTMENT: ENVIRONMENTAL, WATER RESOURCES, AND COASTAL ENGINEERING
COURSE: ENVIRONMENTAL ENGINEERING DESIGN SESSIONAL (EWCE 432)
GROUP NO.: 03
PARK TYPE: DAIRY FARM
TOTAL FOOTPRINT: 90 ACRES

LEGENDS

- Manhole
- Ground Level
- Sewer Pipe

NOTE

All dimensions are in meters, unless otherwise specified explicitly.