DESIGN OF PIPELINE DISTRIBUTION NETWORK

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सिंचनात् राष्ट्रोद्धार :

WATER RESOURCES DEPARTMENT
MAHARASHTRA KRISHNA VALLEY DEVELOPMENT CORPORATION
GOVERNMENT OF MAHARASHTRA

AGENDA

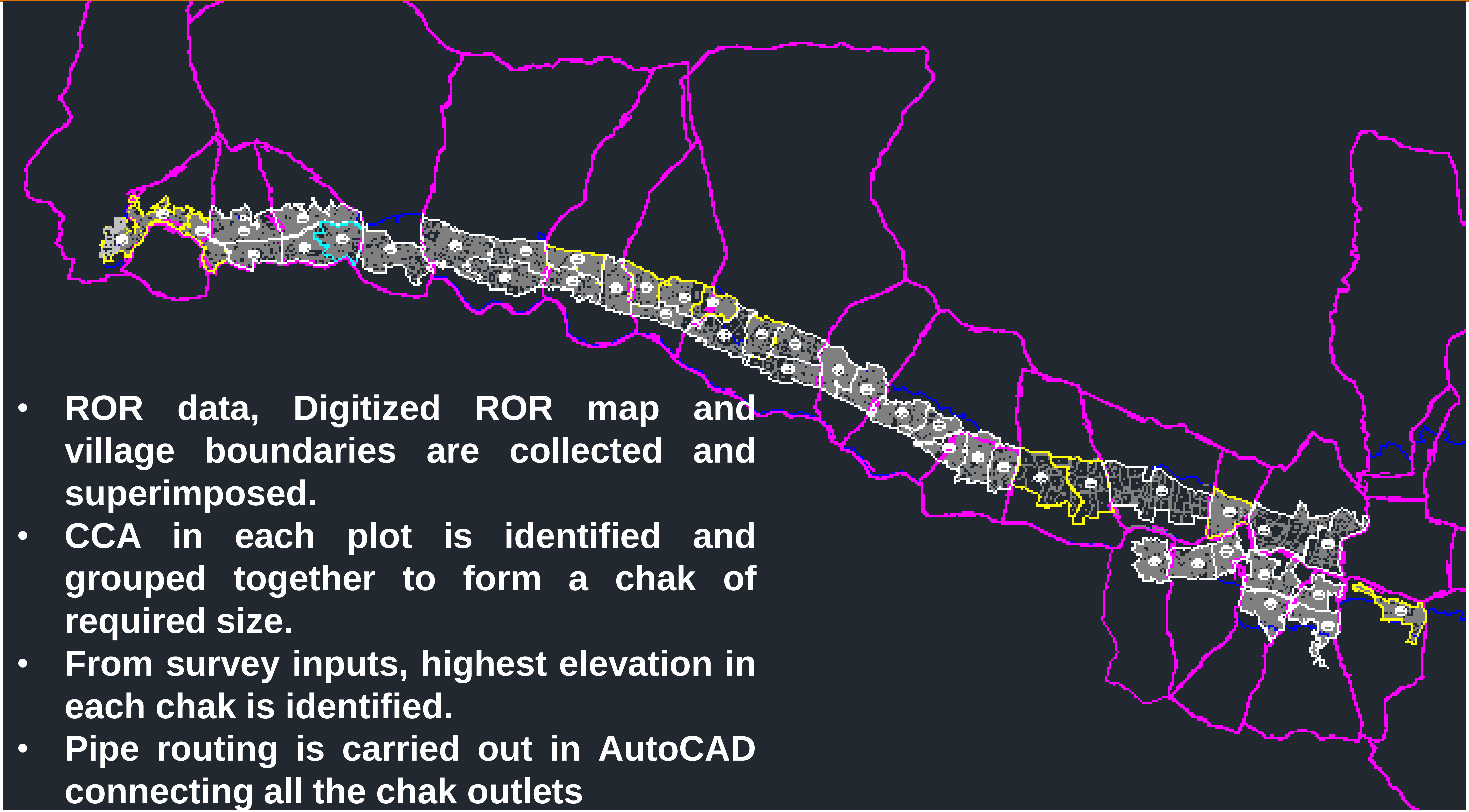
- Pipeline Distribution Network
- Pipeline Hydraulics design & concepts
- Modelling pipeline network in Water Gems Software
- Pipe thickness calculation as per AWWA M11
- Automation in pipeline irrigation
- Surge analysis concepts and modelling in SAP
- Pipeline Alignment LS details

CANAL & PIPED MAJOR IRRIGATION SYSTEM

- **CANAL IRRIGATION – Irrigation main canals & sub canals by Gravity flow – FLOODED IRRIGATION SYSTEM**

- **PIPED IRRIGATION – Pressurized pipeline system by Pumping / Gravity flow with sufficient pressure – EQUITABLE PRESSURIZED IRRIGATION SYSTEM**

CHAK PLANNING & PIPE ROUTING



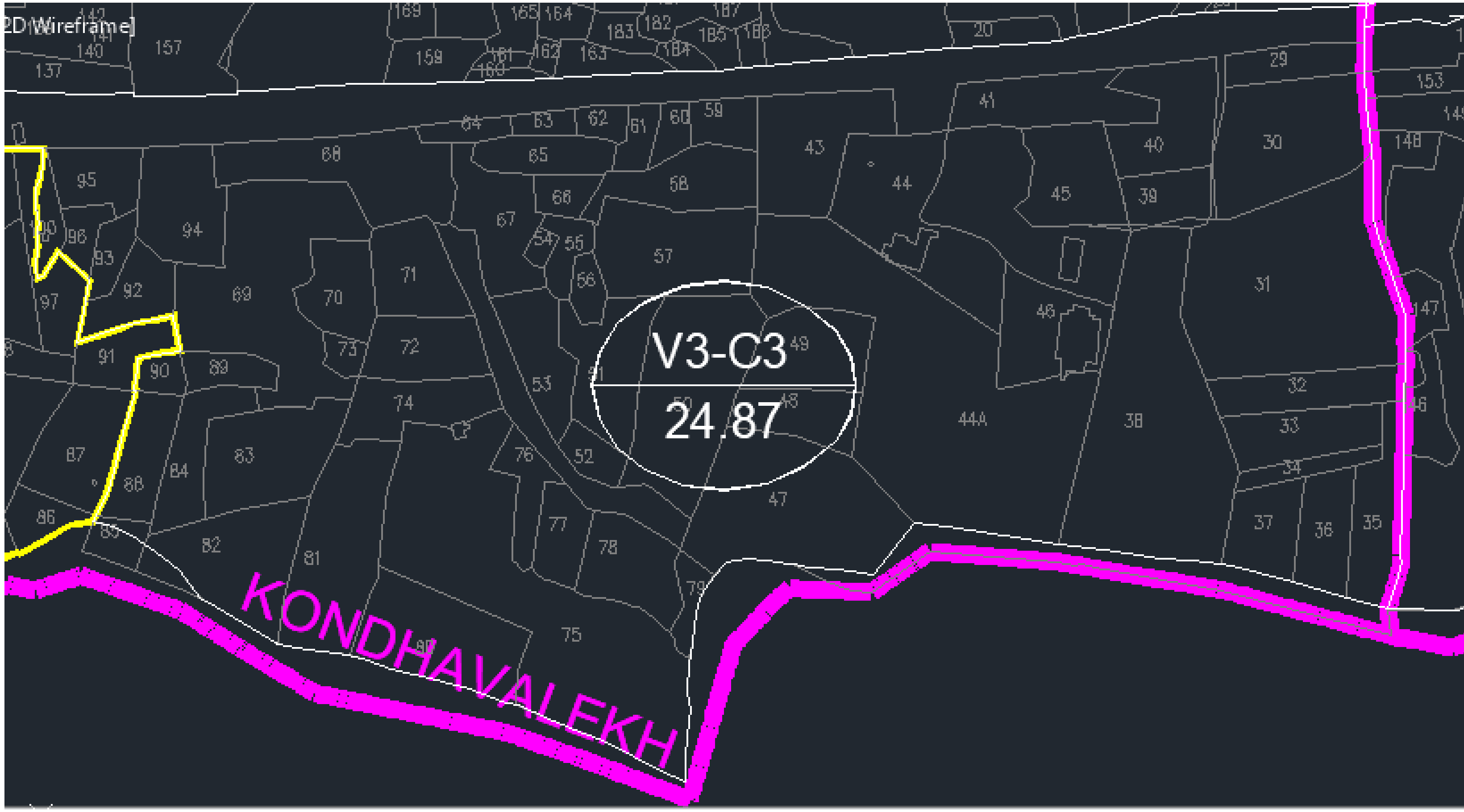
- ROR data, Digitized ROR map and village boundaries are collected and superimposed.
- CCA in each plot is identified and grouped together to form a chak of required size.
- From survey inputs, highest elevation in each chak is identified.
- Pipe routing is carried out in AutoCAD connecting all the chak outlets

CHAK PLANNING - TYPICAL

- **ROR data, Digitized ROR map and village boundaries are collected**
- **Sample ROR data is shown below**

Village Tag	20 Ha Chak Tag	20 Ha Tag	PLOT NO	Village Name	NAME OF OWNER	CCA (Ha)	GCA (Ha)	TYPE OF LAND	LAND DESCRIPTION
V3	C3	V3-C3	38	KONDHAVALE KH	शासकीय औदयोगिक प्रशिक्षण संस्था वेल्हे	1.391	2.782	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	46	KONDHAVALE KH	दत्तात्रय यशवंत देशपांडे	0.400	0.400	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	45	KONDHAVALE KH	रमा गिरीष देशपांडे (72) सुशिला मधुकर देशपां	0.400	0.400	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	75	KONDHAVALE KH	निवृत्ती नबाजी खोपडे	1.628	1.721	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	93	KONDHAVALE KH	दत्तु भागु सरफले (204) नथू भागु सरफले	0.121	0.121	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	34	KONDHAVALE KH	राजु नामदेव चोर (226) सागर सुरेश मळेकर	0.100	0.106	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	57	KONDHAVALE KH	बाळकृष्ण अर्जुन दारवटकर	0.430	0.430	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	60	KONDHAVALE KH	निवृत्ती हरिभाऊ सुतार	0.060	0.060	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	29	KONDHAVALE KH	दत्तु नानु सणस	0.195	0.203	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	39	KONDHAVALE KH	दत्तात्रय यशवंत देशपांडे	0.225	0.225	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	56	KONDHAVALE KH	जयराम लक्ष्मण खोपडे	0.070	0.070	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	72	KONDHAVALE KH	भिमाजी राघु खोपडे	0.290	0.290	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	89	KONDHAVALE KH	पांडुरंग बाळा धायगावे	0.139	0.139	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	71	KONDHAVALE KH	शाल बाबासाहेब कुटे (352) विक्रम बाबासाहेब कु	0.270	0.270	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	90	KONDHAVALE KH	दत्तु भागु सरफले (204) नथू भागु सरफले	0.100	0.100	PRIVATE CULTIVABLE	Cultivable
V3	C3	V3-C3	63	KONDHAVALE KH	हनुवती खंडु धायगांवे	0.035	0.035	PRIVATE CULTIVABLE	Cultivable

ROR - TYPICAL



Village boundary of Kondhavale KH – Village V3

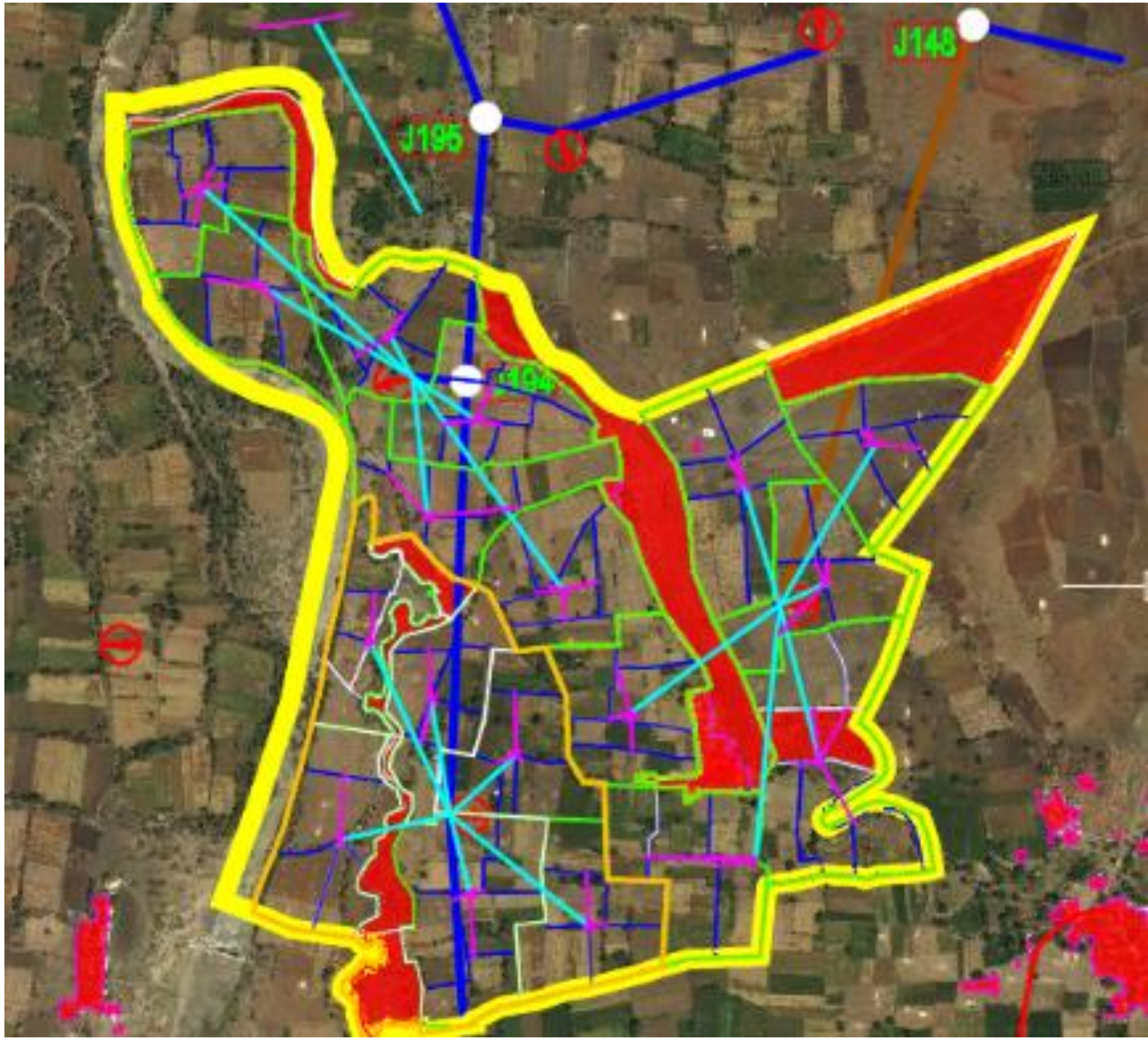
Detailed view of chak V3-C3 with plot numbers as per the digitized ROR map

CHAK PLANNING - TYPICAL

'Khedi' Village boundary-CCA–95.8 Ha
30 Ha Chaks – 3 Nos.

Yellow – Village Boundary
Brown – 30 Ha Boundary
Green – 5 Ha Boundary
Blue – 1 Ha Boundary

Blue Pipe – From main pipe line upto 30 Ha Chak
Cyan Pipe – From 30Ha upto 5 Ha Chak
Pink Pipe – From 5Ha upto 1 Ha Chak



HYDRAULIC DESIGN - CRITERIA

Flow Discharge	Desired @ Demand Point
Pressure Head	Desired @ Demand Point
Head Losses	Intermediate/cumulative
Flow Velocity	Optimum Range (0.6 – 2.1 m/s)
Pipe Size	Cost Effective

Hydraulic Gradient Line (HGL)

Feasibility check w.r.t Ground level

PIPE DIAMETER SELECTION

$$\text{Flow Rate} = \frac{1}{4} \cdot \pi \cdot (\text{pipe diameter})^2 \cdot \text{velocity}$$

- Discharge in m3/s
- Calculated from water requirement / total water intake

- Velocity of flow in m/s
- MS pipe Upto 3,0 m/s as per CWC Guidelines
- MS pipe lined – upto 2.1 m/s as per CPHEEO

SIZING OF PIPES

Factors governing sizing of pipes:

- ➢ Velocity criteria
- ➢ Power Consumption for pressurised distribution network
- ➢ Pressure Head availability for gravity distribution network
- ➢ Total operational cost based on economic pipe sizing

		Diameter(mm)		Velocity(m/s)	
3.	HDPE and PVC	20	100	0.3	1.8
4.	CI/DI (for water with positive Langelier's index)	100	1000	0.3	1.8
5.	CI/DI (For waters with negative Langelier's index)	100	1000	0.3	1.8
6.	Metallic pipes lined with cement mortar or epoxy (for water with negative Langelier's index)	100	2000	0.3	2.1

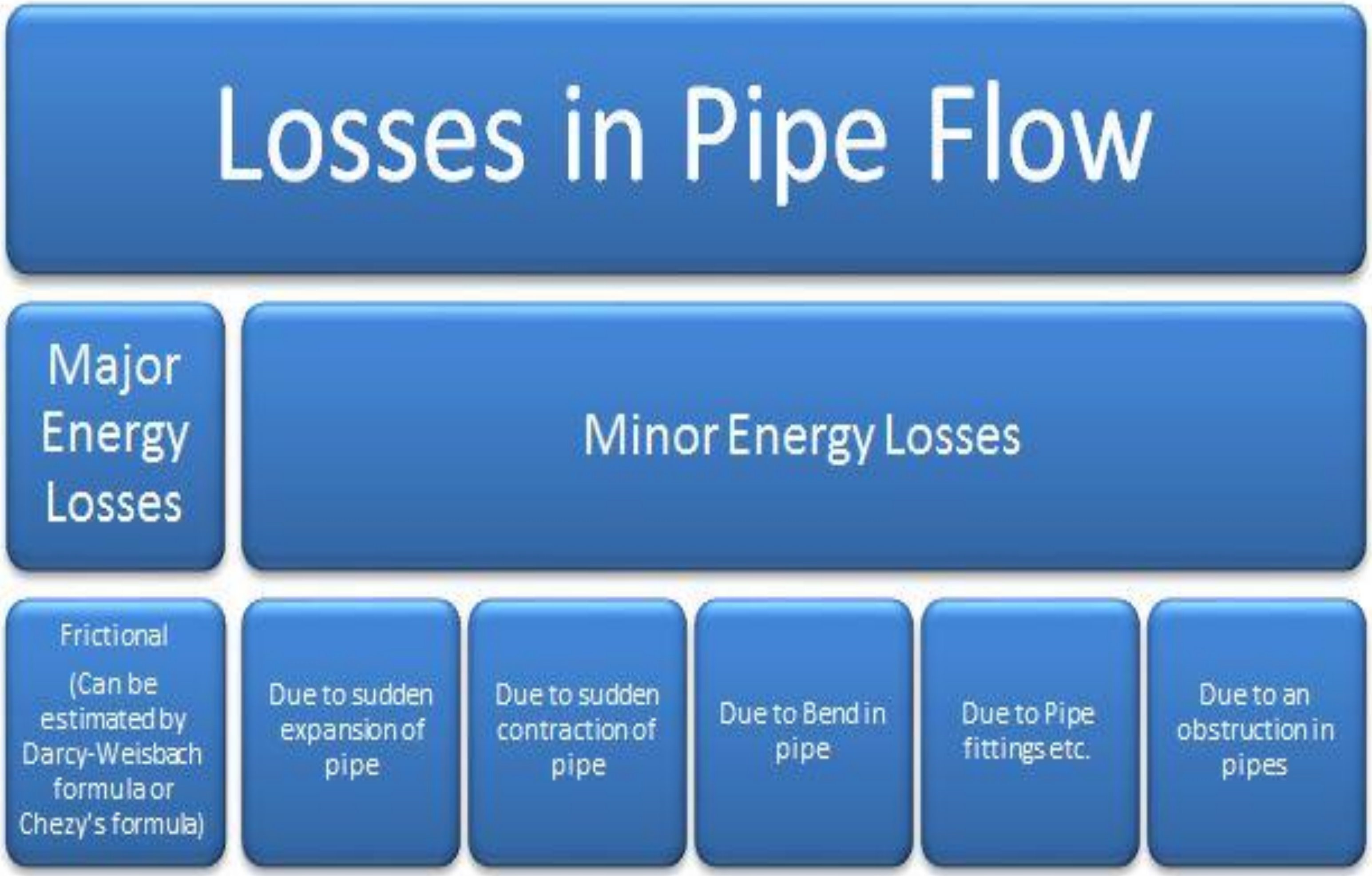
Factors governing selection of pipe material:

- ➢ Contract Conditions
- ➢ Durability and Longevity
- ➢ Work feasibility at site
- ➢ Capital Cost

LOSSES IN PIPELINE

The total head, or pressure, affecting flow may be divided into four parts:

- velocity head loss
- entrance head loss
- loss of head through friction
- Minor losses (fittings losses)



PUMP HEAD

Total Pump Head = Static Head
+ Pipe friction loss
+ Fitting losses (10% of frictional loss)
+ pumping Station loss (1 m)

- **Static Head = Full supply level at DC / Max. peak point – Lifting water level in Pump House**
- **Friction loss is calculated from Hazen Williams / Modified Hazen Williams Formula**

FRICTION LOSS IN PIPELINE

Head Loss may be calculated From Below Hazen Williams Formula

$$h_L = \frac{4.72 Q^{1.852} L}{C^{1.852} D^{4.87}}$$

Wher

h_L = frictional head loss in pipe length L, m

Q = flow (discharge), m^3/sec

L = length of pipe, m

D = inside diameter of pipe, m

C = 140 for MS & HDPE pipe

HAZEN WILLIAM'S CONSTANT

As per CPHEEO manual table 6.1, the recommended C-value of MS, DI & HDPE pipes are tabulated below.

Sl. No.	Material	Diameter (mm)	C-value (Design purpose)
1	MS (Lined metallic)	<1200	140
2	MS (Lined metallic)	>1200	145
3	DI (Lined metallic)	<1200	140
4	Plastic pipes (HDPE)	All Dia	145

FRICTION LOSS IN PIPELINE

Modified Hazen-Williams coefficient C

Head Loss may be calculated From Below Modified Hazen Williams Formula

$$H_f = \frac{L \times Q^{1.81}}{994.62 \times C_R^{1.81} \times D_{in}^{4.81}}$$

Where :

H_f = frictional he

Q = flow (discharge), m^3/sec

L = length of pipe, m

D = inside diameter of pipe, m

C_R = Modified Hazen William's constant = 1

HYDRAULIC DESIGN - OUTCOMES

Pumping station - Parameters	Total Discharge
	Each Pump Flow & Head
	Power consumption
Pipe line network- Parameters	Optimum Pipe Size & Rating
	Valve Ratings
	Control & Automation (if any)

HGL GRAPH OF A LIFT IRRIGATION PROJECT (NORMAL OPERATION)

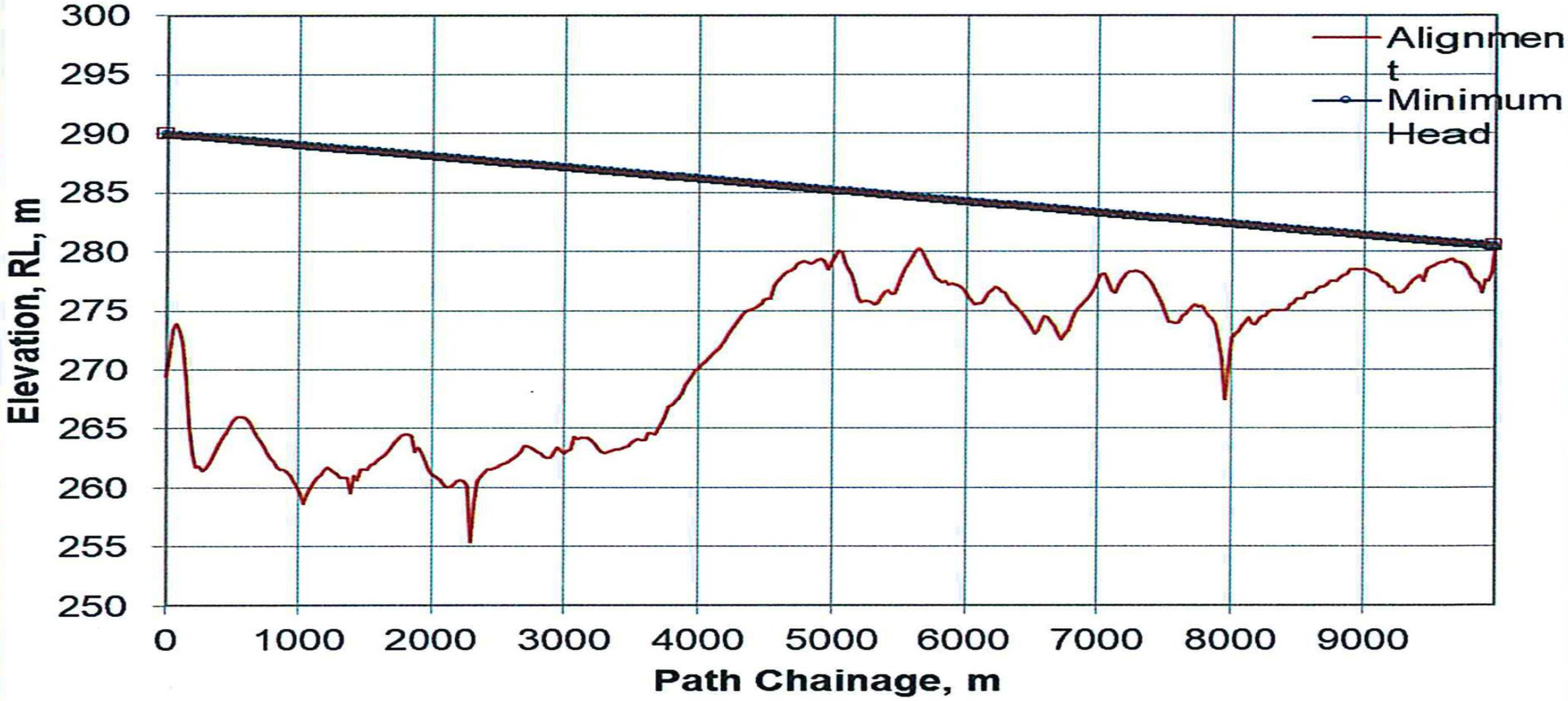


Fig.:Minimum and Maximum Piezometric Heads

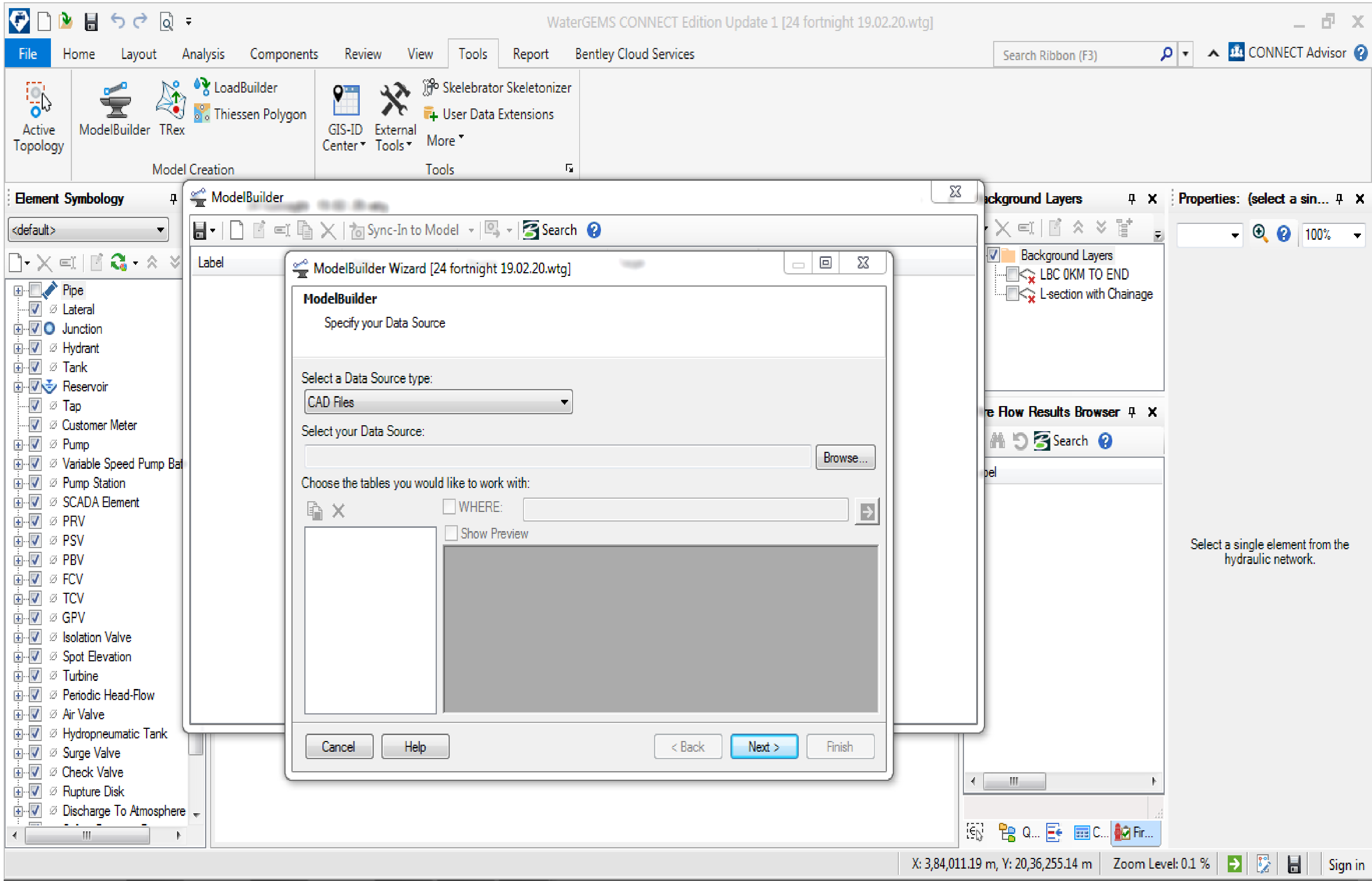
Hydraulics in Bentley WaterGEMS - Preprocessing

Pipe routing

After chak planning is carried out, the **pipe routing** is done in AutoCAD and saved as a dwg file.

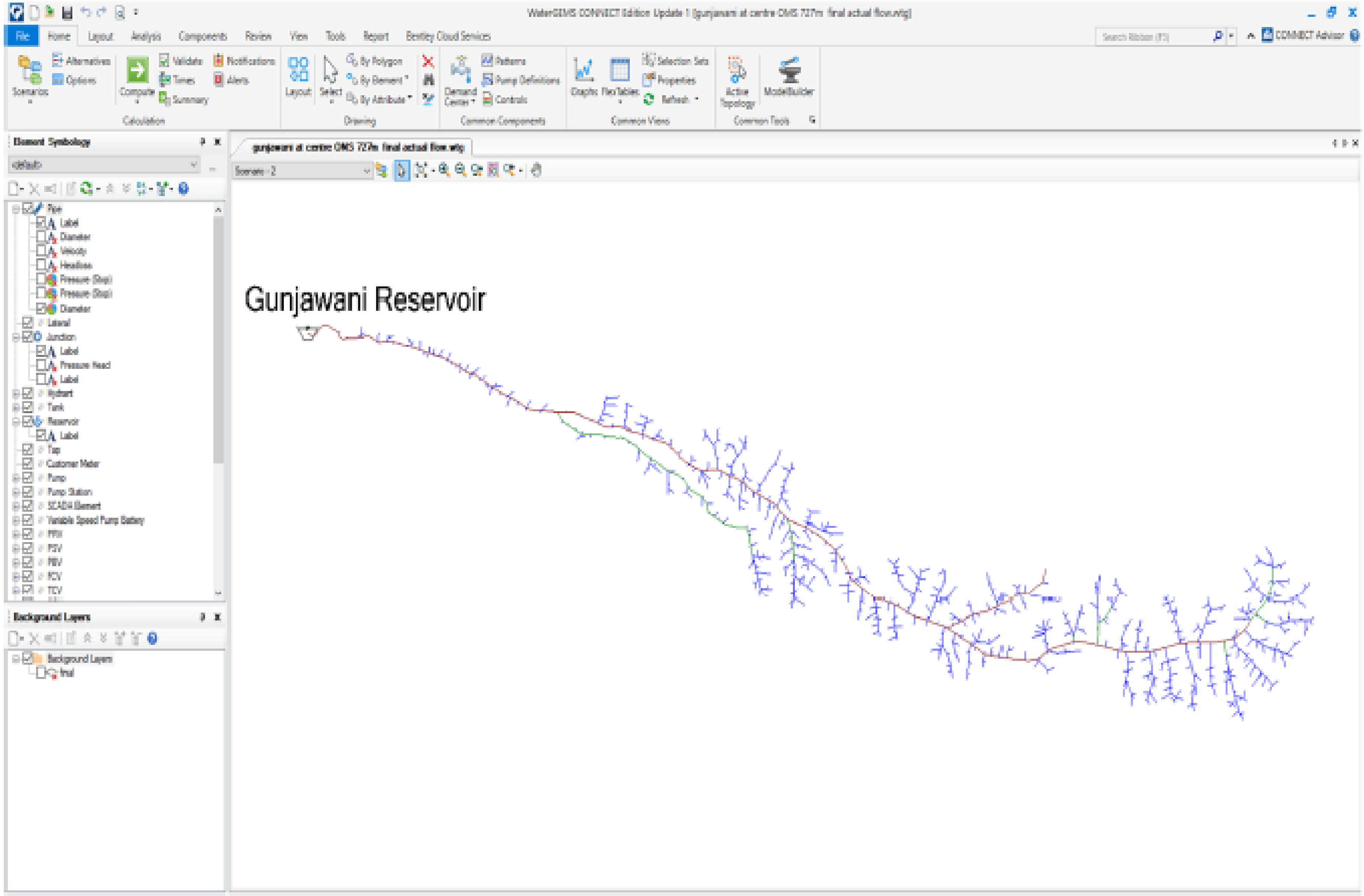
File Import

The **pipe routing** in dwg format is **imported** into the Bentley WaterGEMS software.



Hydraulics in Bentley WaterGEMS

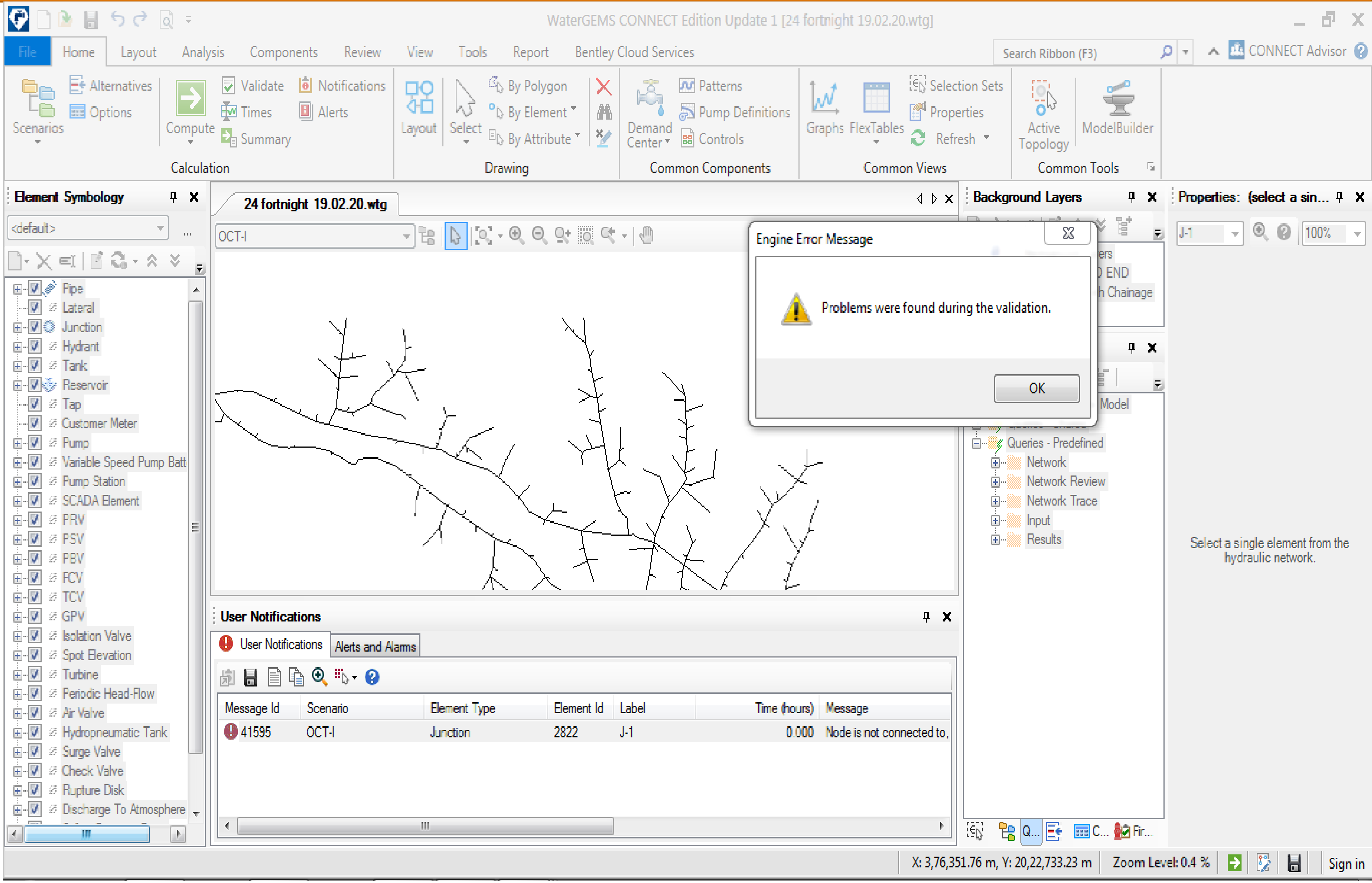
DWG file is now imported into the software in true coordinates



Hydraulics in Bentley WaterGEMS

Pipeline validation

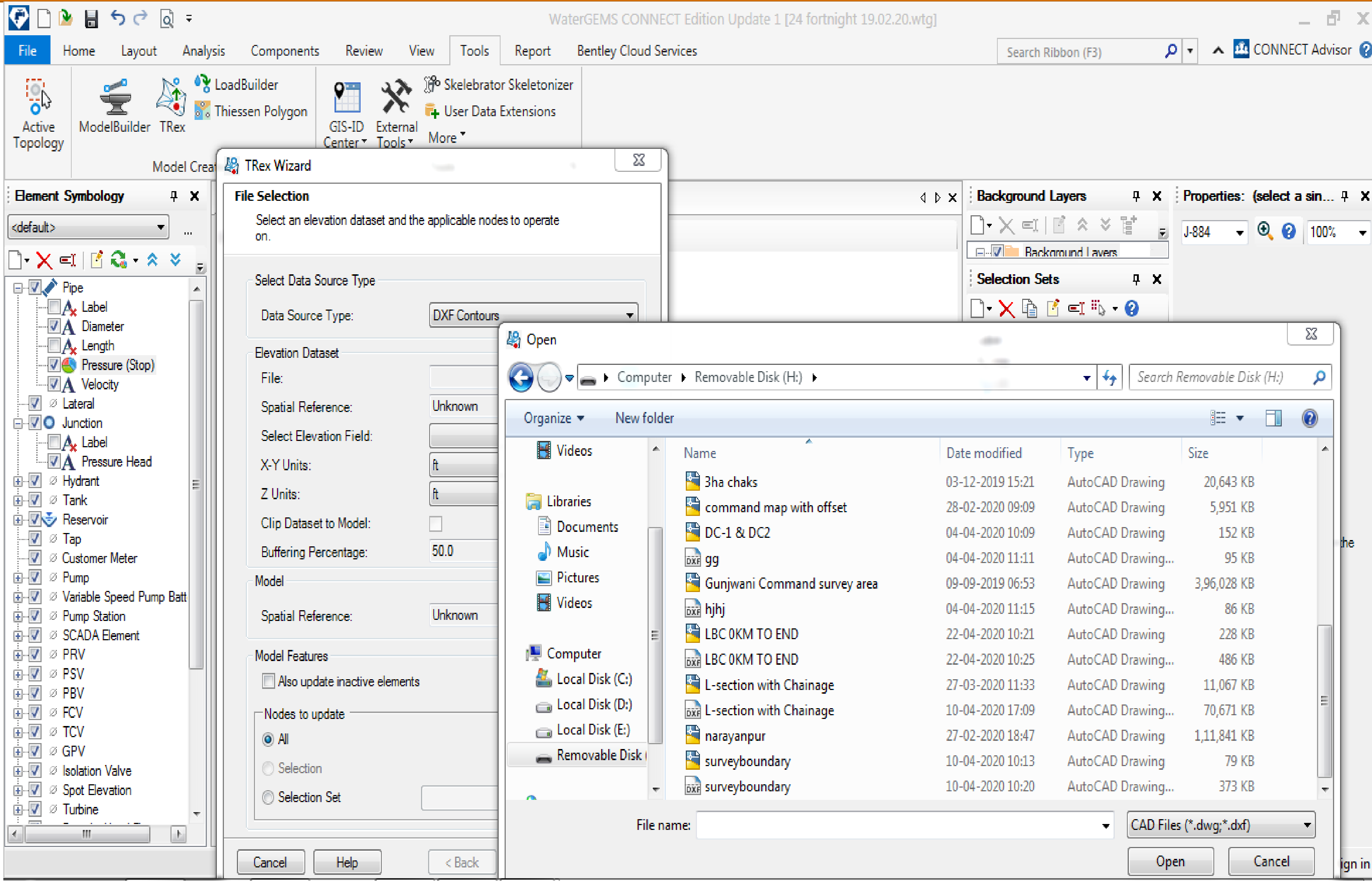
The uploaded pipe route is checked for its correctness using the validation option available.



Uploading Contour

From survey points a contour is generated using the Civil 3D software and saved as a dwg file

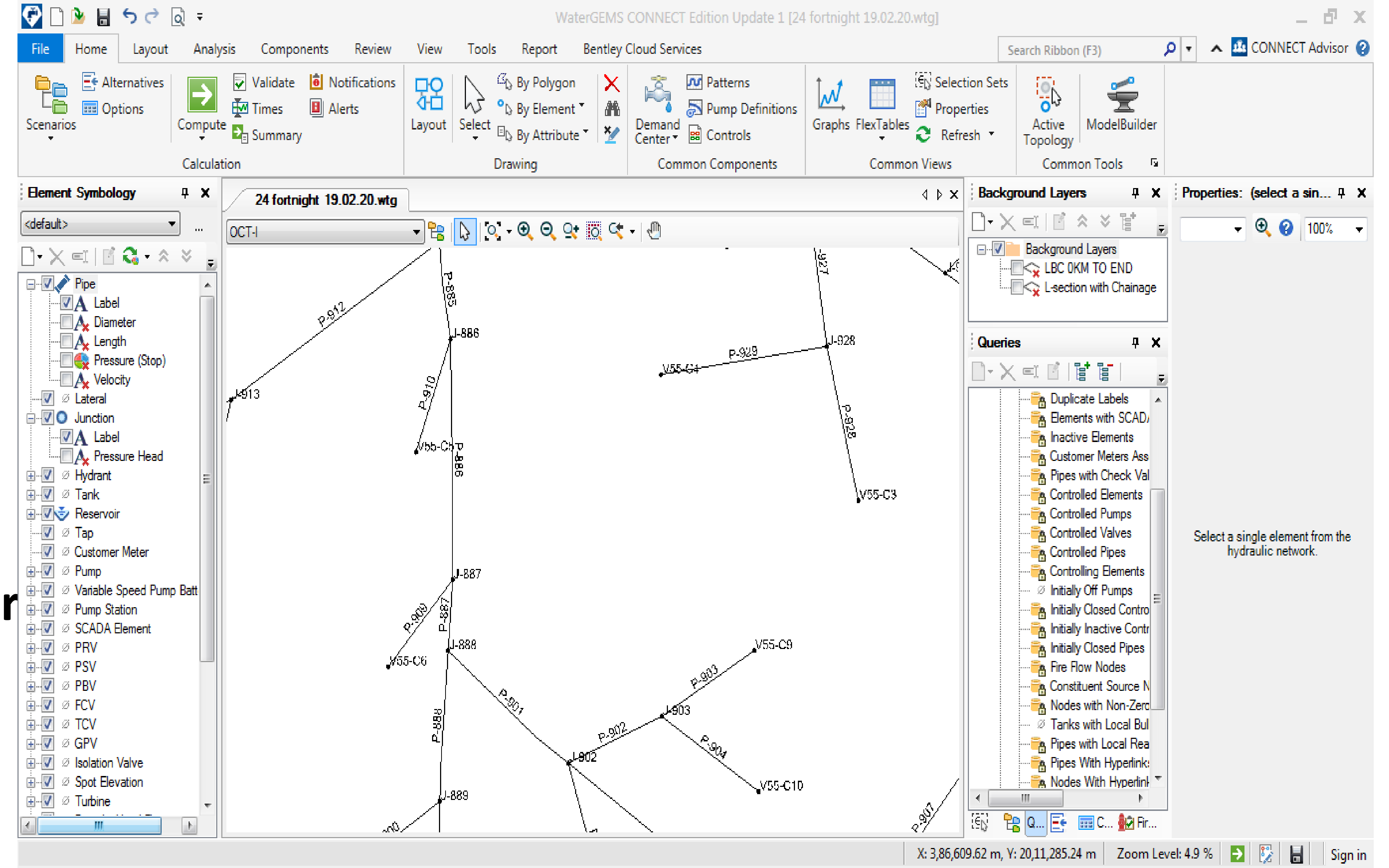
The contour file in dwg is imported using Trex option & the juntions are automatically assigned elevations



Hydraulics in Bentley WaterGEMS

Each Pipe and Junction is assigned a name by the software & analysis (friction loss) is carried out for each pipe.

Output is derived for each junction (pressure head at entry and exit).

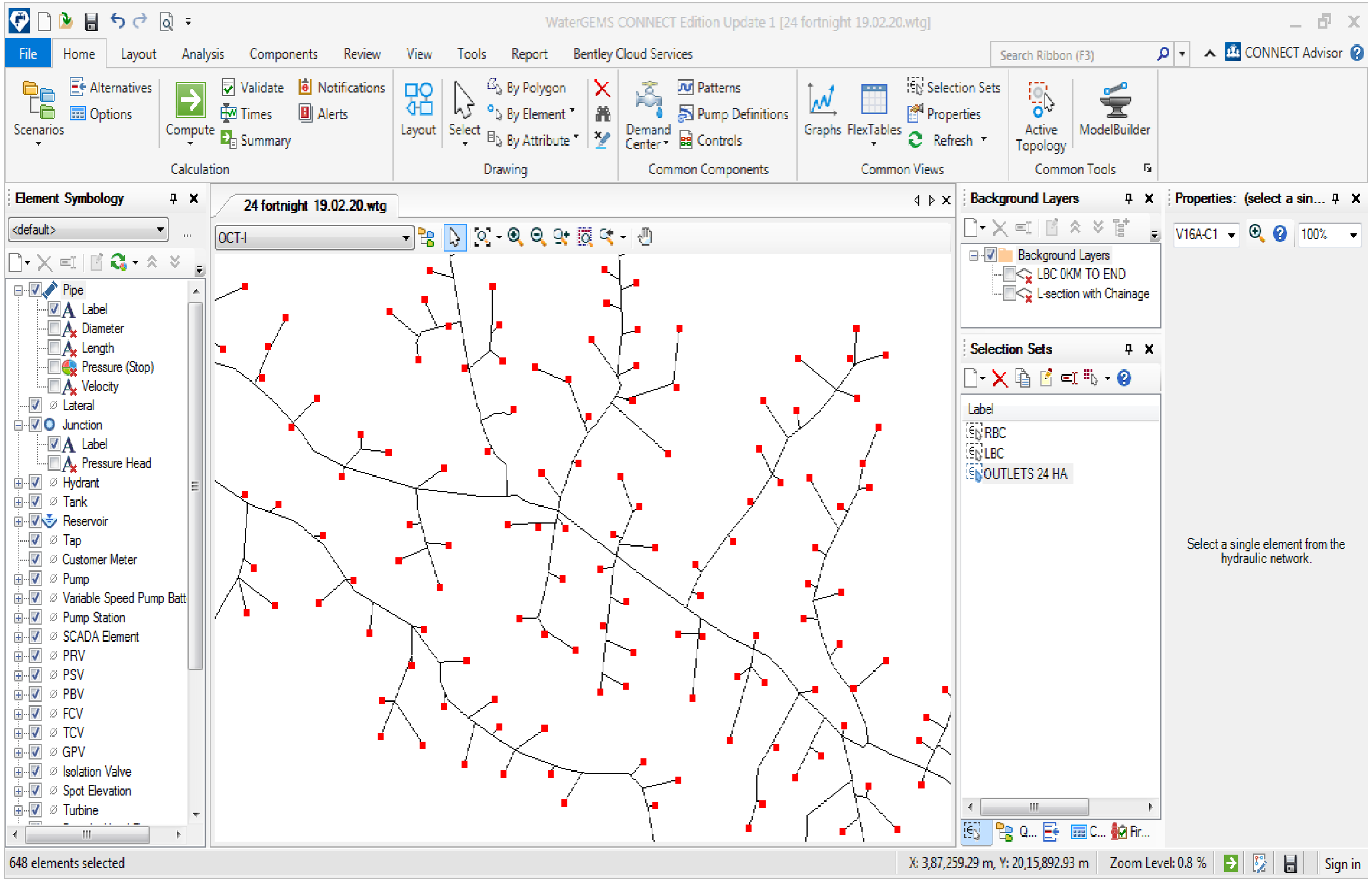


Hydraulics in Bentley WaterGEMS

All the chak outlet points are called demand points.

The demand points are identified as end nodes.

A selection set is created consisting of all end nodes.

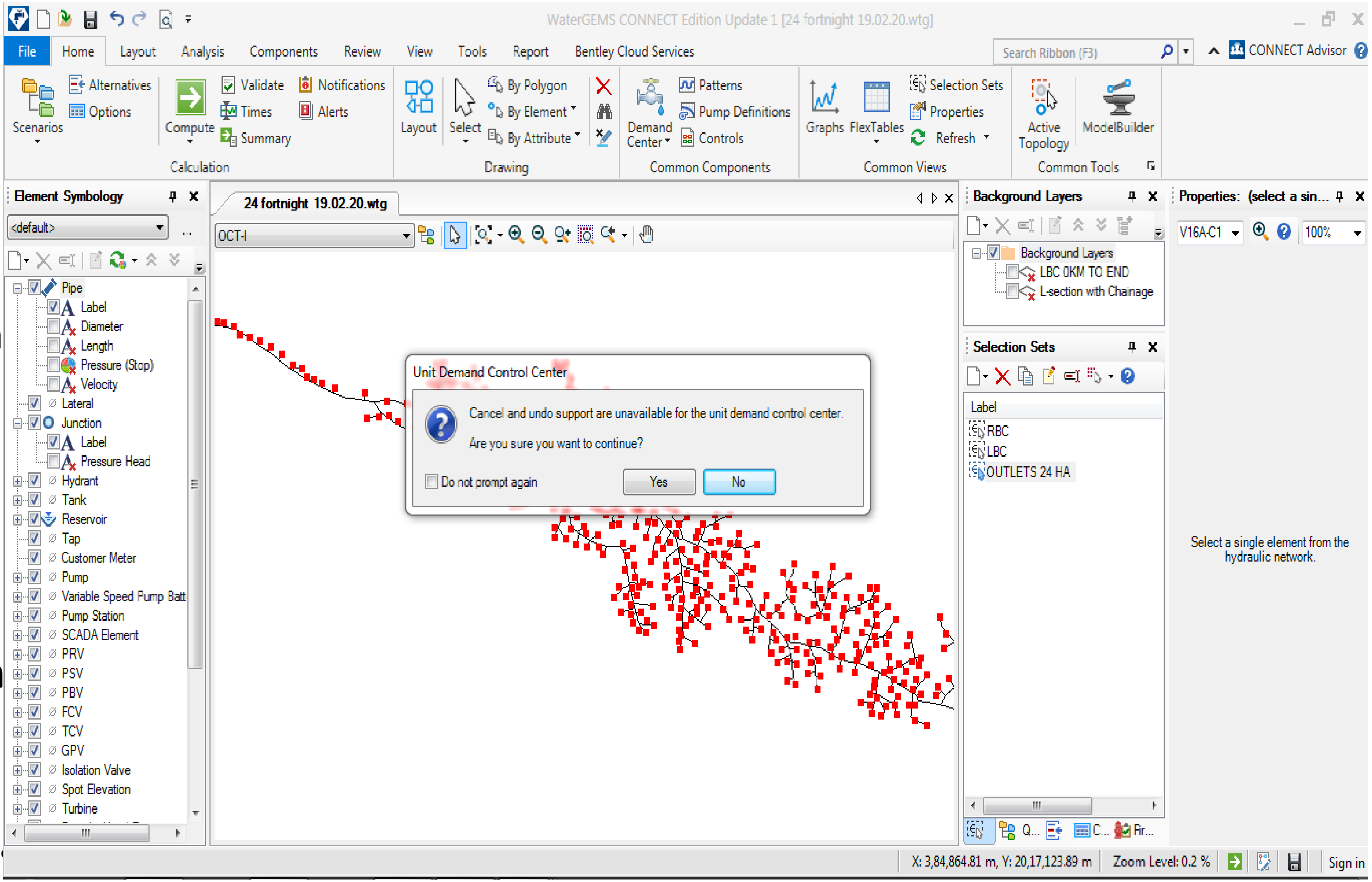


Hydraulics in Bentley WaterGEMS

Demand Inputs

The reservoirs pumphouse in case of rising main (LWL) & delivery chamber (FSL) in case of a gravity main is assigned with a **water level.**

Demand points are identified and **demand** for each point in the earlier created selection set is assigned a flow as per the duty point and chak size for the project.

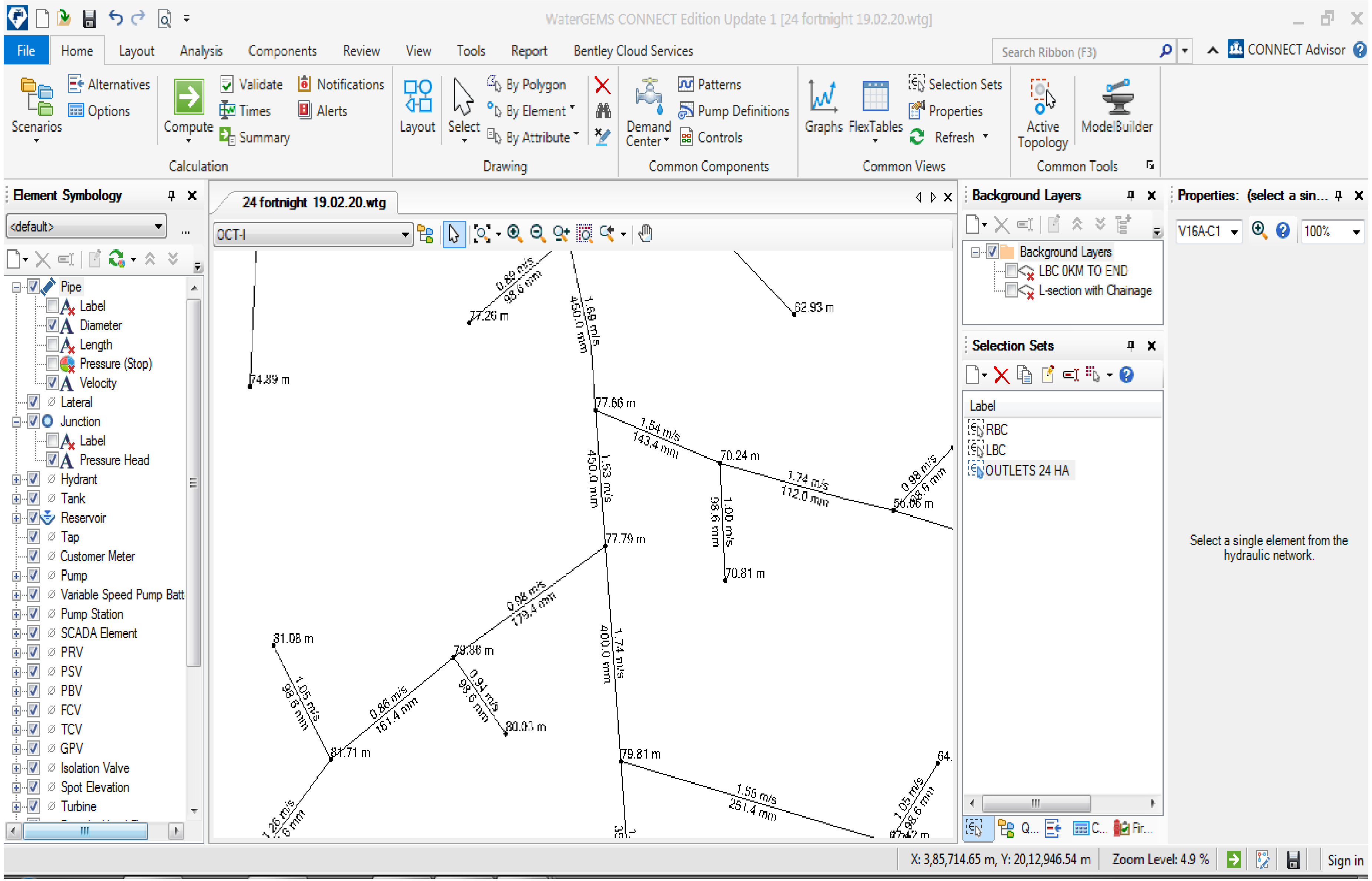


Analysis

After all the inputs are assigned, the analysis is carried out in the software.

The friction loss is calculated using the Hazen Williams formula

All the pipes are annotated with the required details.



Hydraulics in Bentley WaterGEMS

Analysis

After all the inputs are assigned, the analysis is carried out in the software.

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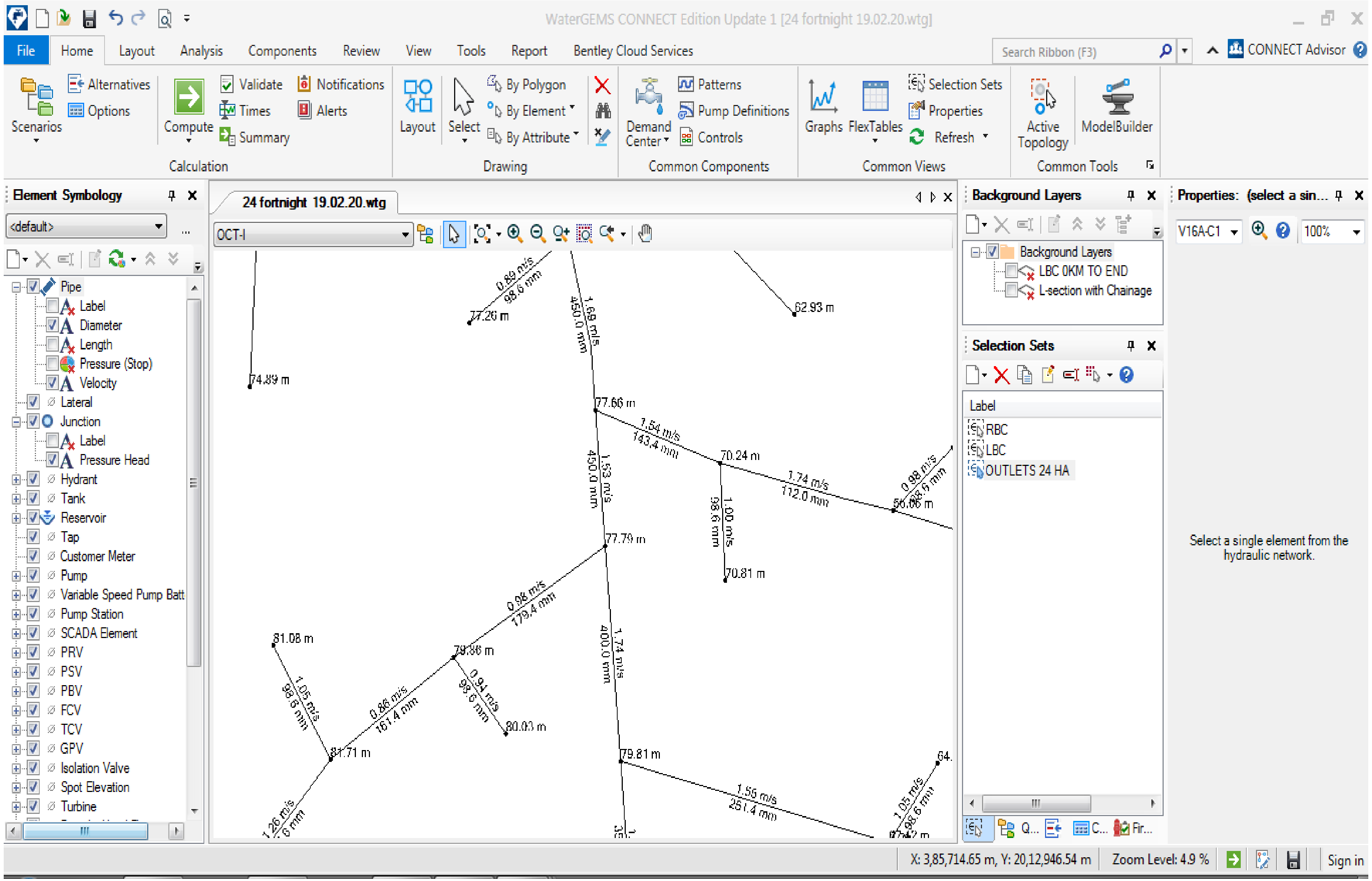
All the pipes are annotated with the required details.



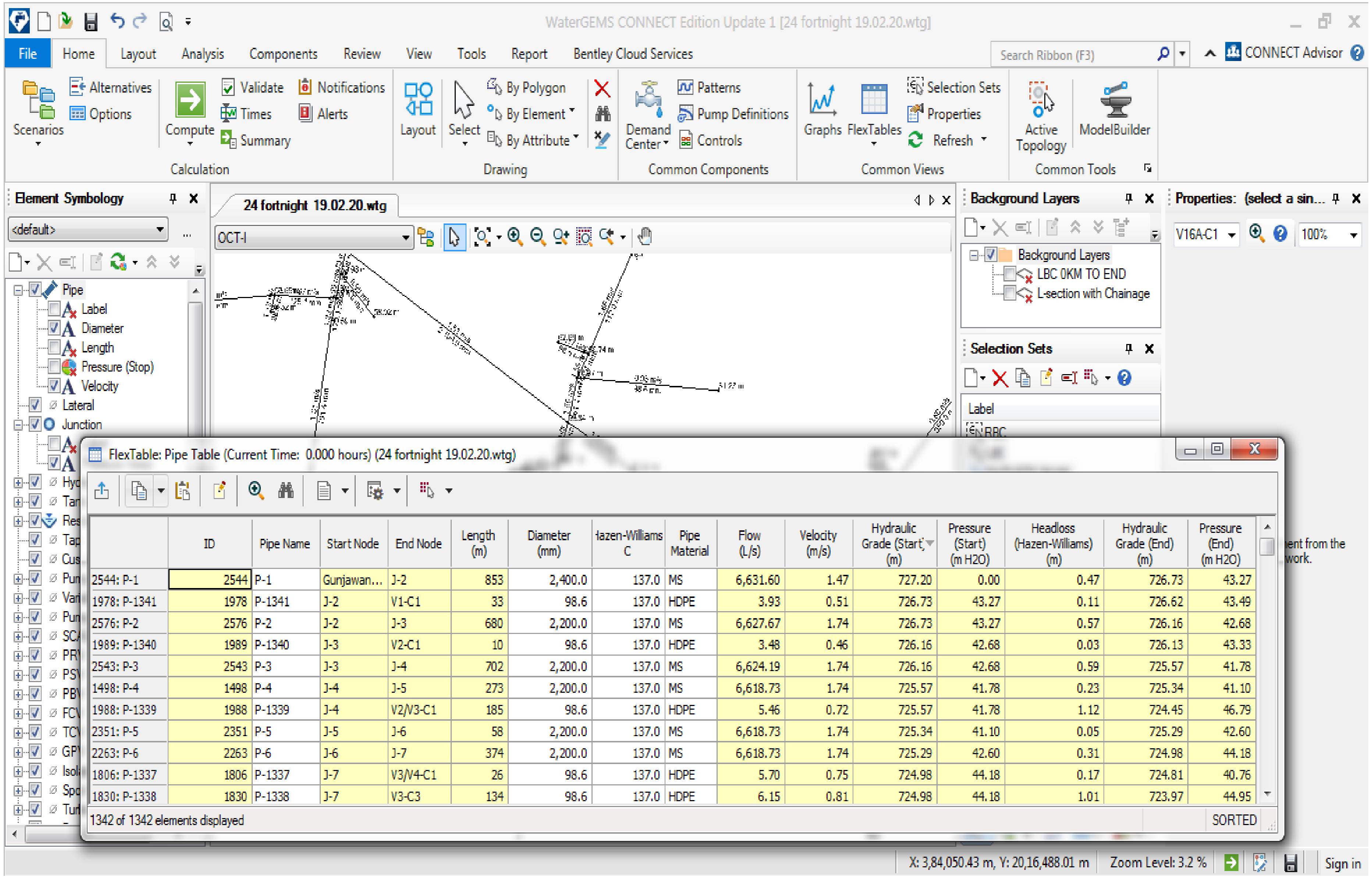
Hydraulics in Bentley WaterGEMS

Analysis

The pipe diameters are assigned using the pipe flex table in the software.

The velocity criteria is considered and the minimum pipe diameters are assigned.

The analysis is re-run and post processing results are taken.

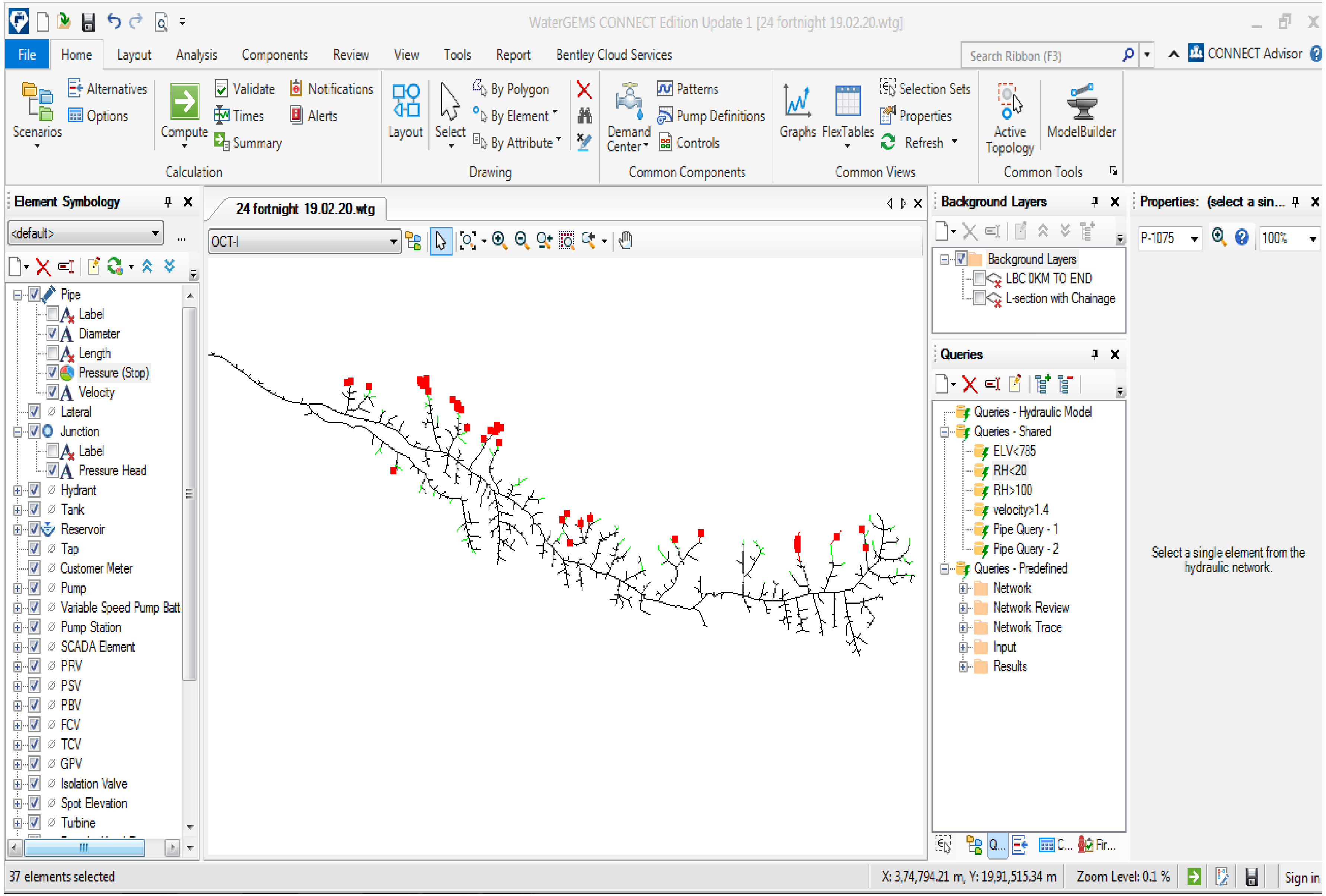


Output After Analysis

All the demand points are checked for the required pressure

Whereever the required pressure is not achieved, the same is highlighted.

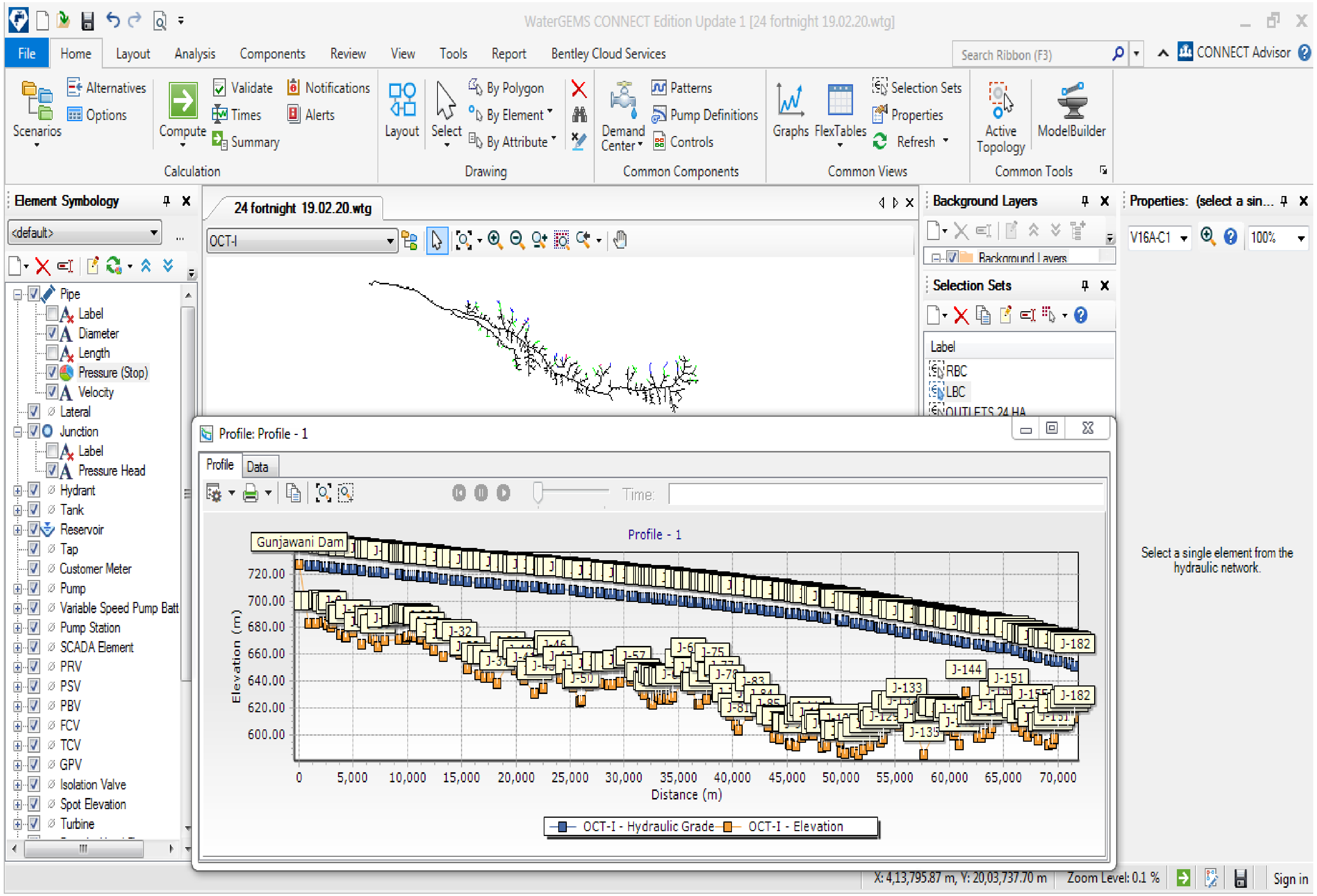
The pipe diameters are increased and required residual pressure is achieved.



Hydraulics in Bentley WaterGEMS

Hydraulic Gradient Line is generated by the software.

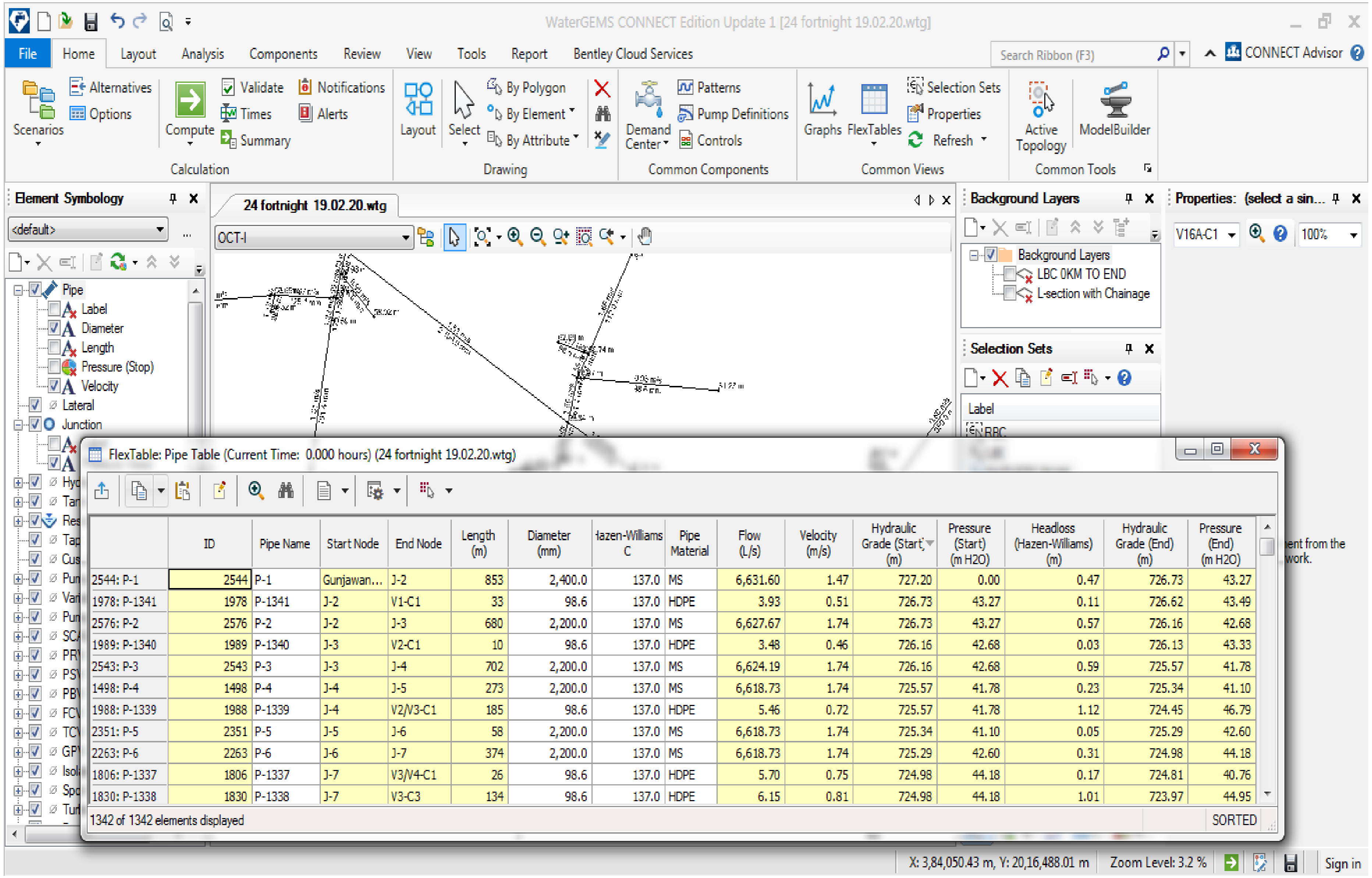
It is checked for the correctness or possibilities of optimization in the system.



Hydraulics in Bentley WaterGEMS

Results

The results are exported from the Pipe Flex table into an excel for further processing.



PIPE THICKNESS SELECTION

The pipe thickness is selected based on the following criteria as per various codal provisions.

- Minimum thk based on hoop stress as per IS 5822
- Minimum thk considering collapse pressure as per AWWA M11
- Minimum thickness for handling as per AWWA M11
- Minimum thk considering buckling pressure as per AWWA M11
- Minimum thk considering deflection as per AWWA M11

INTRODUCTION TO PIPE THICKNESS CALCULATION

$$t = \frac{pd}{2s} \tag{4-1}$$

Where:

t = minimum pipe wall thickness for the specified internal design pressure, in. (mm)

p = internal design pressure, psi (kPa)

d = outside diameter of pipe steel cylinder (not including coatings), in. (mm)

s = allowable design stress, psi (kPa)

PIPE THICKNESS SELECTION

MINIMUM THICKNESS FOR WORK AND TEST PRESSURE CONSIDERATION AS PER IS 5822

MS Pipe Thickness calculation as per IS 5822 & Checking as per AWWA M11 (Size:1100mm)					
A) : Pipe Thickness Calculation as per IS 5822 - 1994					
Minimum Thickness to sustain Internal Pressure	$t = \frac{P\ D}{(2\ a\ f_y\ e\ +\ P)}$				
Selected thickness	t	=	7	mm	
Internal Design Pressure (Max pressure head)	Pd (mwc)	=	125	mwc	
	Pd	=	1.23	N/mm^2	
Internal Diameter	Di	=	1000	mm	
Outer Diameter	Do	=	1014	mm	
Velocity in the pipeline (max. considered)	V	=	1.800	m/s	
Test pressure = 1.5 times of Internal Design pressure or Surge pressure whichever is higher		=	1.84	N/mm^2	

PIPE THICKNESS SELECTION

MINIMUM THICKNESS FOR WORK AND TEST PRESSURE CONSIDERATION AS PER IS 5822 (Continued....)

	Joint effiency (As Per IS 5822 Cl. B 9.2)				
	Shop Weld	e	=	0.9	
	Field Weld	e	=	0.8	
	Design Factor (As per IS: 5822, Cl. B 9.2)				
	For Work Pressure	a	=	0.6	
	For Test Pressure	a	=	0.9	
	Minimum Yield Strength as per IS 2062 E250 Gr Br	Fy	=	250	Mpa
	Minimum Tensile Strength as per IS 2062 E250 Gr Br	Ft	=	410	Mpa
	Permissible Stress				
	For Work Pressure	a*Fy	=	150	N/mm^2
	For Test Pressure	a*Fy	=	225	N/mm^2
	Calculated Thickness				
	For Work Pressure		=	5.15	mm
	For Test Pressure		=	5.15	mm
	Min. Thickness required	tmin	=	5.15	mm
Hence the selected pipe thickness		**t**	**=**	**7**	**mm**

PIPE THICKNESS SELECTION

MINIMUM THICKNESS CONSIDERING COLLAPSE PRESSURE

B).Calculation of Collapse (Negative) Pressure				
Pc = (2×E_S)/(1−[ϑ_s]^2)×(t/D_0)^3+(2×E_C)/(1−[ϑ_c]^2)×(t_L/D_I)^3+(2×E_C)/(1−[ϑ_c]^2)×(t_C/D_C)^3	**(AWWA M11-FIFTH EDITION - Equ- 4-6)**			
Pc = Collapse(Negative) Pressure in psi				
t = Pipe steel thickness =	0.276 In			
t_L = Cement mortar lining thickness in inch =	0 In			
t_C = Cement mortar coating thickness =	1.182 In			
D_0 = Outside Diameter of steel cylinder =	39.922 In			
D_I = inside diameter of steel cylinder (cement-mortar lining outside diameter) =		39.371 In		
D_C = Outside Diameter of cement mortar coating =	42.286 In			
v_s = Poisson's ratio for steel (taken as 0.3) =	0.3			
v_c = Poisson's ratio for cement mortar (taken as 0.25) =	0.25			
E_S = Modulus of elasticity for steel =	30000000 psi			
E_C = Modulus of elasticity for cement mortar =	4000000 psi			
Pc = -208.2 psi = -146.45 mWC =	-14.16437078 atm			
Calculated collapse pressure is more than 1/3 of atmospheric pressure, hence the pipeline is safe				

PIPE THICKNESS SELECTION

MINIMUM THICKNESS REQUIRED FOR HANDLING

C) Calculation of minimum pipe thickness for handling		
	$t\_min = (D)/288$	**(AWWA M11-FIFTH EDITION - Equ- 4-3)**
	t_min= Minimum pipe thickness required	
	D= Pipe Inside Diameter in inch	
t_min =	**0.14 inch (required)**	
t_min =	3.47 mm (required)	
Since the required thickness for handling is less than the selected thickness, hence the pipe is safe		

MINIMUM THICKNESS CONSIDERING BUCKLING PRESSURE

D) Allowable buckling pressure calculation					
E_S	=	Modulus of elasticity for MS pipe	=	30000000	psi
E_C	=	Modulus of elasticity for Guniting Layer	=	4000000	psi
t_S	=	Steel Pipe wall thickness	=	0.275590551	In
t_L	=	Lining Layer wall thickness	=	0	In
t_C	=	Coating Layer wall thickness	=	1.182	In
I_S	=	Moment of Inertia for MS pipe = $t_S^3/12$	=	0.001744262	In^3
I_L	=	Moment of Inertia for Lining Layer = $t_L^3/12$	=	0	In^3
I_C	=	Moment of Inertia for Coating Layer = $t_C^3/12$	=	0.137616714	In^3
EI	=	Pipe wall stiffness = $E_S{*}I_S + E_L{*}I_L + E_C{*}I_C$	=	602794.7166	Lb-In

PIPE THICKNESS SELECTION

MINIMUM THICKNESS CONSIDERING BUCKLING PRESSURE continued….

C_n	=	Scalar calibration factor	=	0.55	
Φ_S	=	factor to account for variability of stiffness of			
		compacted soil	=	0.9	
v_S	=	Poisson's Ratio of Soil	=	0.3	
k_v	=	Modulus correction factor for poisson's ratio, of the soil			
	=	$(1+v_S)*(1-2*v_S)/(1-v_S)$	=	0.742857143	
r	=	mean radius of the pipe = $(D_0-t)/2$	=	19.82283465 In	
H_c	=	Height of ground surface above top of Pipe	=	47.24409449 In	
R_H	=	correction factor for depth of fill			
	=	$11.4/(11+(2*r/H_c))$	=	0.96290561	
E'	=	modulus of soil reaction considering	=	700 psi	
		compaction 85% for soil category SC1 from			
		Table 5-3 of AWWA M11 Edition 2017 Pg. 63			
FS	=	factor of safety	=	2	
r_o	=	Outside radius of steel cylinder	=	19.96062992 In	
q_a	=	Allowable buckling pressure			
	=	$(1.2\times C\_n\times[(EI)]^{\wedge}0.33\times[(\emptyset\_S\times E^{\wedge\prime}\times k\_v)]^{\wedge}0.67\times$		79.14874808 psi	**(AWWA M11-FIFTH EDITION - Equ- 5-7) (Pg. No. 67)**
			'=	55.68484123 mWC	

PIPE THICKNESS SELECTION

MINIMUM THICKNESS CONSIDERING BUCKLING PRESSURE continued….

H_c	=	Height of ground surface above top of Pipe	=	47.24409449	In		
D_o	=	Outer Diameter of pipe with coating	=	39.92125984	In		
H_w	=	Height of water above top of Pipe	=	47.24409449	In		
γ_w	=	Unit weight of water	=	62.4	lb/ft^3		
P_v	=	Internal vacuum pressure (atmospheric					
		pressure less absolute pressure inside pipe) =		0.3	atm	=	4.4087964 psi
R_w	=	Water buoyancy factor = $1-0.33*(H_w/H_c)$	=	0.67	for $0 \leq H_w \leq H_c$		
W_L	=	Live load considering Highway load for 3 ft	=	600	lb/ft^2		
		soil cover above pipe top from Table No. 5-1					
		Pg. 59 of AWWA M11- Fifth edition 2017					
w	=	unit weight of fill	=	2000	Kg/m^3	=	124.854628 lb/ft^3
D_C	=	Outside diameter of coated pipe	=	39.922	In		
H_c	=	Height of ground surface above top of Pipe	=	3.937007874	ft		
W_C	=	prism load = dead load on the conduit	=				
	=	$W\_C=(w \times H\_C \times D\_C)$	=	1635.31708	lb/lin ft of pipe	**(AWWA M11-FIFTH EDITION - Equ- 5-3) (Pg. No. 58)**	

PIPE THICKNESS SELECTION

MINIMUM THICKNESS CONSIDERING BUCKLING PRESSURE continued....

Load Combination - 1 : Buckling Pressure due to Earth Pressure +			
Vacuum Pressure + External Water Pressure =			
=	$\gamma_w/1728\times H_w+R_w\times W_C/(12\times D_0)+P_v$	8.401965465 psi	(AWWA M11-FIFTH EDITION - Equ- 5-8] No. 67)

since buckling pressure due to load combination-1 is less than/equal to allowable buckling pressure so pipe thickness is OK.

Load Combination - 2 : Earth pressure + Pressure due to Live load +			
External Water Pressure =			
	$\gamma_w/1728\times H_w+R_w\times W_C/(12\times D_0)+W_L/(144\times D$	4.097541189 psi	(AWWA M11-FIFTH EDITION - Equ- 5-9] No. 67)

since buckling pressure due to load combination-2 is less than/equal to allowable buckling pressure so pipe thickness is OK.

MINIMUM THICKNESS CONSIDERING DEFLECTION

E) Pipe Deflection Calculation

Δx	=	predicted horizontal deflection of pipe	=			
D_l	=	Deflection lag factor	=	1		
K	=	Bedding constant	=	0.1		
D_c	=	Outside diameter of coated pipe	=	39.922	In	
W_c	=	prism load = dead load on the conduit	=	1635.31708	lb/lin ft of pipe	
W_L	=	Live load per linear foot of coated pipe	=	600	lb/ft^2	
W	=	load per unit of pipe length	=W_c/12+(W_L =	302.61809	Lb/lin In	**(AWWA M11-FIFTH EDITION - Equ- 5-4) No. 62)**

PIPE THICKNESS SELECTION

MINIMUM THICKNESS CONSIDERING DEFLECTION

t	=	Pipe cylinder wall thickness	=	0.275590551 In	
t_L	=	Lining Layer wall thickness	=	0 In	
t_C	=	Coating Layer wall thickness	=	1.182 In	
r	=	mean radius of the pipe = $(D_C-t-t_L-t_C)/2$	=	19.23220472 In	
E'	=	modulus of soil reaction considering	=	700 psi	
EI	=	Pipe wall stiffness = $E_S*I_S + E_L*I_L + E_C*I_C$	=	602794.7166 Lb-In	
Δx	=	D_l×(K×W×r^3)/(E×I+0.061	=	0.237461537 In	(AWWA M11-FIFTH EDITION - Equ- 5-4) (Pg No. 61)
			=	6.1 mm	
Δx %	=	$(\Delta x/D_C)*100$	=	0.59 %	
Δx allowable %	=	Allowable Deflection as per AWWA M11	=	2 %	(AWWA M11-FIFTH EDITION) (Pg. No. 62)
			=	0.799 In	
			=	20 mm	

since actual deflection of the coated pipe is less than allowable deflection so pipe thickness is OK.

HENCE SELECTED THICKNESS IS OK

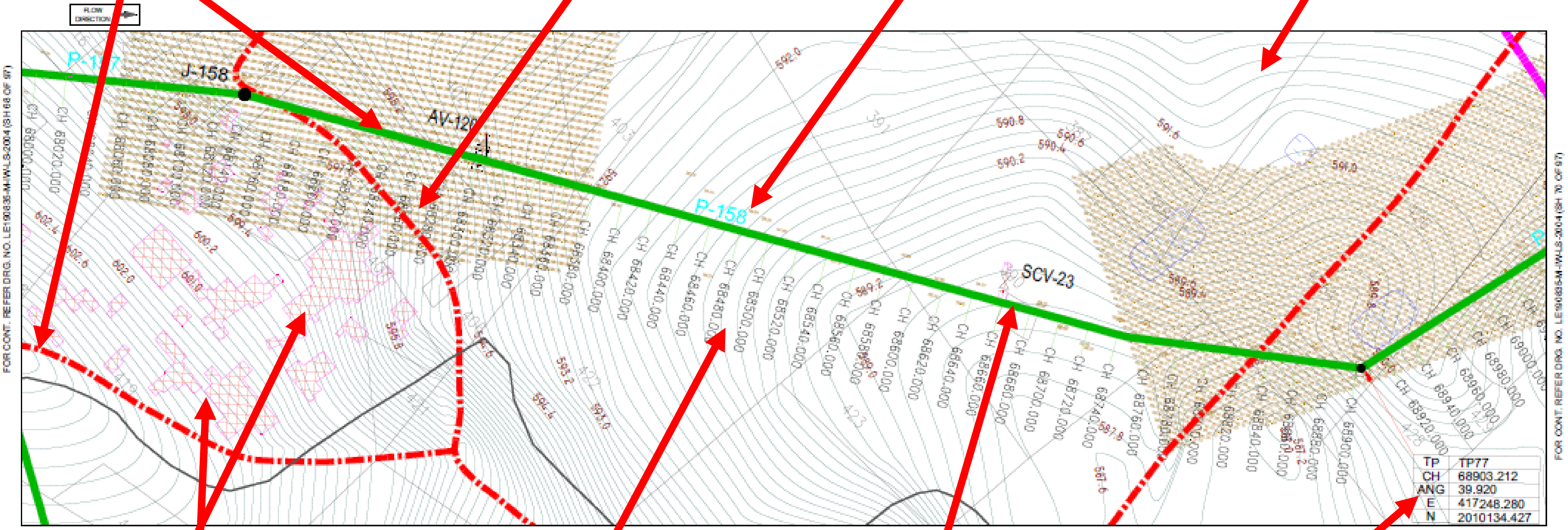
TYPICAL ALIGNMENT PLAN

Road Crossing

Air Valve Location

Pipe Alignment

Elevation Contour



Settlements

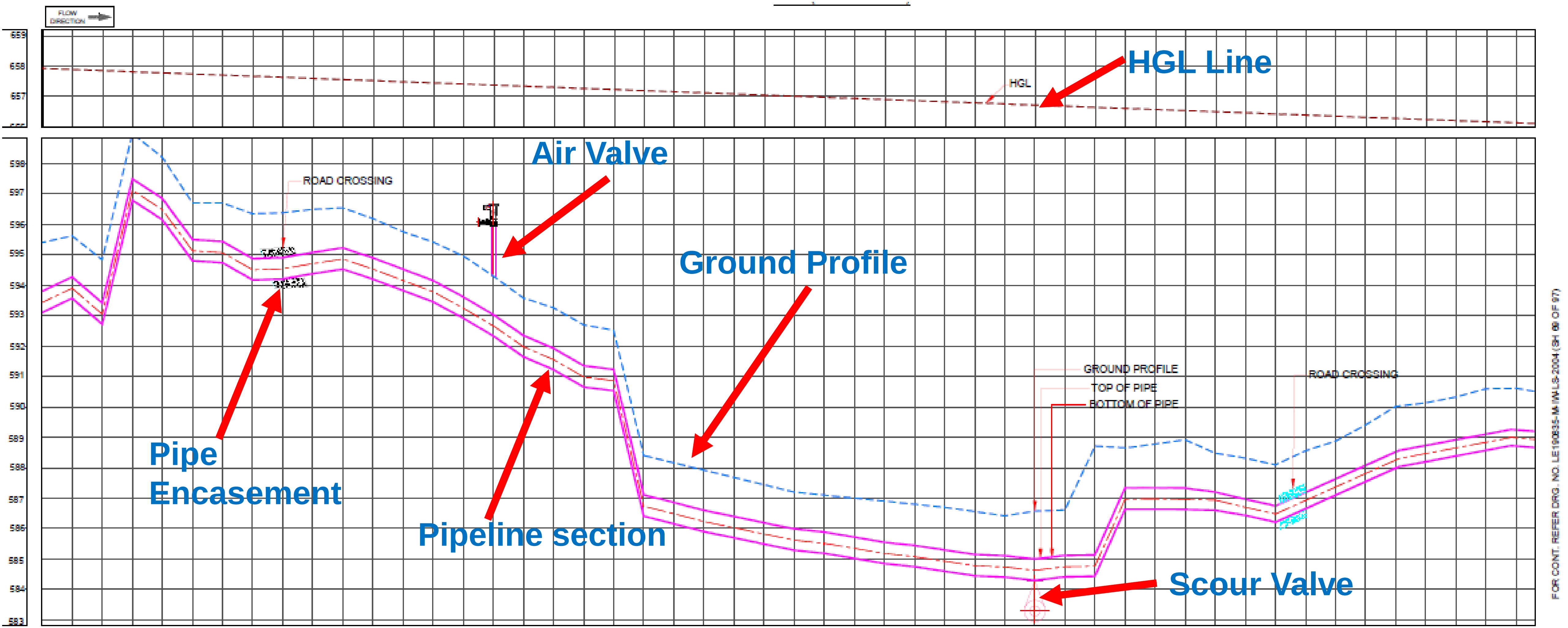
Chainages

Scour Valve Location

Turning Point Details

LONGITUDINAL SECTION

A vertical sectional drawing is usually scaled for better readability. The below section is scaled 100 time vertically and 2000 times horizontally.



LONGITUDINAL SECTION

CHAINAGE (M)	68000.00	68020.00	68040.00	68060.00	68080.00	68100.00	68120.00	68139.00 68140.00	68160.00	68180.00
GROUND (M)	595.200	595.618	594.834	598.985	598.200	596.700	596.783	596.380 596.345	596.379	596.492
PIPE TOP (M)	593.808	594.268	593.414	597.494	596.849	595.500	595.438	594.907 594.872	594.905	595.077
PIPE BOTTOM (M)	593.276	593.736	592.882	596.962	596.317	594.968	594.906	594.375 594.340	594.373	594.545
HGL (M)	657.927	657.890	657.853	657.817	657.780	657.743	657.710	657.700 657.670	657.633	657.597
WORKING PRESSURE (M)	64.119	63.622	64.439	60.323	60.931	62.243	62.272	63.325 62.798	62.728	62.520
COVER DEPTH	1.392	1.350	1.420	1.491	1.351	1.200	1.345	1.473 1.473	1.474	1.415
TURNING POINT & VALVE DETAILS								J-158		
DISCHARGE (LPS)							204.48		204.48	

CHAINAGE (M)	68200.00	68220.00	68240.00	68260.00	68280.00	68300.00	68320.00	68340.00	68360.00	68380.00
GROUND (M)	596.538	596.186	595.756	595.417	594.960	594.300	593.578	593.257	592.695	592.519
PIPE TOP (M)	595.227	594.896	594.524	594.151	593.615	593.031	592.347	591.923	591.354	591.229
PIPE BOTTOM (M)	594.695	594.364	593.992	593.619	593.083	592.499	591.815	591.391	590.822	590.697
HGL (M)	657.561	657.524	657.488	657.451	657.415	657.378	657.342	657.305	657.269	657.232
WORKING PRESSURE (M)	62.334	62.628	62.964	63.300	63.800	64.347	64.995	65.382	65.915	66.003
COVER DEPTH	1.311	1.290	1.232	1.266	1.345	1.269	1.231	1.334	1.341	1.290
TURNING POINT & VALVE DETAILS						AV-120				

CHAINAGE (M)	68400.00	68420.00	68440.00	68460.00	68480.00	68500.00	68520.00	68540.00	68560.00
GROUND (M)	588.400	588.160	587.920	587.680	587.440	587.200	587.090	586.980	586.870
PIPE TOP (M)	587.106	586.858	586.601	586.397	586.193	585.989	585.887	585.719	585.520
PIPE BOTTOM (M)	586.574	586.326	586.069	585.865	585.661	585.457	585.355	585.187	584.988
HGL (M)	657.196	657.160	657.123	657.087	657.050	657.014	656.977	656.941	656.904
WORKING PRESSURE (M)	70.090	70.302	70.522	70.690	70.857	71.025	71.090	71.222	71.384
COVER DEPTH	1.294	1.302	1.319	1.283	1.247	1.211	1.203	1.261	1.350

PIPE SPECIFICATION: DI PIPE DIA 500 & K9 CLASS

A vertical sectional drawing is usually scaled for better readability.

The below section is scaled 100 time vertically and 2000 times horizontally.

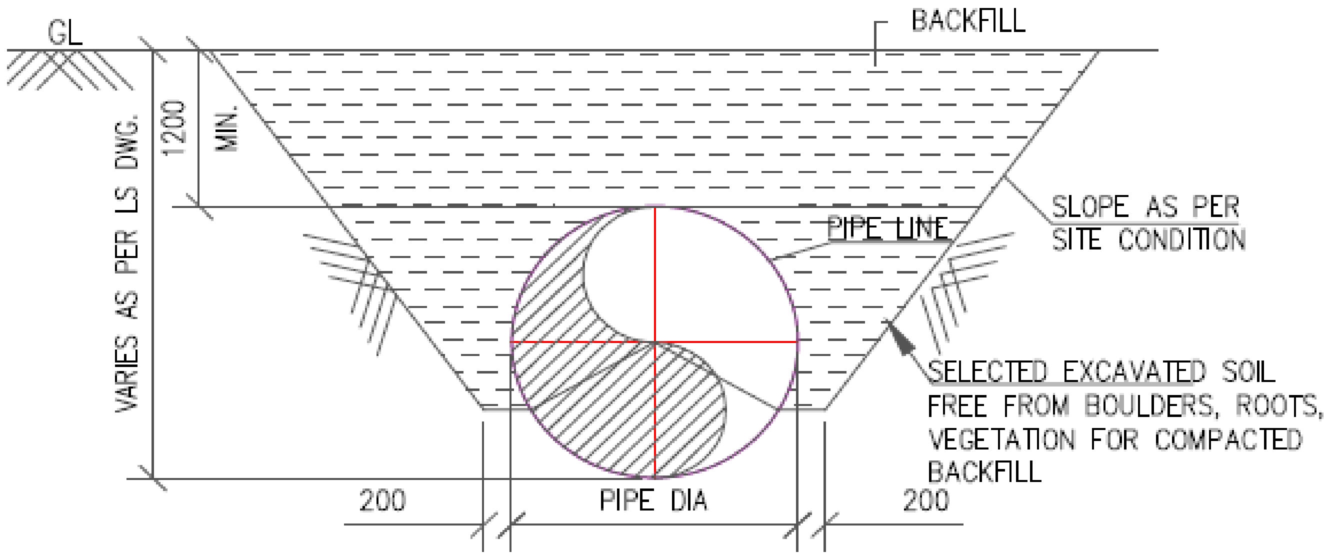
PIPE CROSS-SECTIONAL DRAWING

Typical Cross-Sectional drawing

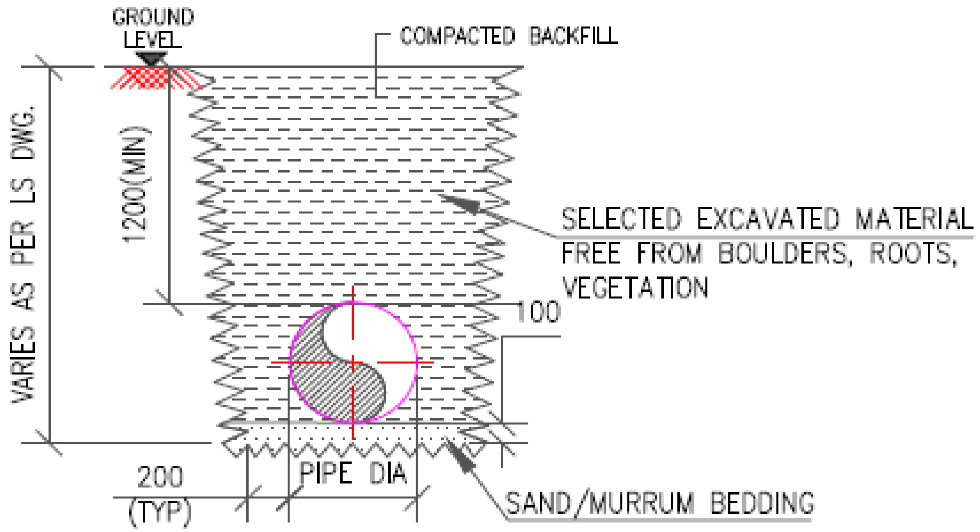
The slopes are maintained as per site conditions

Trenches are backfilled using the excavated soil.

Trenches in rocky terrain are much more steeper than in normal soil conditions



TYPICAL CROSS SECTION OF TRENCH IN SOIL TERRAIN



TYPICAL CROSS SECTION OF TRENCH IN ROCKY TERRAIN

LONGITUDINAL SECTION DRAWING

A typical Longitudinal-Section drawing will contain all the below details

In addition, it contains following details as well.

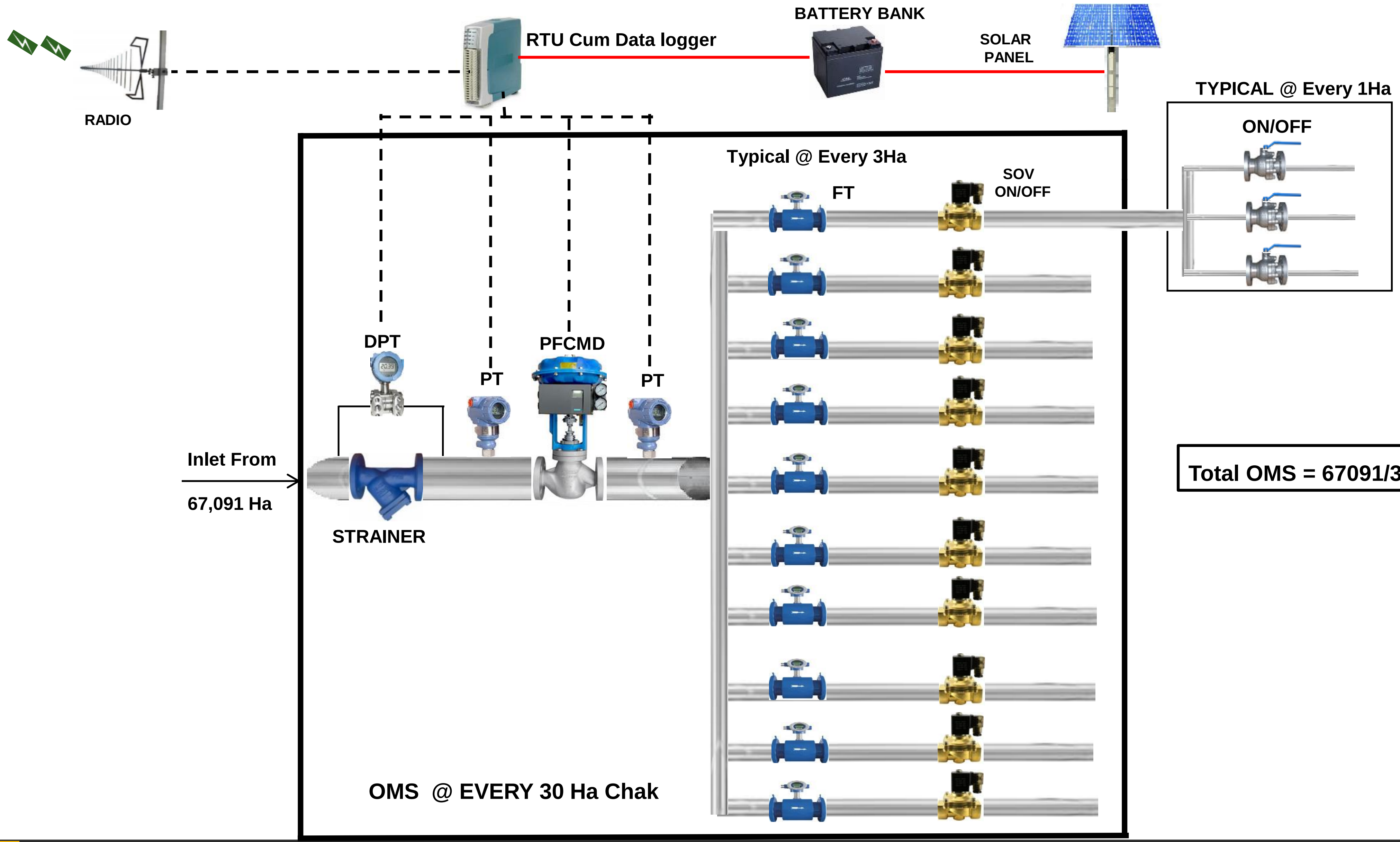
- **Running chainage**
- **Pipe dia**
- **Cover depth**
- **Ground level**
- **MOC of Pipe**
- **Pipe Dia**
- **Coordinates of turning points**
- **Crossings details**
- **Valve details (Air, Scour and butterfly valves**

SR. NO.	DESCRIPTION	SYMBOL	SR. NO.	DESCRIPTION	SYMBOL
1	H.G.L		14	VILLAGE AREA	
2	R.L. OF PIPE		15	SURVEY BOUNDARY	
3	GROUND LEVEL		16	SURVEY NUMBER	42
4	ROAD		17	BORE WELL / WELL	
5	CART TRACK/FOOT PATH		18	MS – PIPE	
6	THRUST/ANCHOR BLOCK		19	DI – PIPE	
7	BUTTERFLY VALVE		20	HDPE – PIPE	
8	AIR VALVE		21	DISNET NOMENCLATURE	BR1
9	SCOUR VALVE		22	IRRIGATION WATER OUTLET	
10	NATURAL DRAIN/STREAMS		23	TEMPLE	
11	VILLAGE BOUNDARY		24	OUTLET NUMBER	V2–C2
12	TANK / POND		25	JUNCTION NUMBER	J12
13	HT LINE	----			

AUTOMATION IN PIPELINE DISTRIBUTION

- Avoid the Draining of the Network
- Uniform Distribution of Water to the Chak
- Isolation of System from Remote as and when required
- Record, Monitor and Control of the flow Delivered to the Chak as per water demand
- No Need of External Electric Energy
- Wireless Communication
- Protective Enclosure capable of giving Vandalism Alert

OUTLET MANAGEMENT SYSTEM



Total OMS = 67091/30 ➔ 2237 Sets

SURGES IN PIPELINE

A Simple formula for Surge

(Recommended by CPHEEO)

$$\Delta H = \frac{a\,V}{g}$$

a = pressure wave velocity

V = Flow Velocity

ΔH = Surge Pressure

g = Acceleration due to gravity

Pressure increase is up surge & pressure decrease is down surge

The equation focuses only on UPSURGE (& not on down surge)

SURGE ANALYSIS PROGRAM - SAP

Waterhammer or surge or hydraulic transients is a phenomenon occurring in closed conduit or pipe flows, associated with rapid changes in discharge in the pipe.

CASES CONSIDERED

- Surge Phenomenon Following Single Pump Failure
- Surge Phenomenon Following Multiple Pump Failure
- Surge Phenomenon Following Power Failure

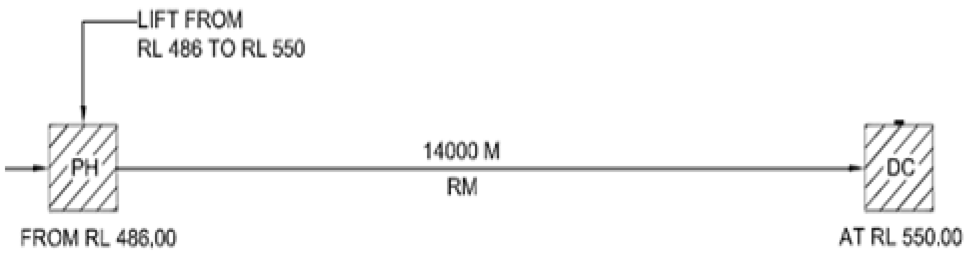
Commonly used softwares

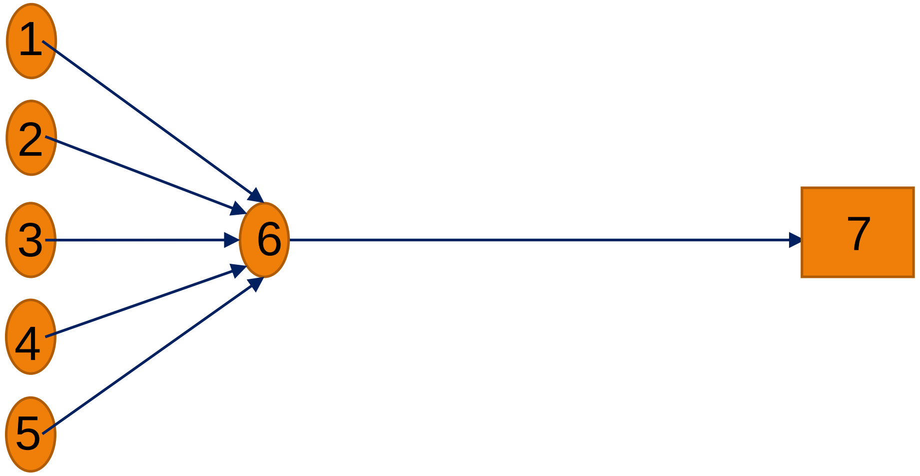
SAP – developed by IISc

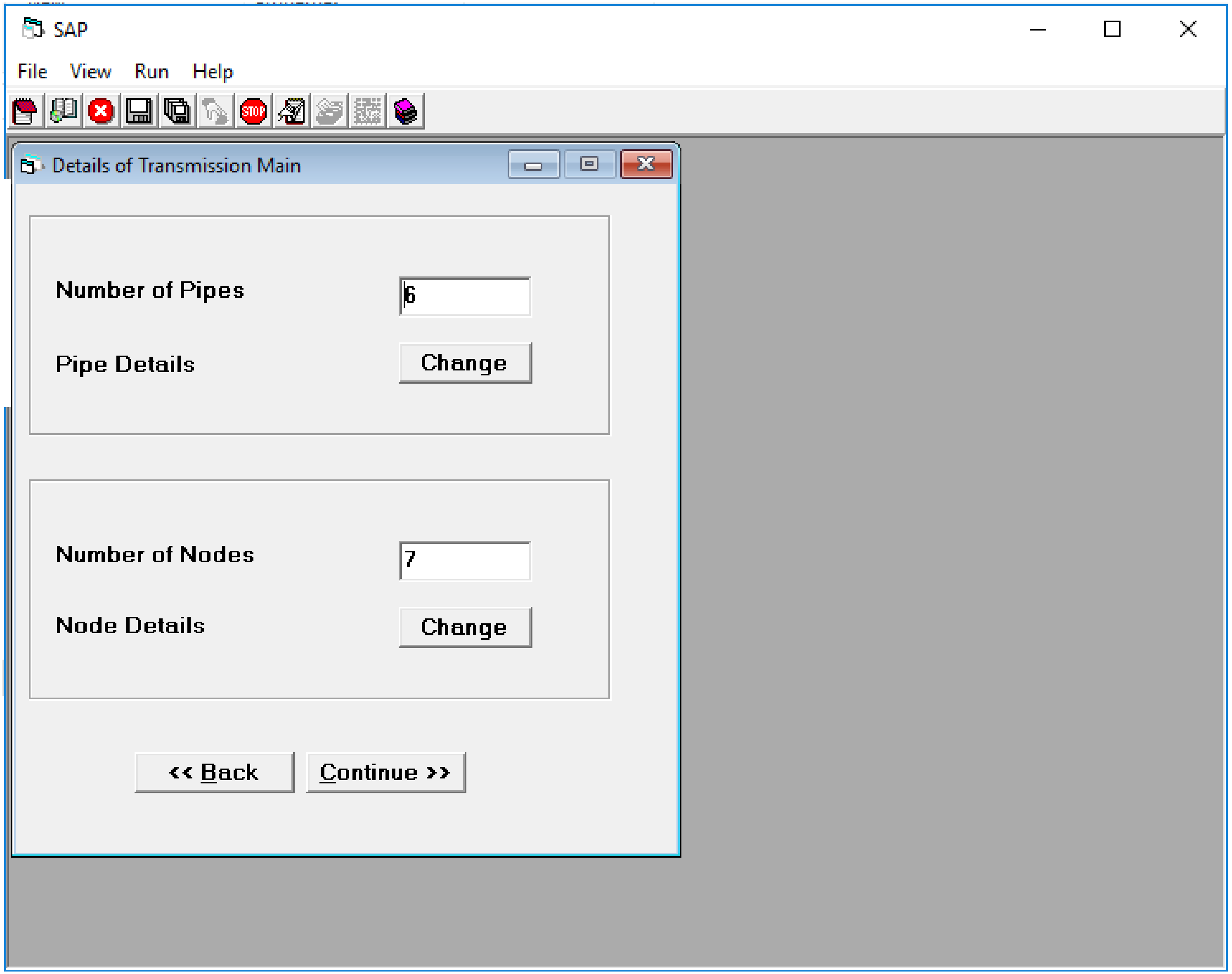
Water Hammer – Bentley

SURGE ANALYSIS PROGRAM - SAP

The pipeline system is modelled as a line diagram and fed as input to the software

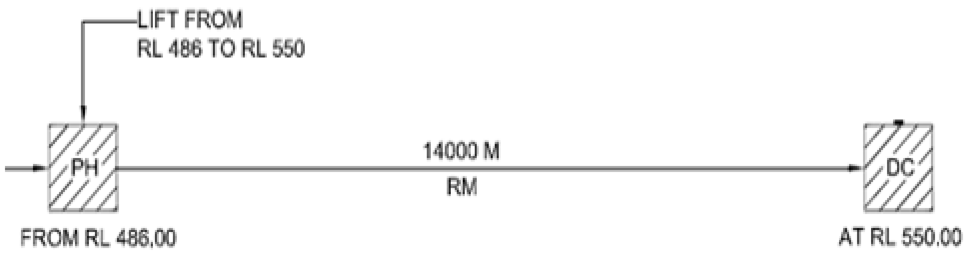


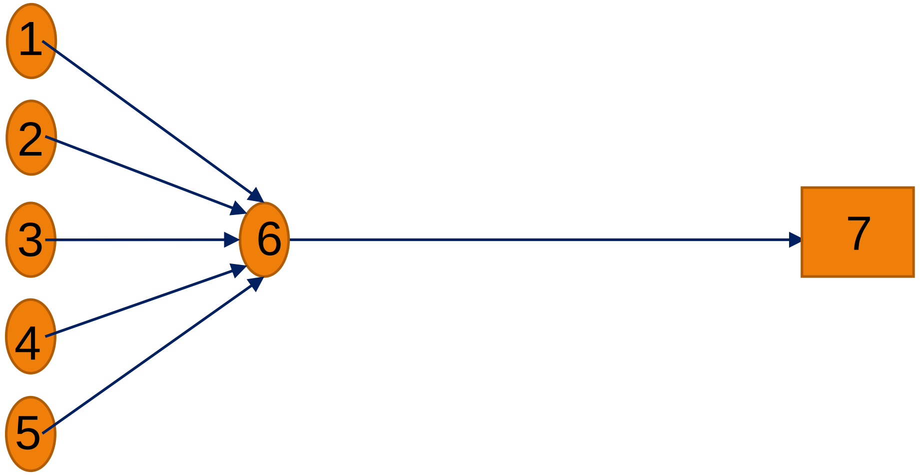


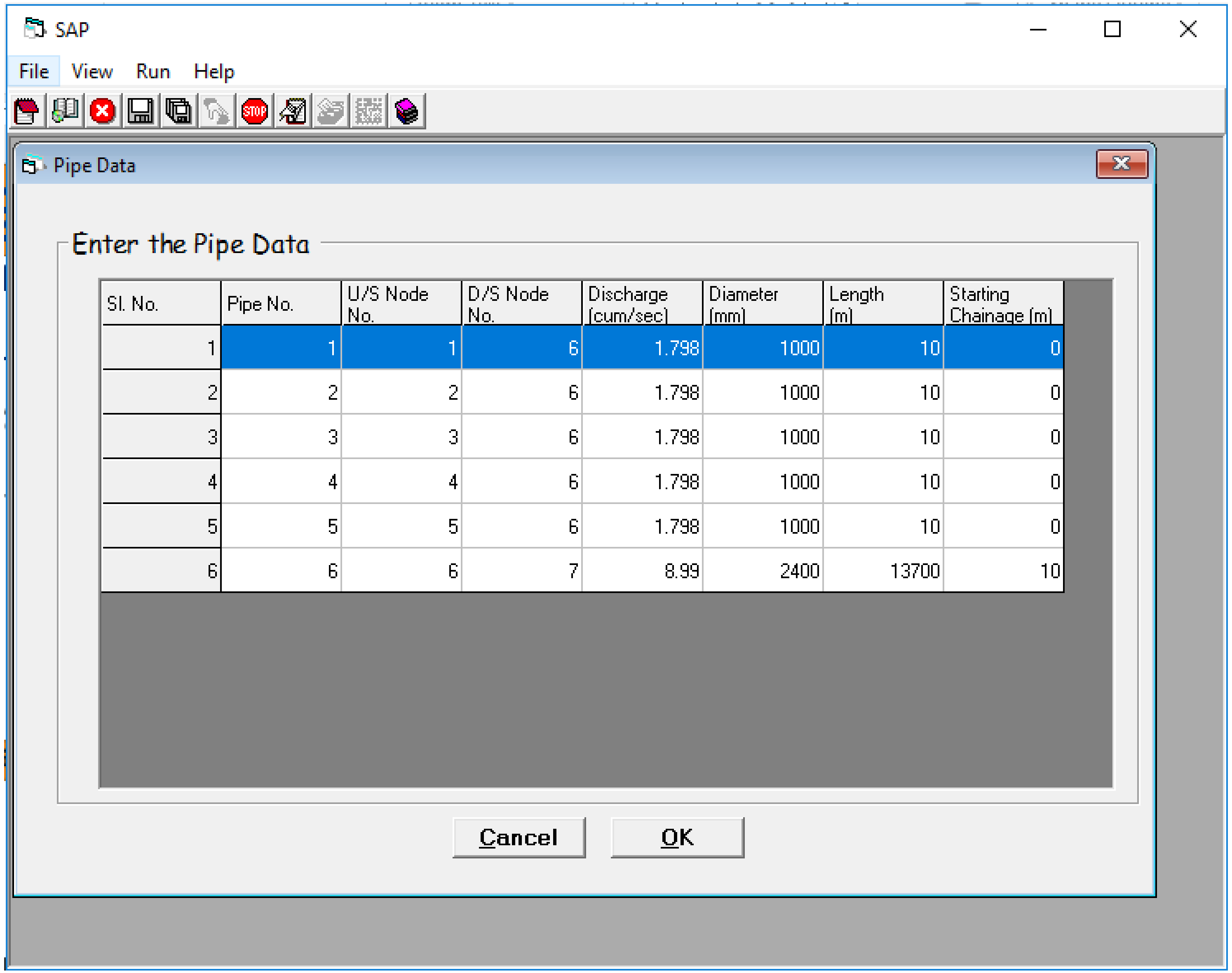


SURGE ANALYSIS PROGRAM - SAP

All pipe and junction details are provided as inputs



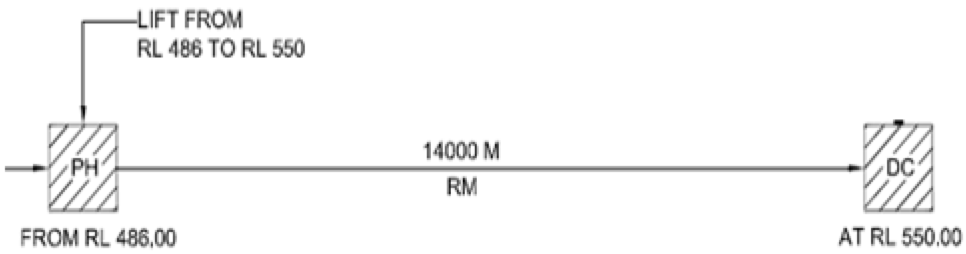


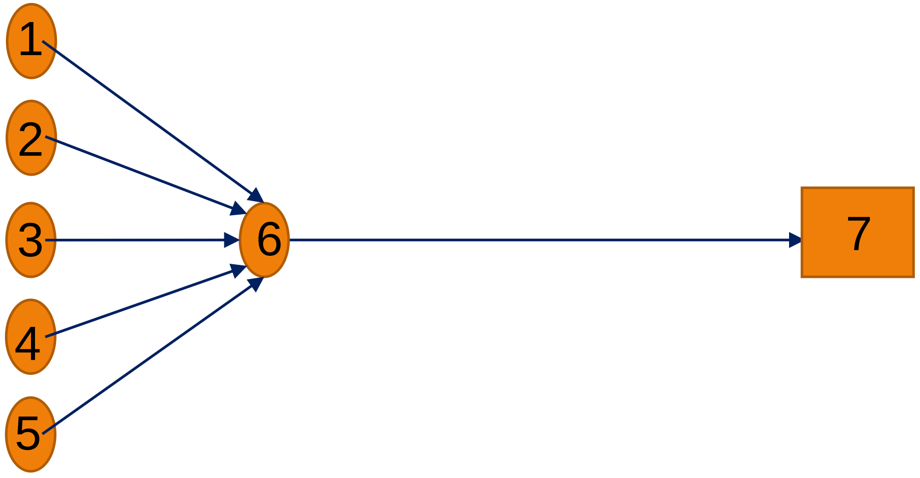


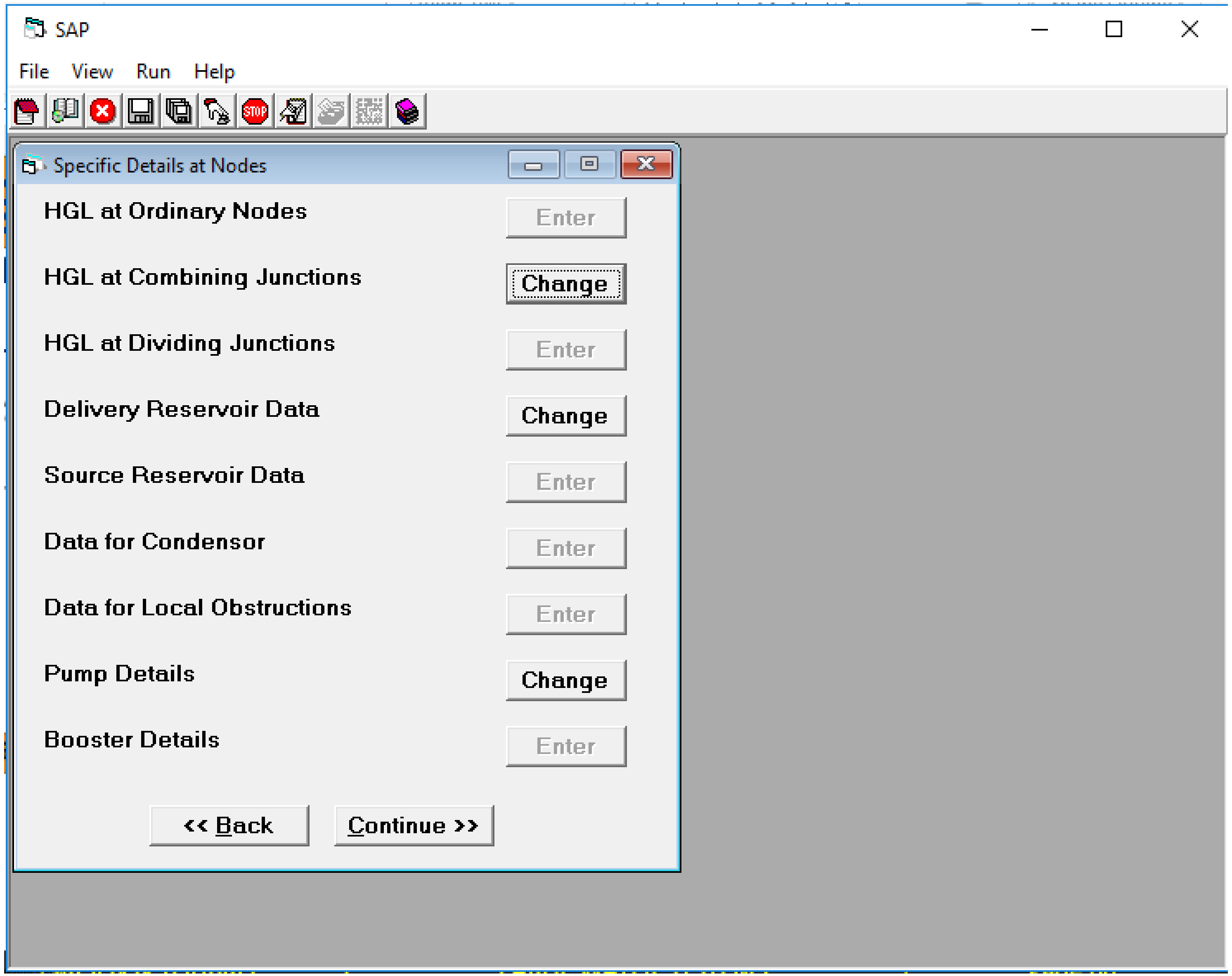
Sl. No.	Pipe No.	U/S Node No.	D/S Node No.	Discharge (cum/sec)	Diameter (mm)	Length (m)	Starting Chainage (m)
1	1	1	6	1.798	1000	10	0
2	2	2	6	1.798	1000	10	0
3	3	3	6	1.798	1000	10	0
4	4	4	6	1.798	1000	10	0
5	5	5	6	1.798	1000	10	0
6	6	6	7	8.99	2400	13700	10

SURGE ANALYSIS PROGRAM - SAP

The HGL at all junctions and delivery reservoir is provided



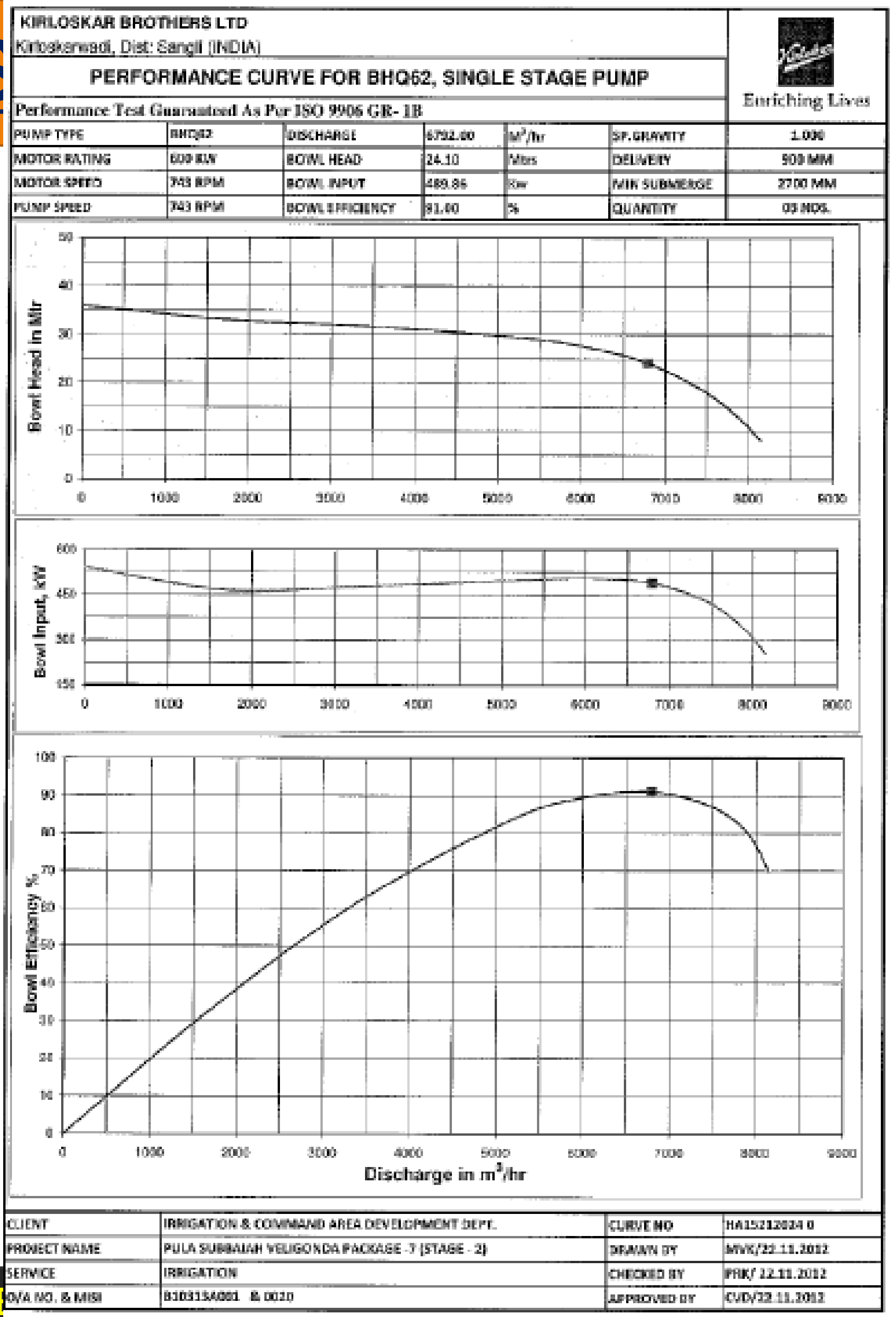




SURGE ANALYSIS PROGRAM - S

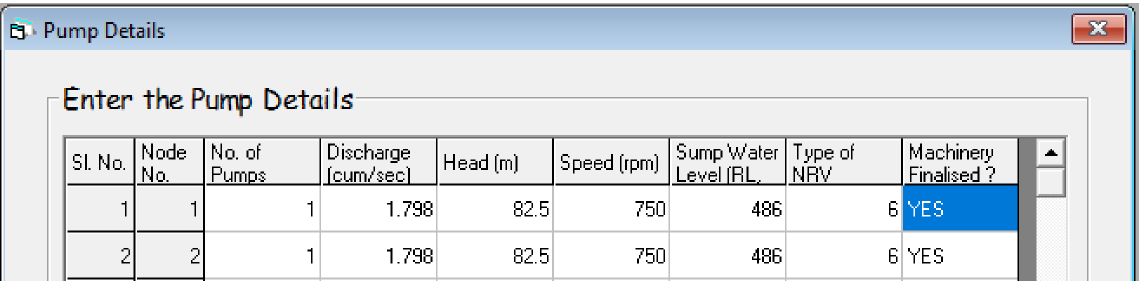
All details required for analysis is obtained from the performance curve.

Details regarding GD2 values of motor and pump is obtained from the Pump Datasheet & GA provided by the pump vendor.

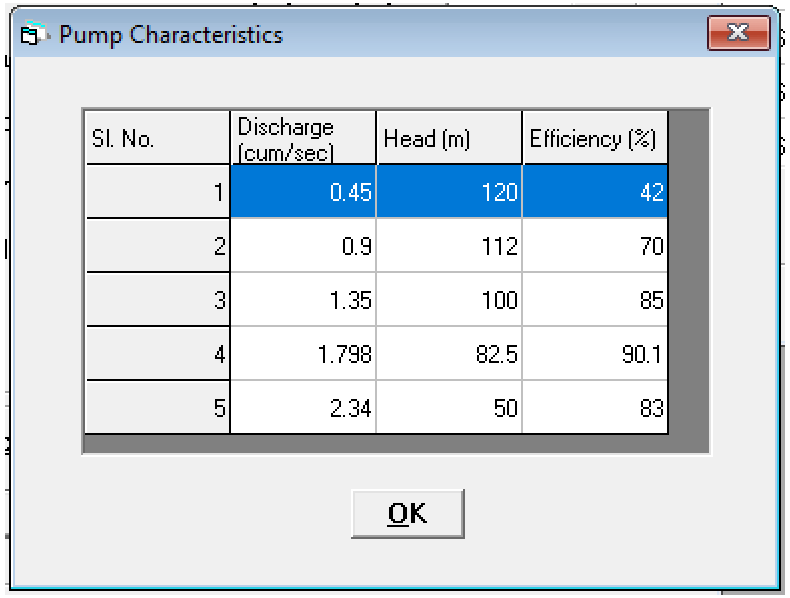


SURGE ANALYSIS PROGRAM - SAP

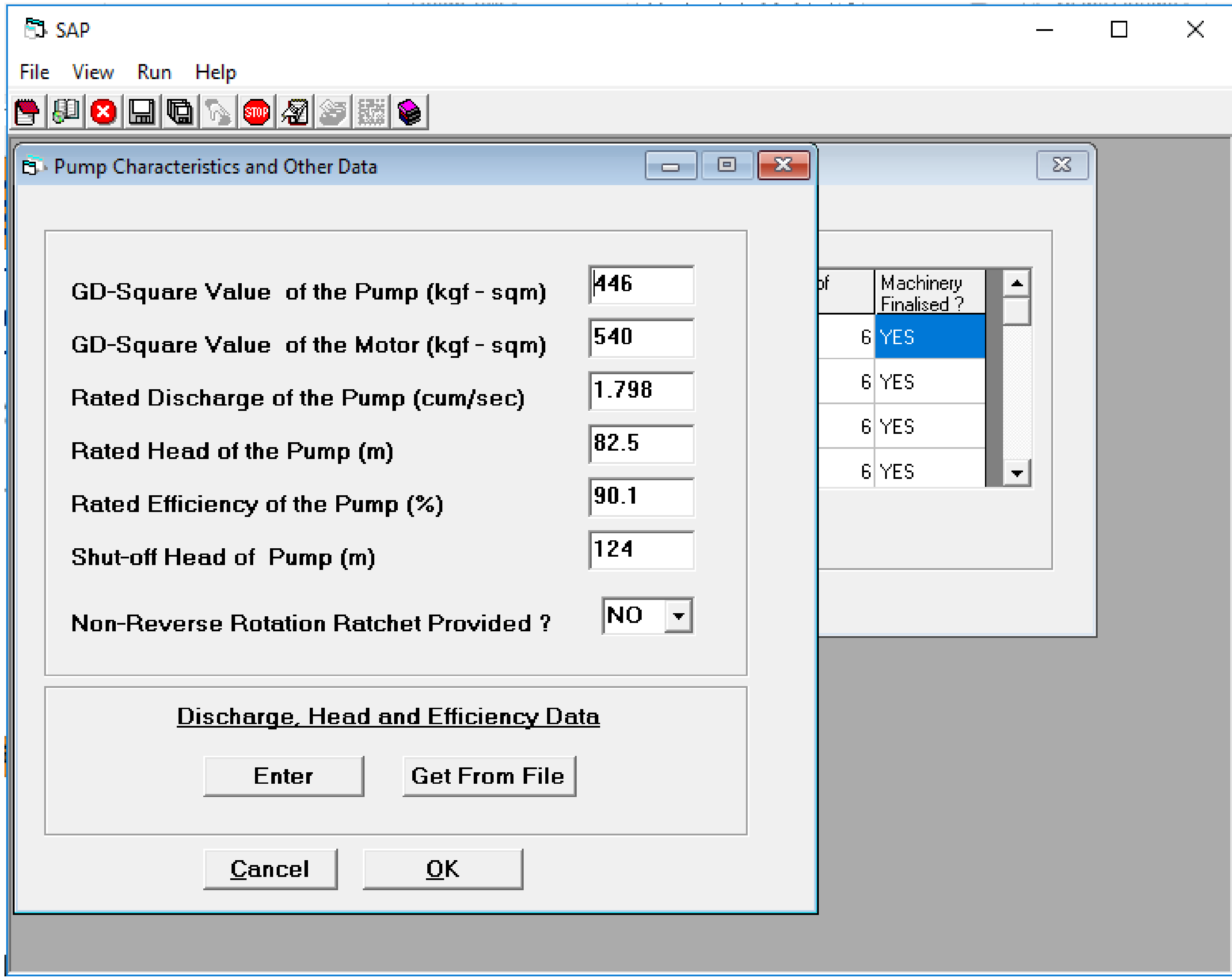
Pump details are obtained from the pump vendor and provided as input to the software.



Sl. No.	Node No.	No. of Pumps	Discharge (cum/sec)	Head (m)	Speed (rpm)	Sump Water Level (RL	Type of NRV	Machinery Finalised ?
1	1	1	1.798	82.5	750	486	6	YES
2	2	1	1.798	82.5	750	486	6	YES



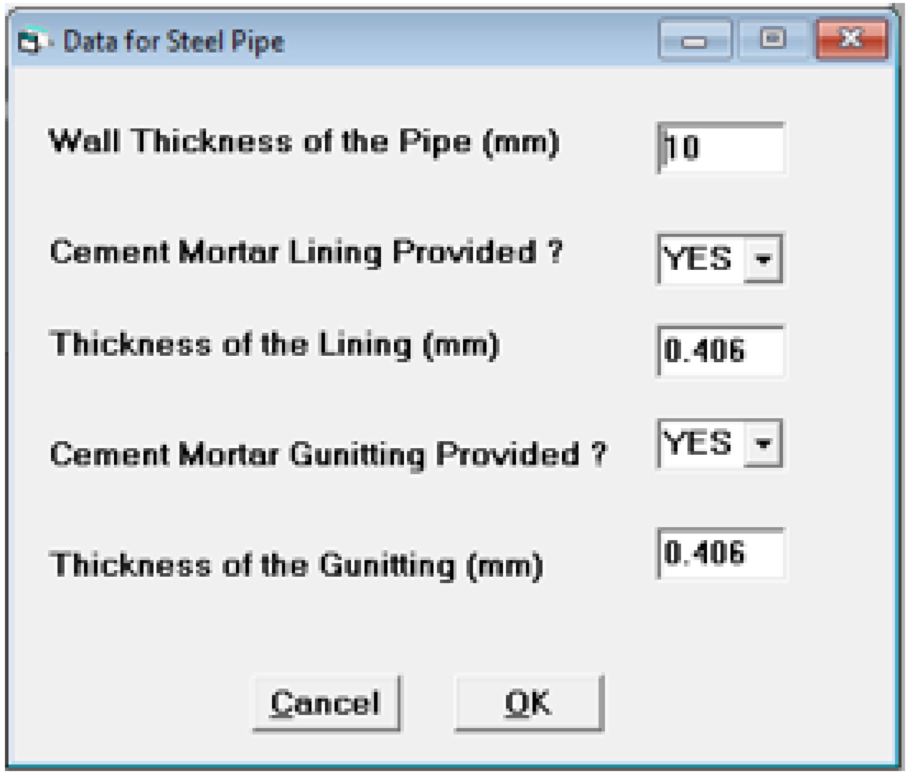
Sl. No.	Discharge (cum/sec)	Head (m)	Efficiency (%)
1	0.45	120	42
2	0.9	112	70
3	1.35	100	85
4	1.798	82.5	90.1
5	2.34	50	83

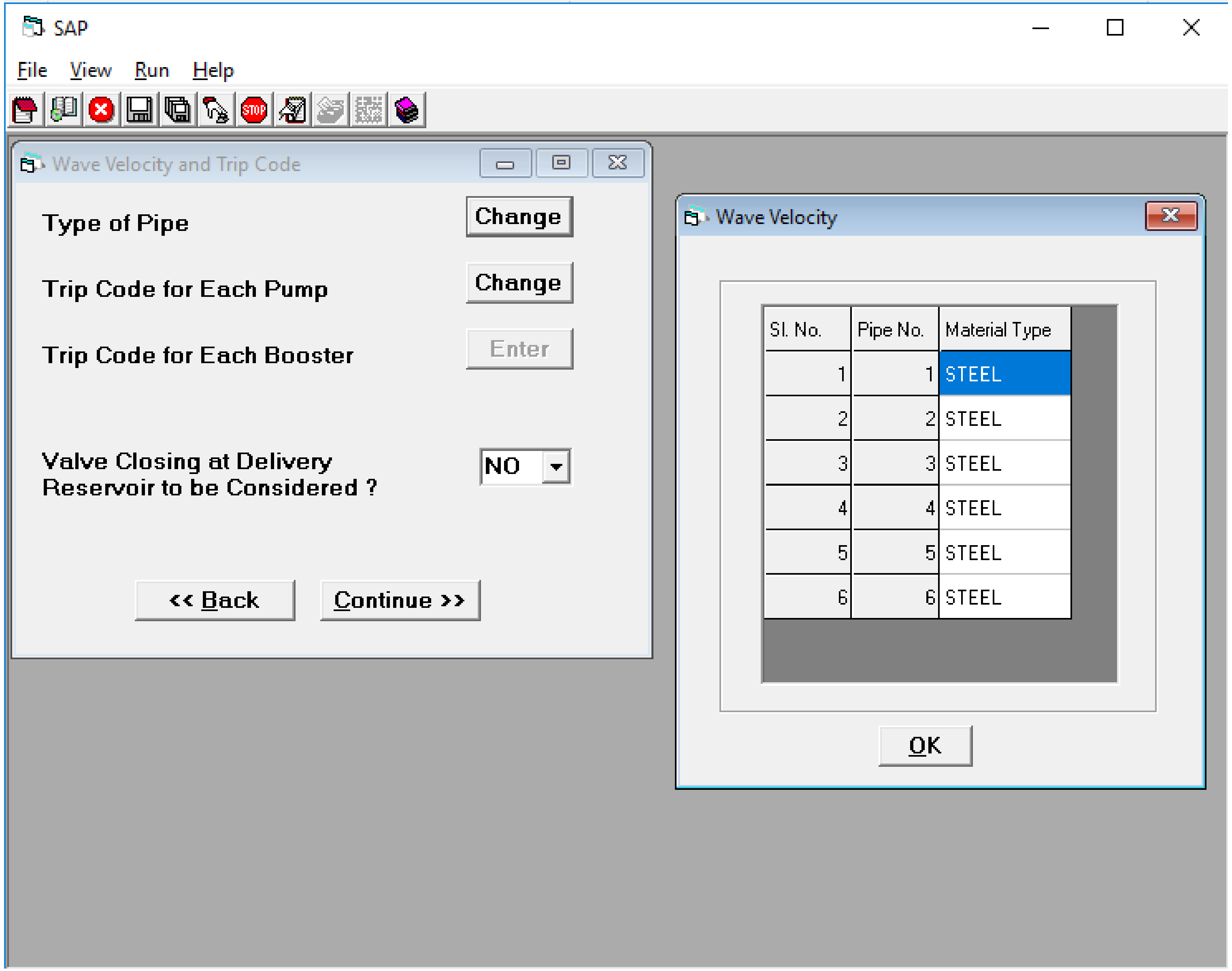


SURGE ANALYSIS PROGRAM - SAP

Pipe details such as MOC of pipe and thickness of lining and coating is provided as input.

Trip code (Running/Failure) for each pump is also assigned.





SURGE ANALYSIS PROGRAM - SAP

Pump working condition

The HGL graph is generated for the pump working condition to check for the correctness of inputs

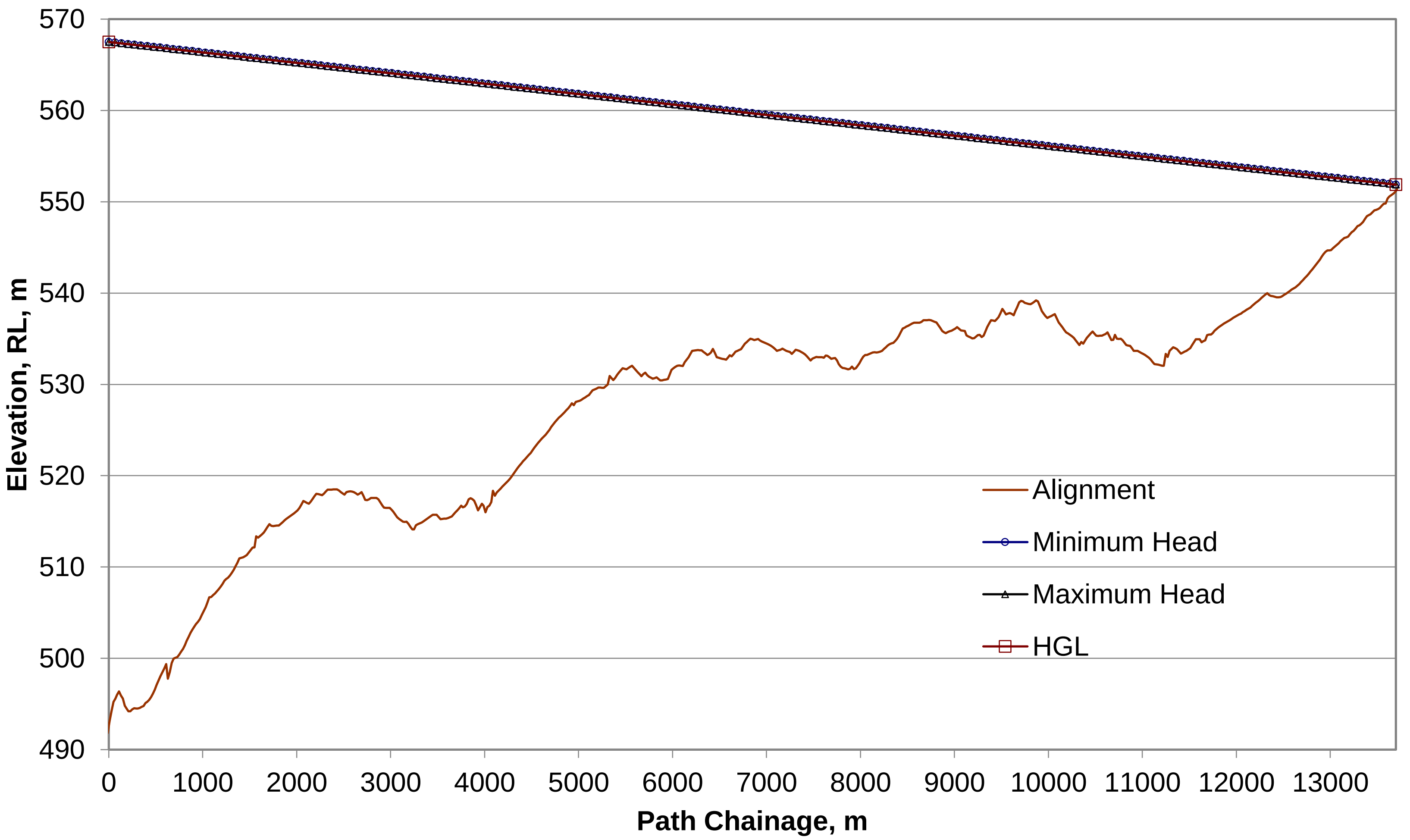


Fig.:Minimum and Maximum Piezometric Heads

SURGE ANALYSIS PROGRAM - SAP

Single Pump Failure

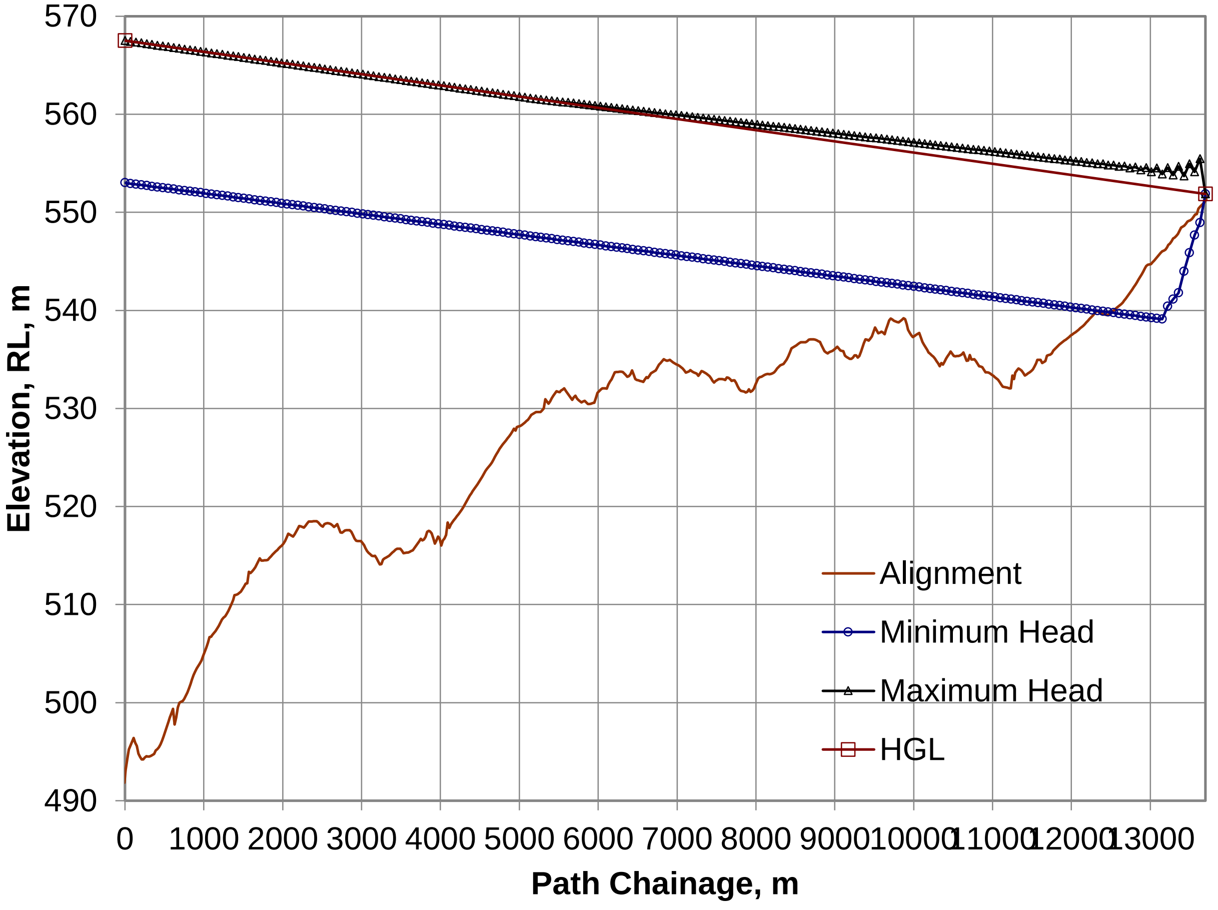


Fig.:Minimum and Maximum Piezometric Heads

Two Pump Failure

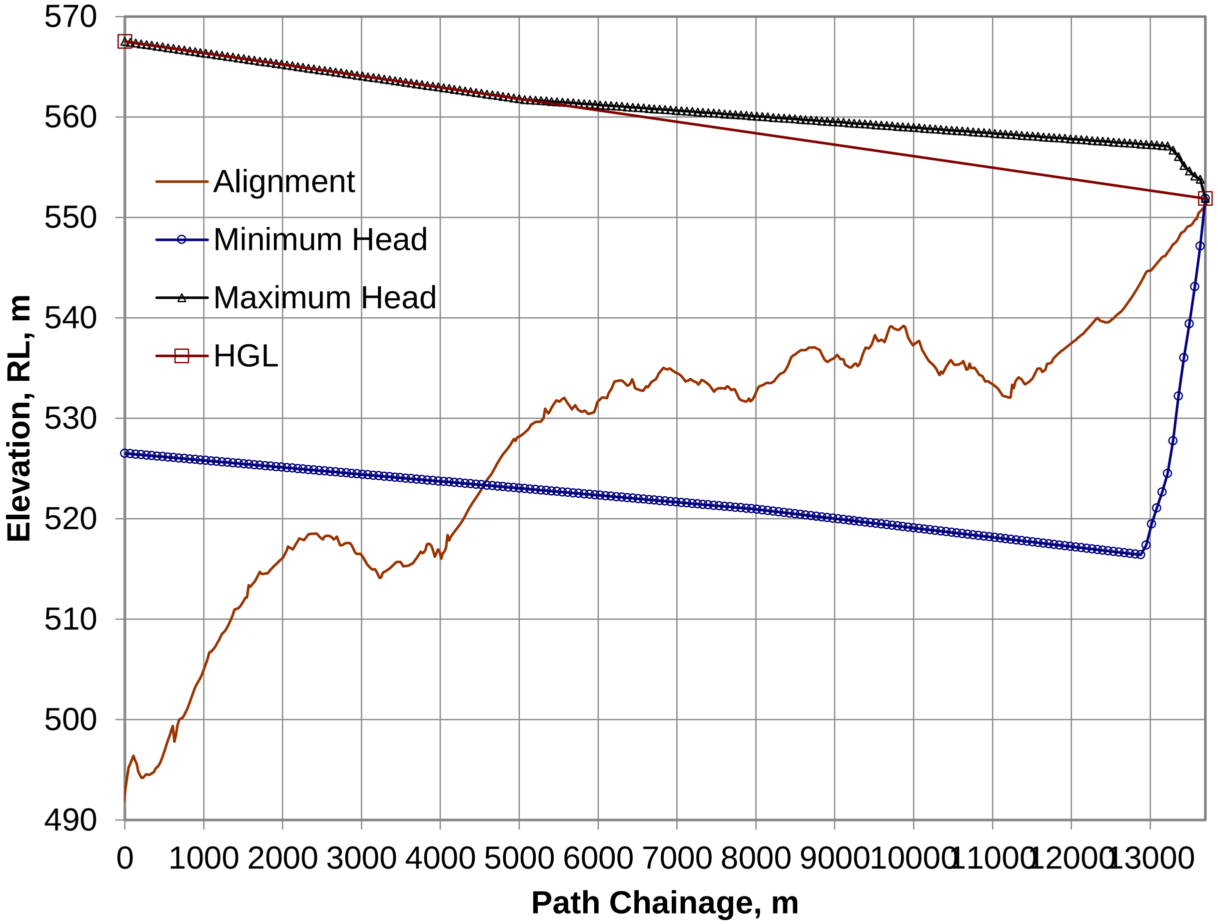


Fig.:Minimum and Maximum Piezometric Heads

SURGE ANALYSIS PROGRAM - SAP

Power Failure

Worst Case scenario is when all pumps fail at a time during the power failure condition.

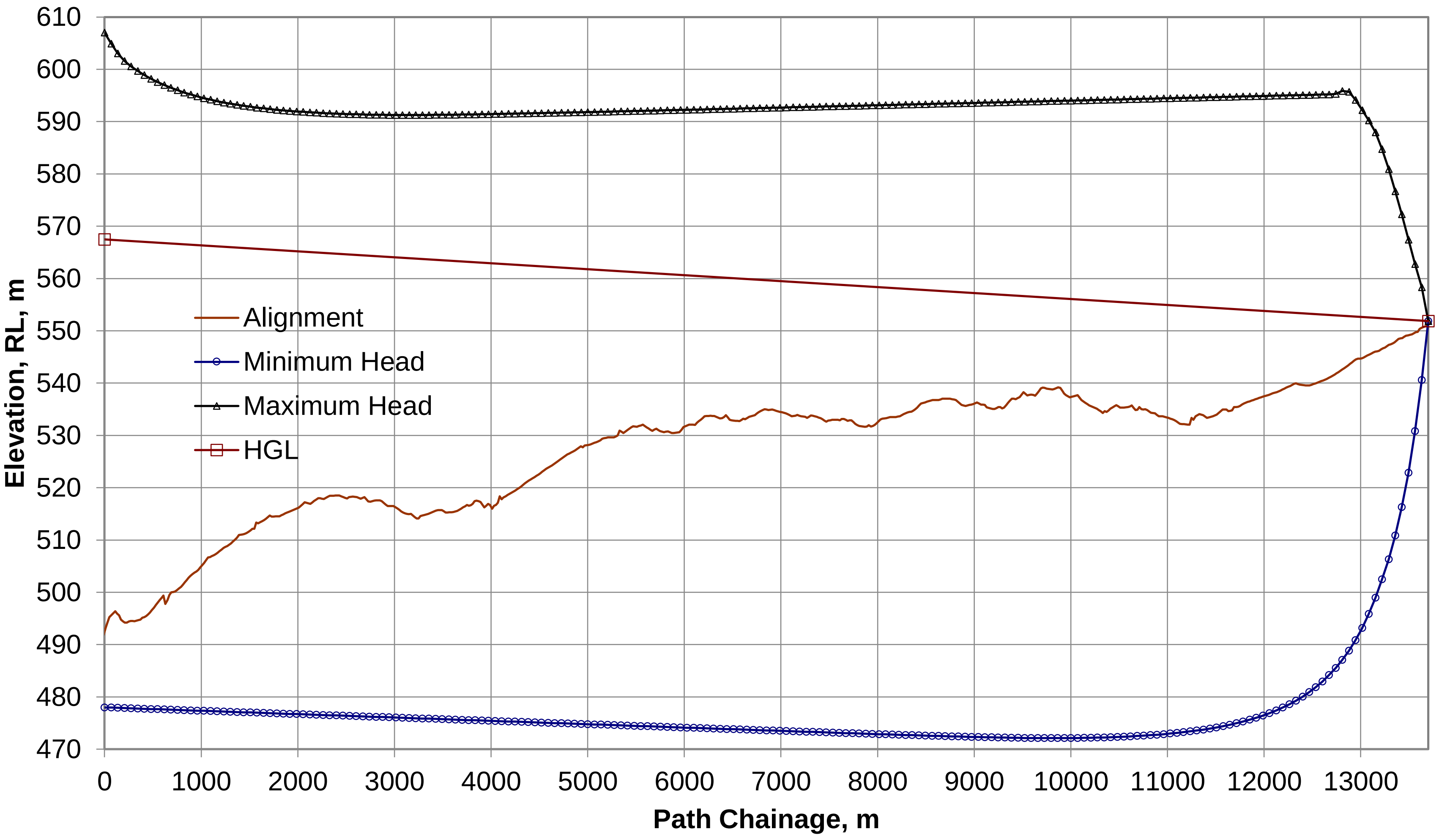
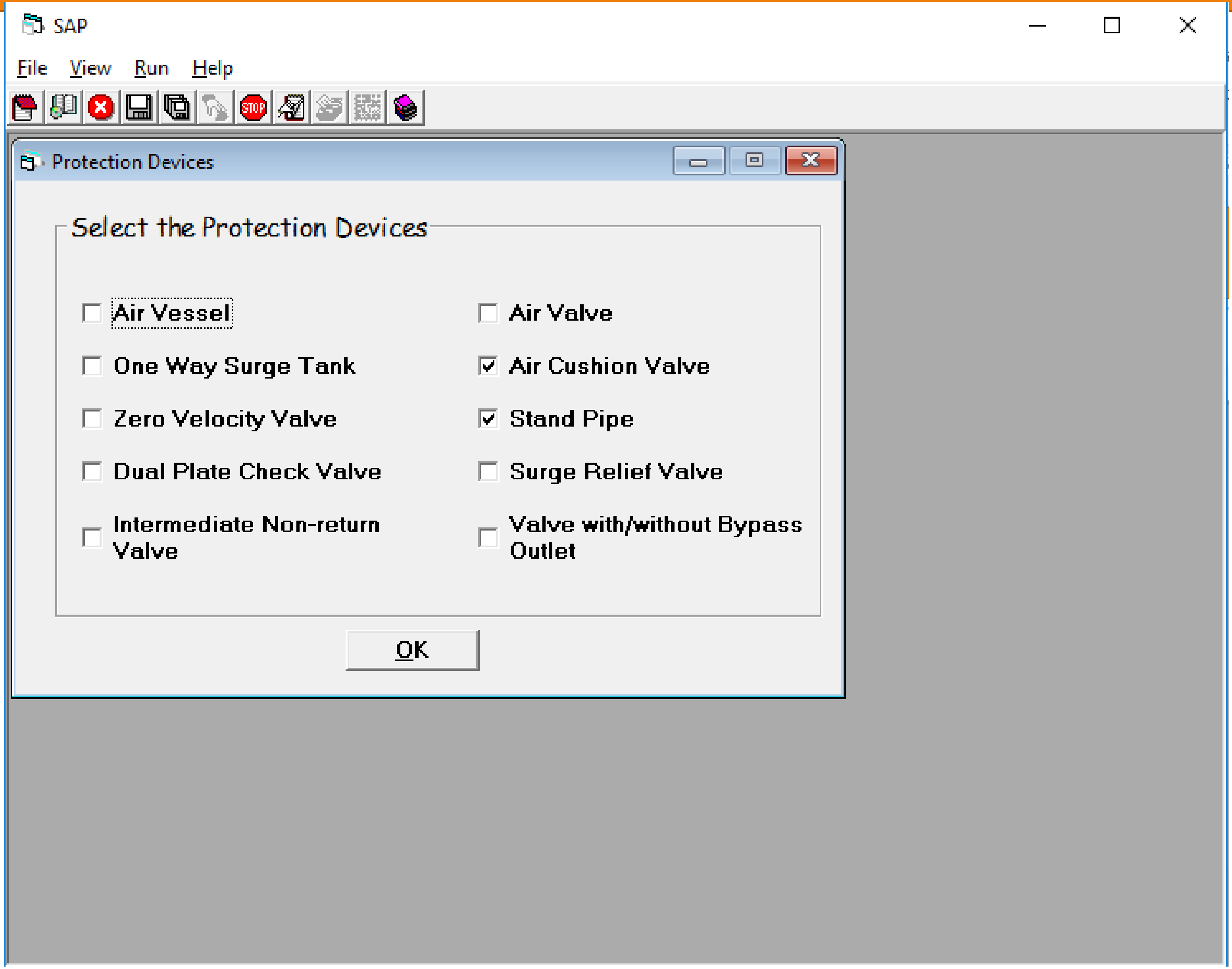


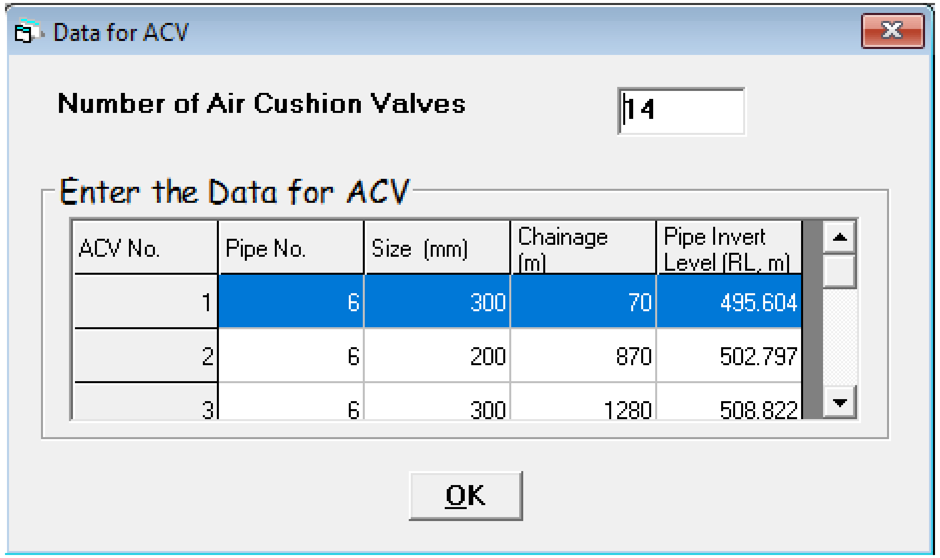
Fig.:Minimum and Maximum Piezometric Heads

SURGE ANALYSIS PROGRAM - SAP

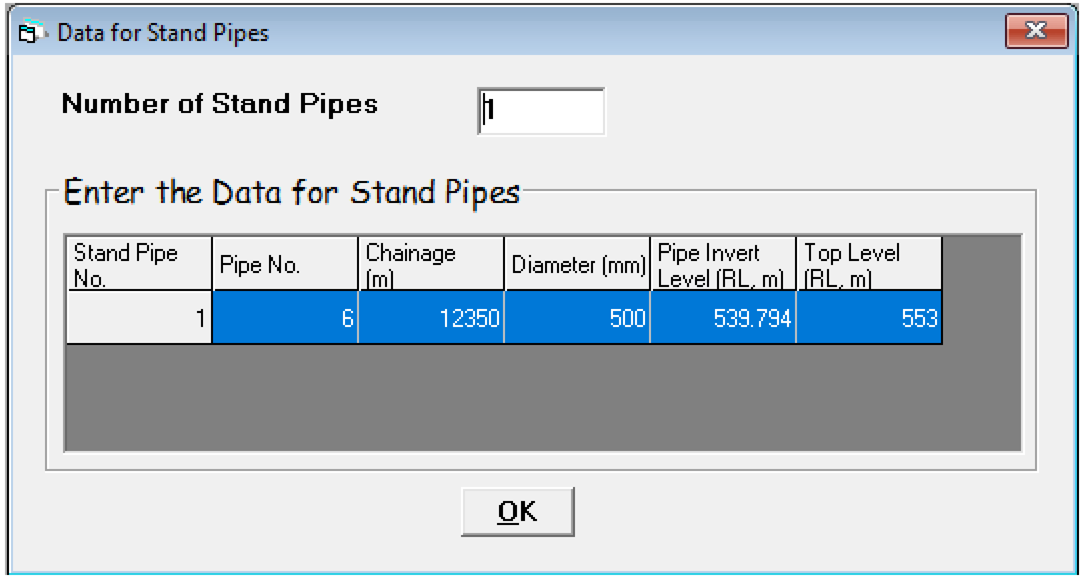
Following are the protection devices available in the software.



SURGE ANALYSIS PROGRAM - SAP



ACV No.	Pipe No.	Size (mm)	Chainage (m)	Pipe Invert Level (RL, m)
1	6	300	70	495.604
2	6	200	870	502.797
3	6	300	1280	508.822



Stand Pipe No.	Pipe No.	Chainage (m)	Diameter (mm)	Pipe Invert Level (RL, m)	Top Level (RL, m)
1	6	12350	500	539.794	553

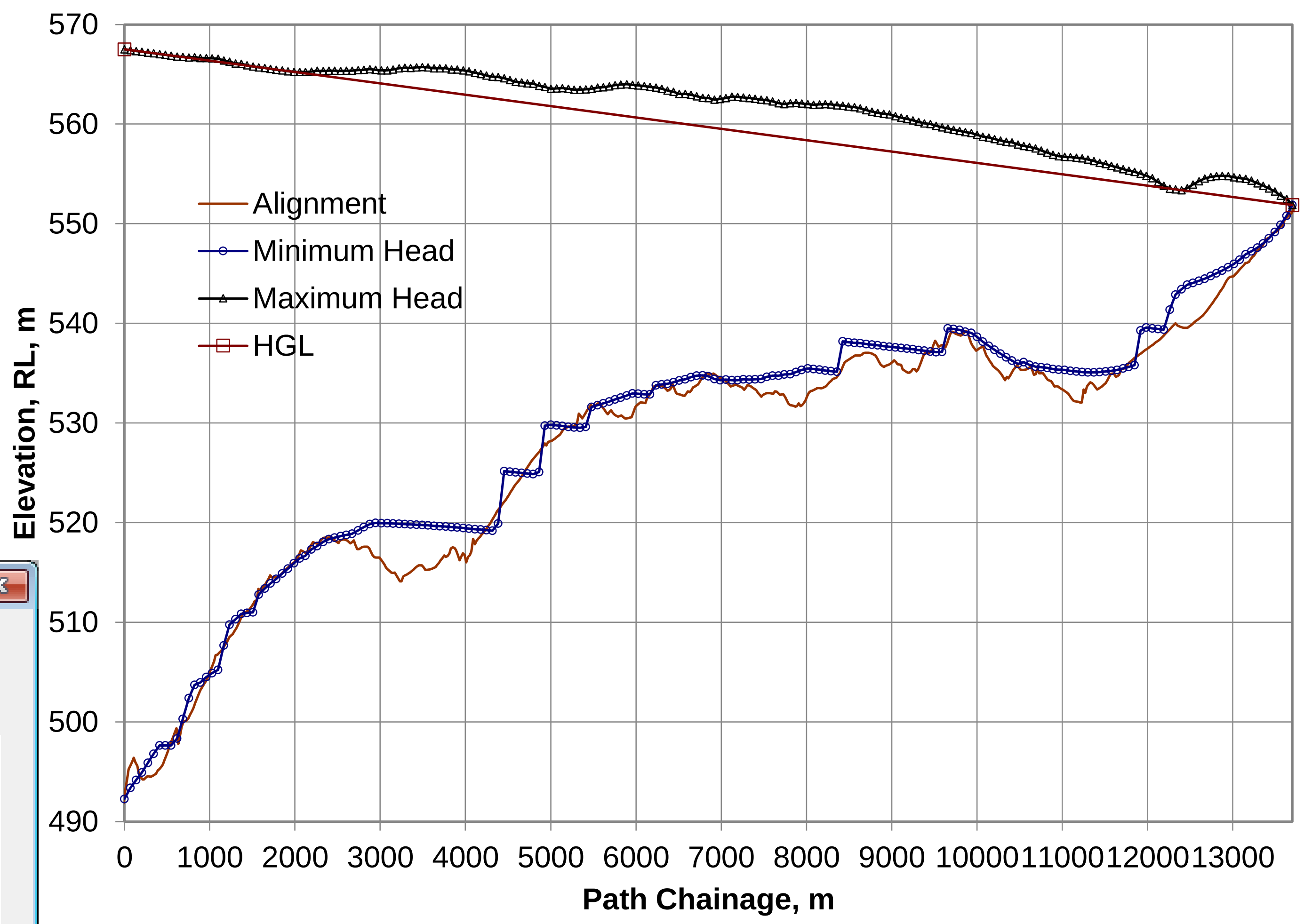


Fig.:Minimum and Maximum Piezometric Heads

HGL GRAPH OF A LIFT IRRIGATION PROJECT (NORMAL OPERATION)

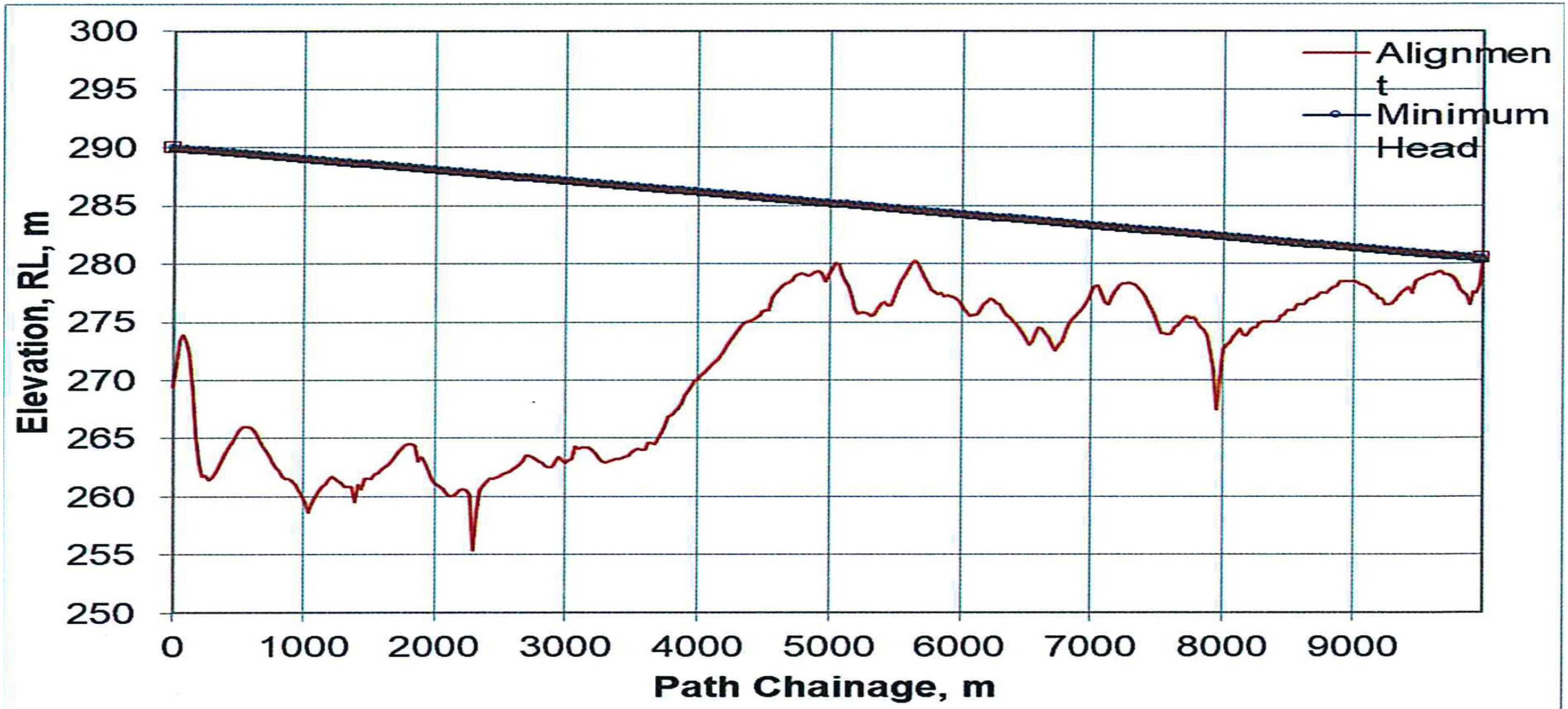


Fig.:Minimum and Maximum Piezometric Heads

HGL GRAPH OF A LIFT IRRIGATION PROJECT (RESULT OF SURGE CAUSED BY POWER FAILURE & PROPOSED PROTECTION SCHEME)

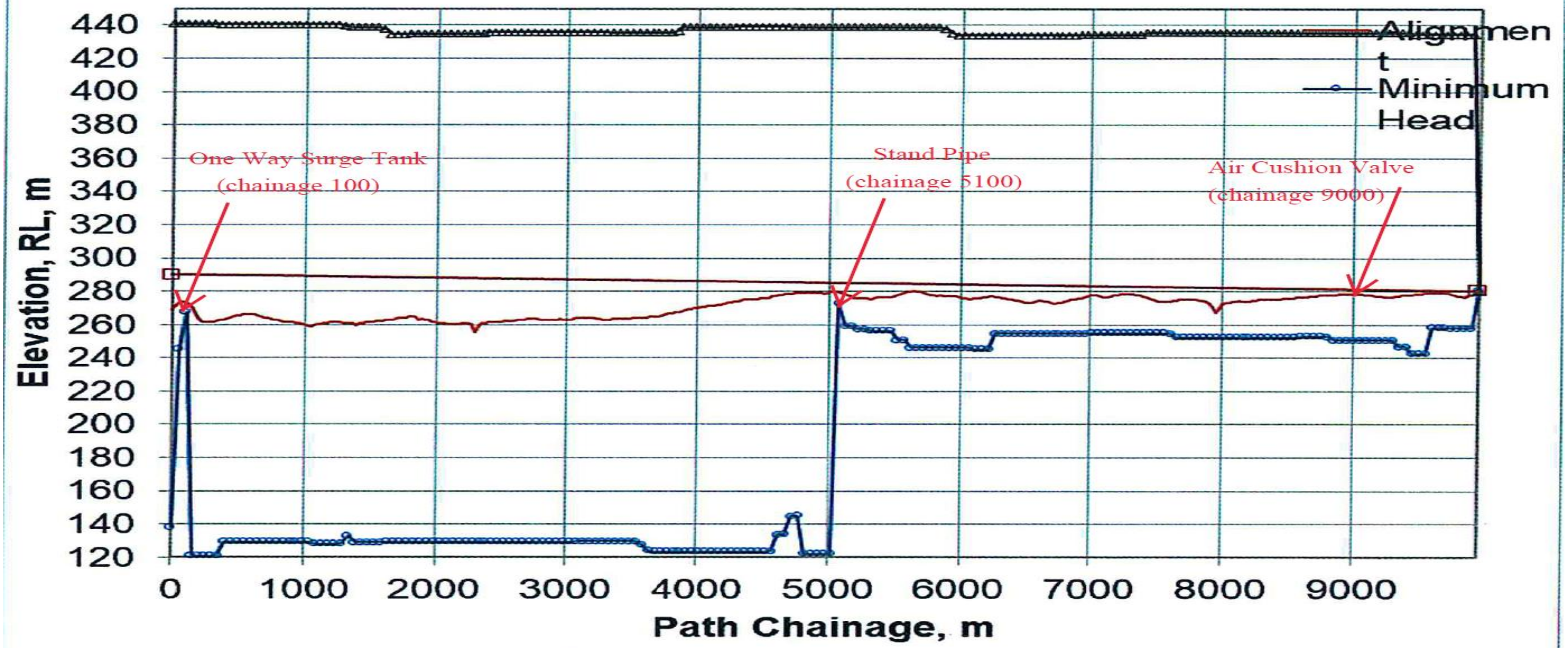


Fig.:Minimum and Maximum Piezometric Heads

HGL GRAPH OF A LIFT IRRIGATION PROJECT (MODIFIED RESULT DUE TO PROPOSED SURGE PROTECTION SCHEME)

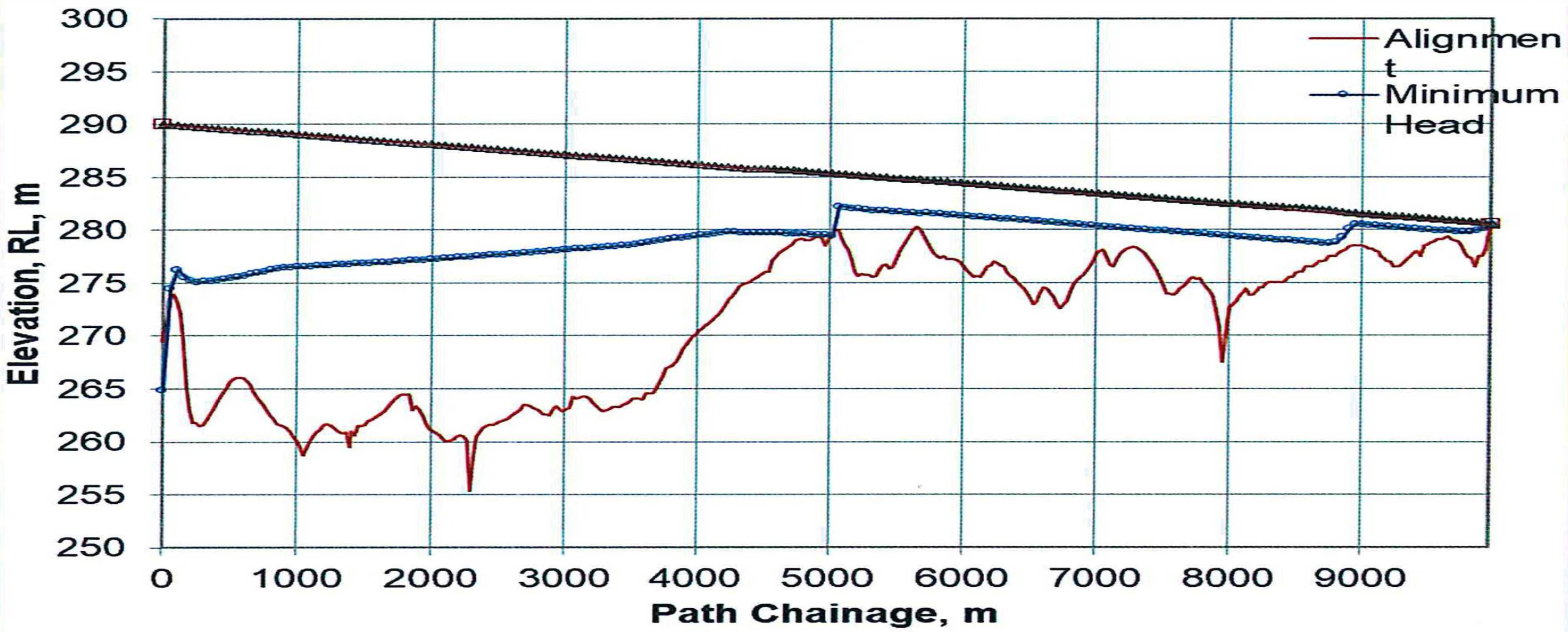


Fig.:Minimum and Maximum Piezometric Heads

PIPE FAILURE DUE TO SURGE

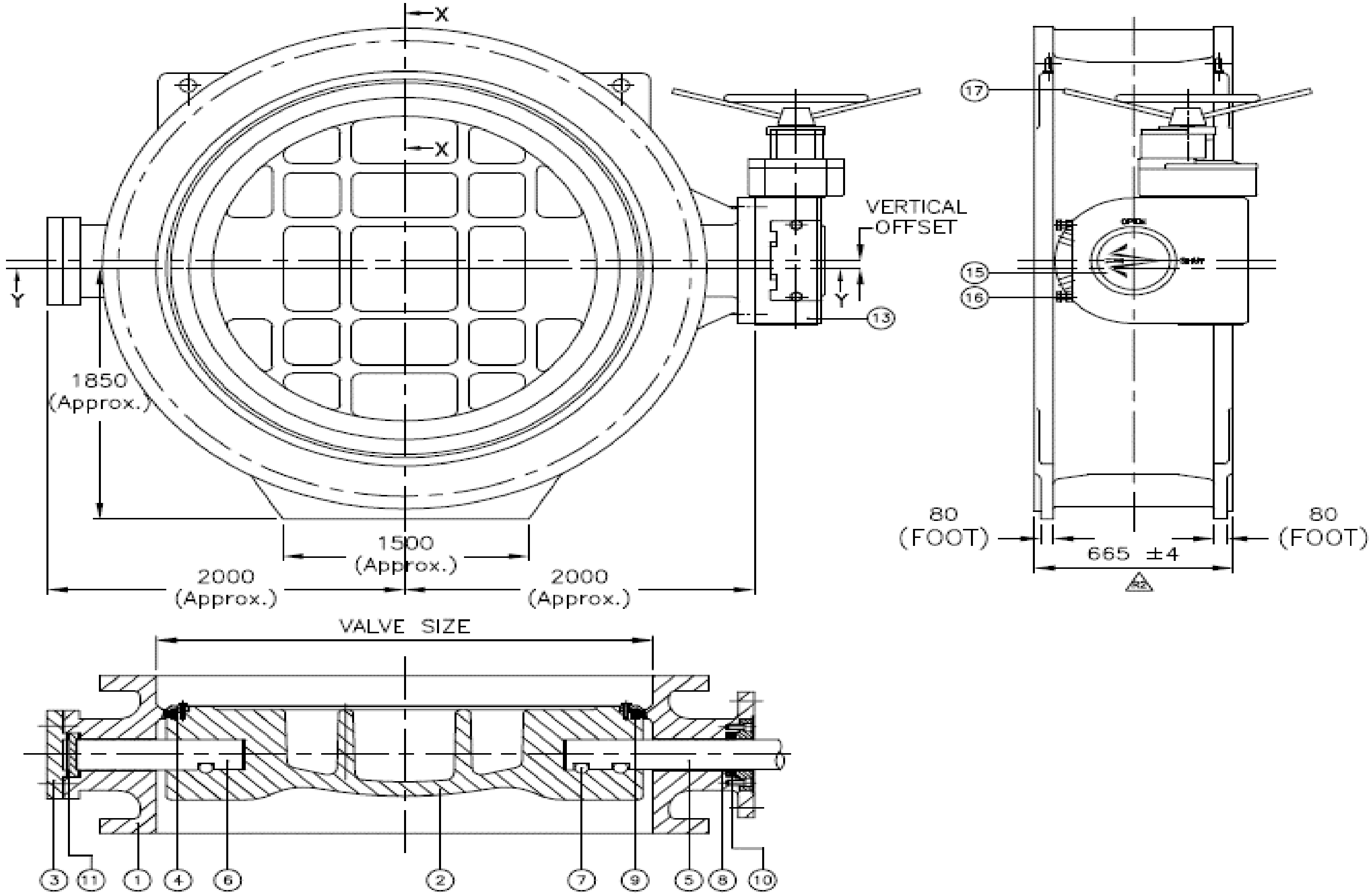
TYPES OF VALVES

1. Manually Operated Butterfly Valve
2. Hydraulically Operated Butterfly Valve
3. Electrically Operated Butterfly Valve
4. Sluice Valve
5. Kinetic Air Valve
6. Air Cushion Valve
7. Zero Velocity Valve
8. Swing Check Valve (Multi Door Type)

TYPES OF VALVES COMMONLY USED IN LIFT IRRIGATION SYSTEM

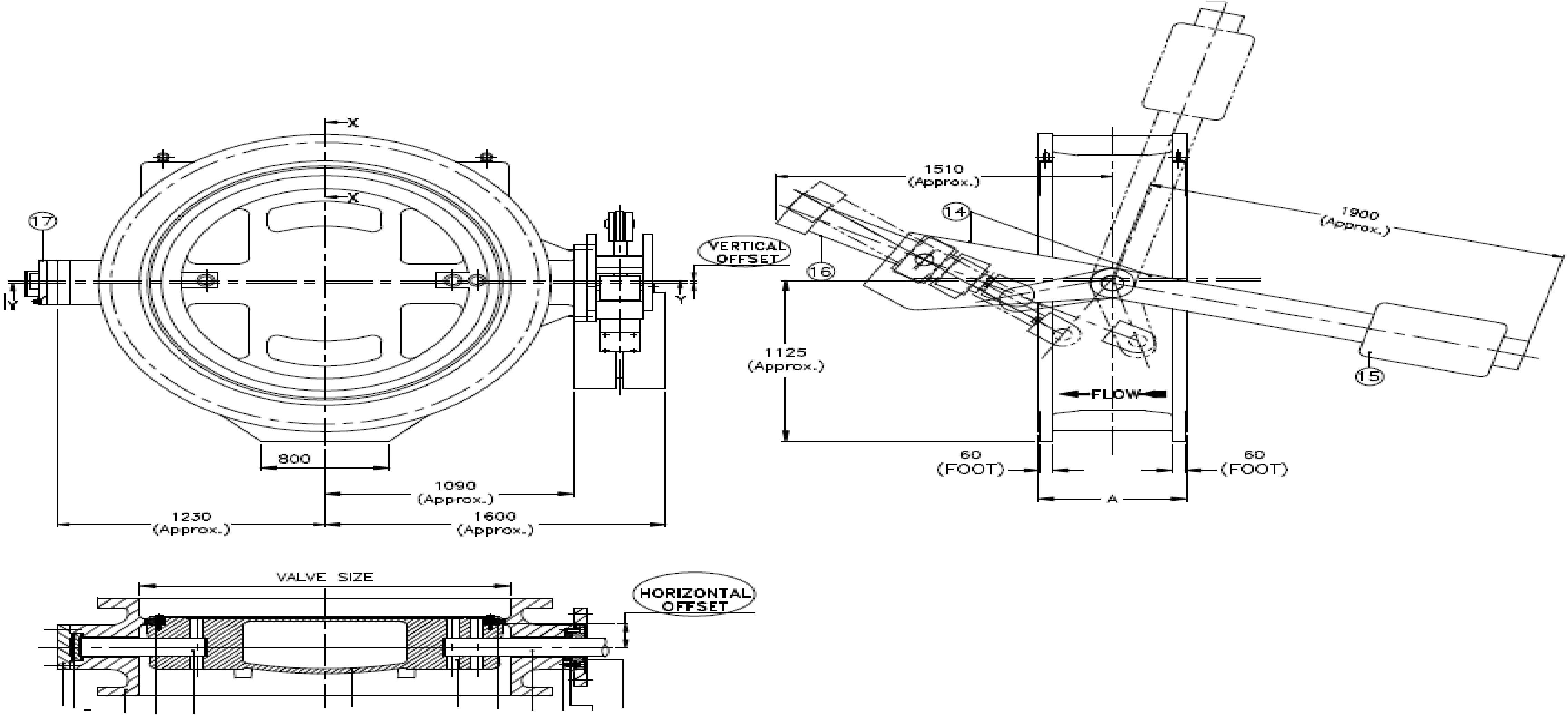
1. Manually Operated Butterfly Valve

The valve may also be opened incrementally to throttle flow. Butterfly valves are generally favored because they cost less than other valve designs, and are lighter weight so they need less support.



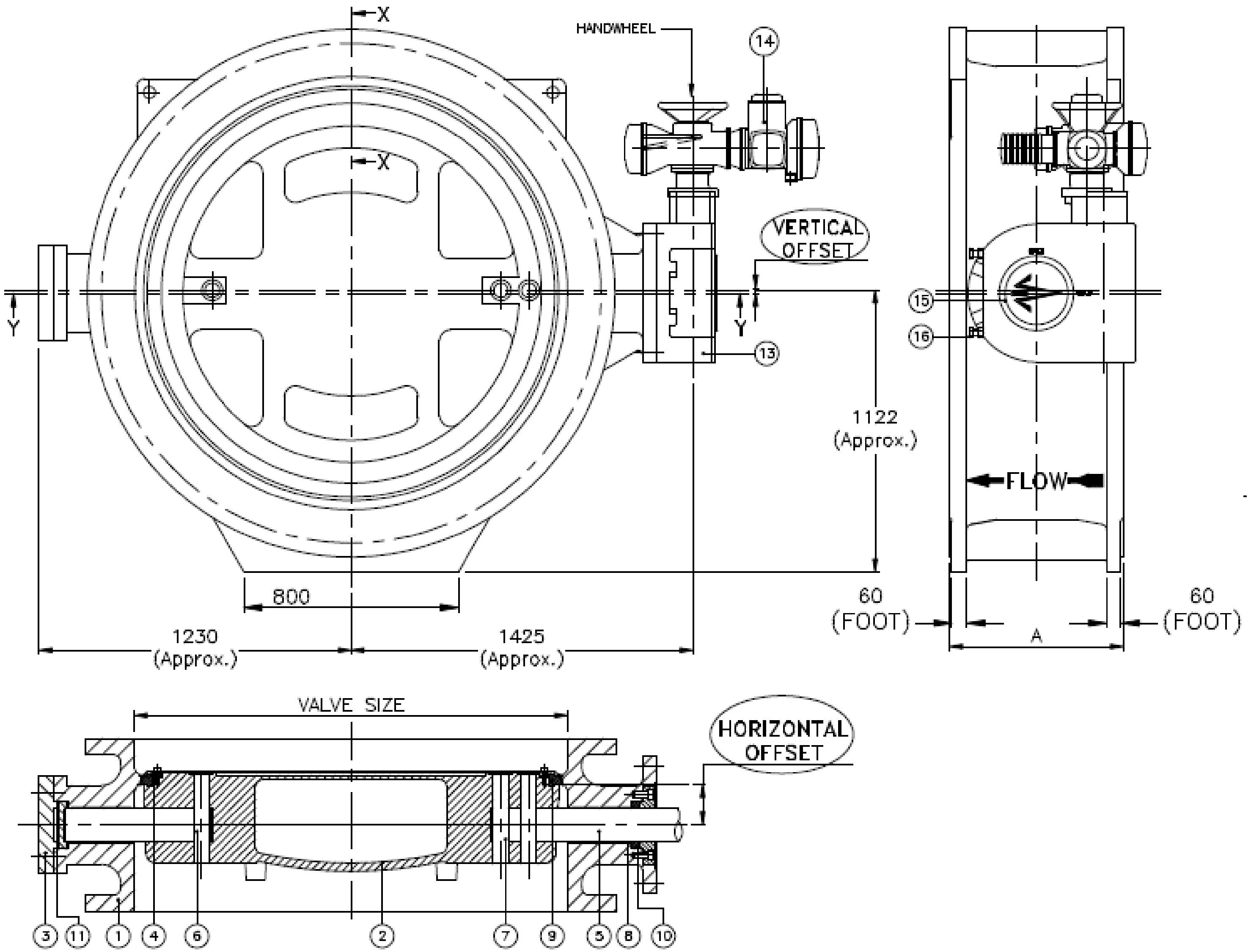
2. Hydraulically Operated Butterfly Valve

These are Normal Butterfly Valves coupled with Hydraulic Actuators for quick and precise reaction as per situational requirement.



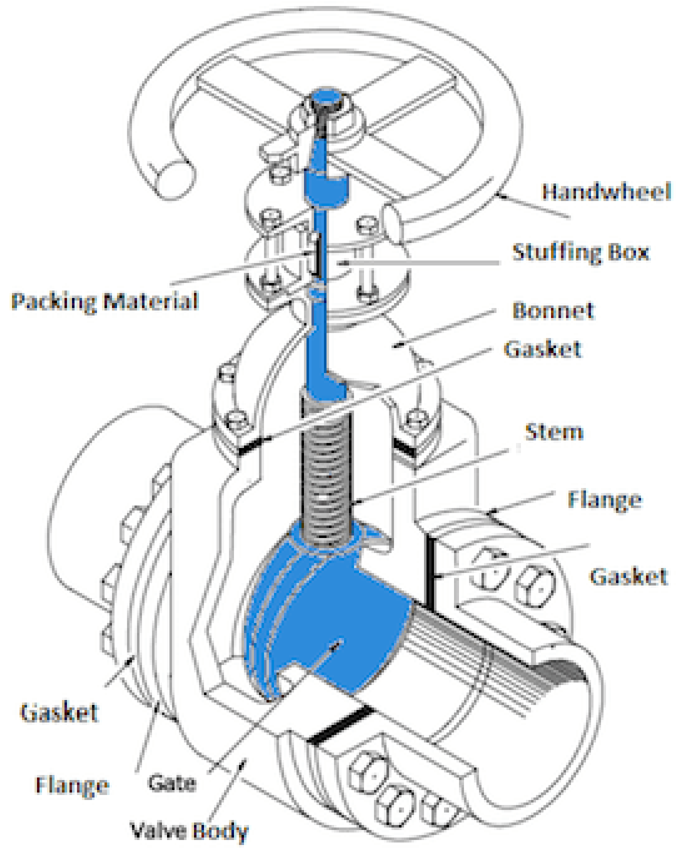
3. Electrically Operated Butterfly Valve

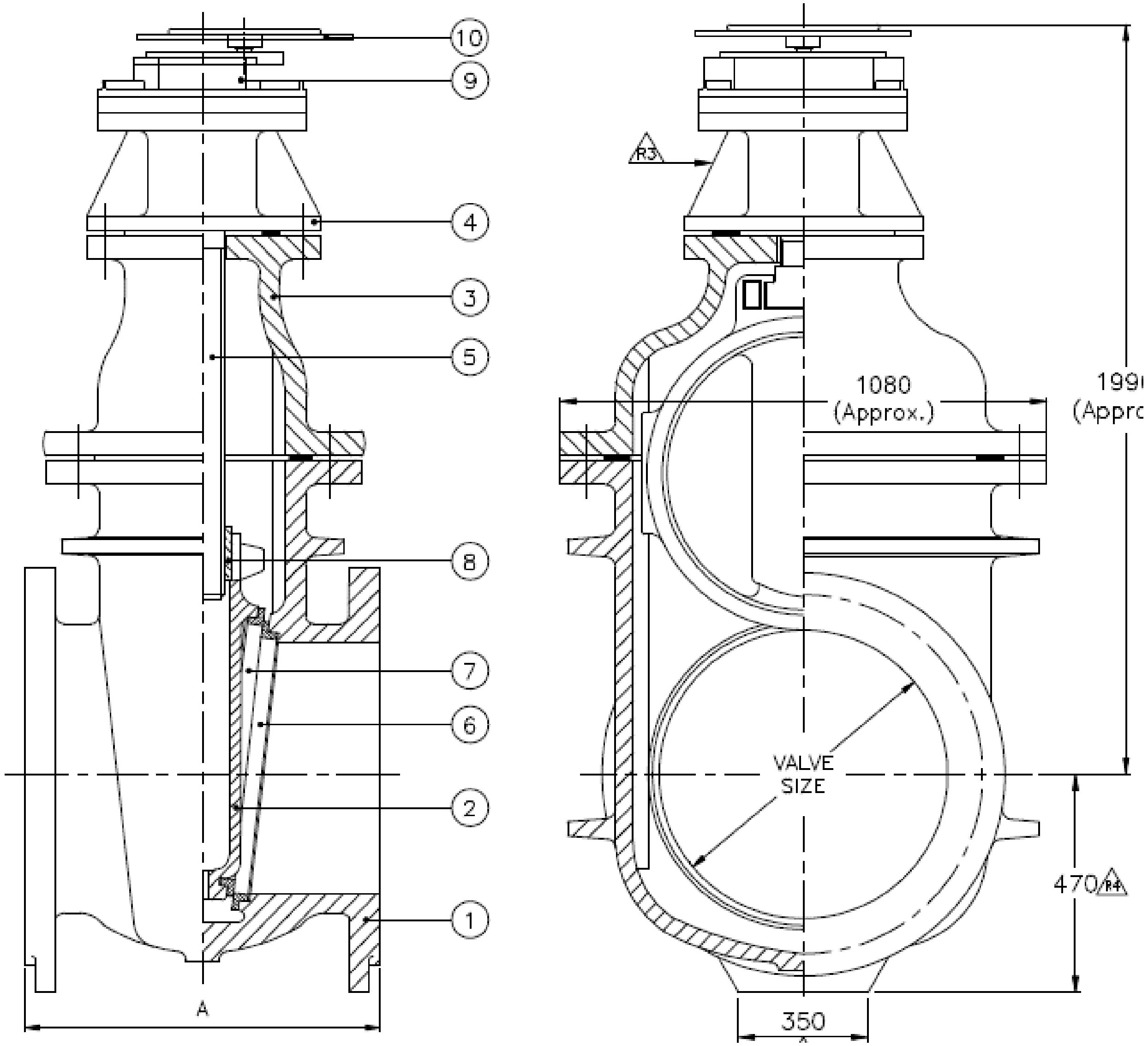
These are Normal Butterfly Valves coupled with Electric Motor and Gear Box for isolation purpose remote handling capability.



4. Sluice Valve (Non Rising Spindle)

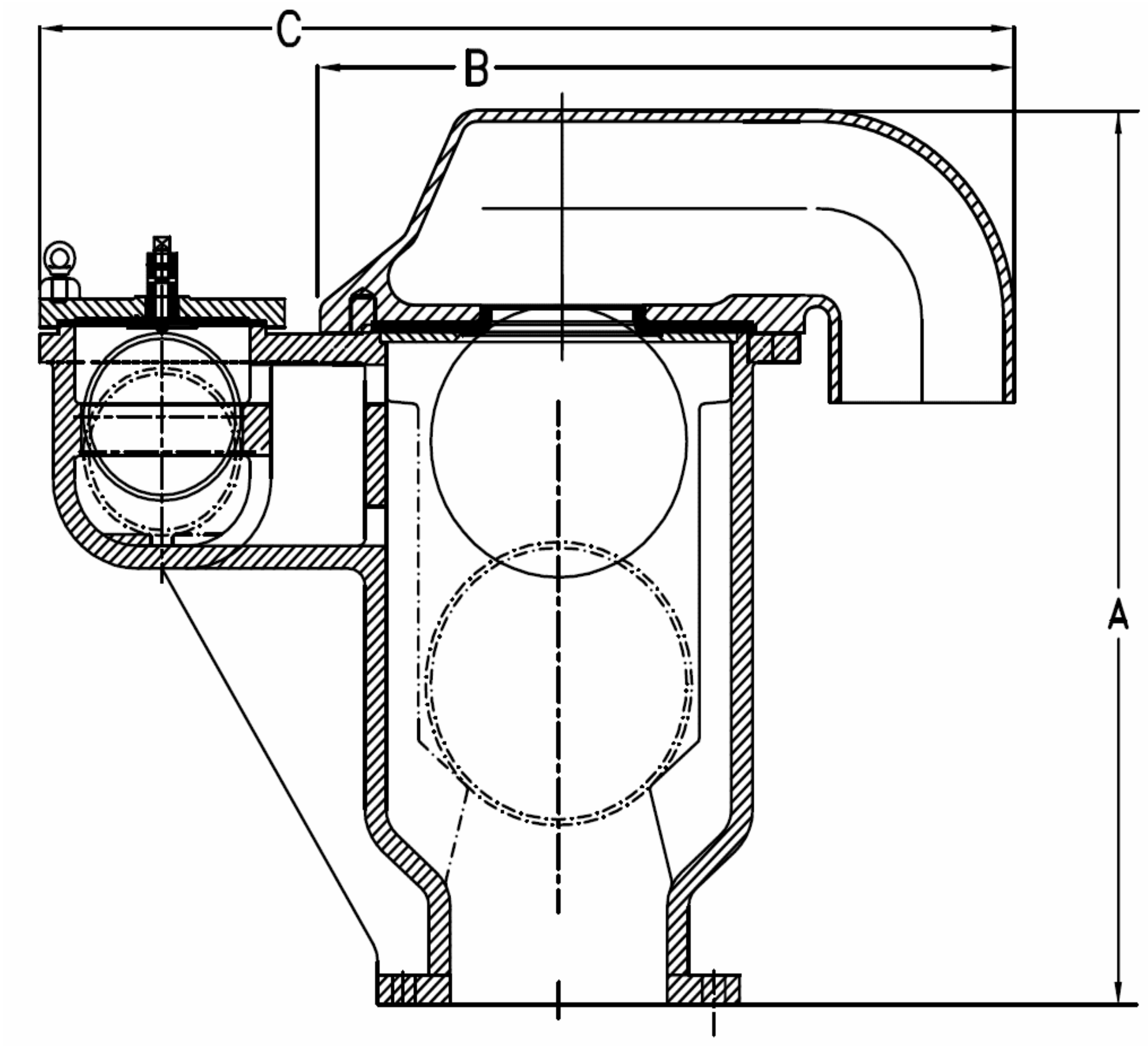
These are Normally used as on / off valves, however, they can also be used for throttling purpose.





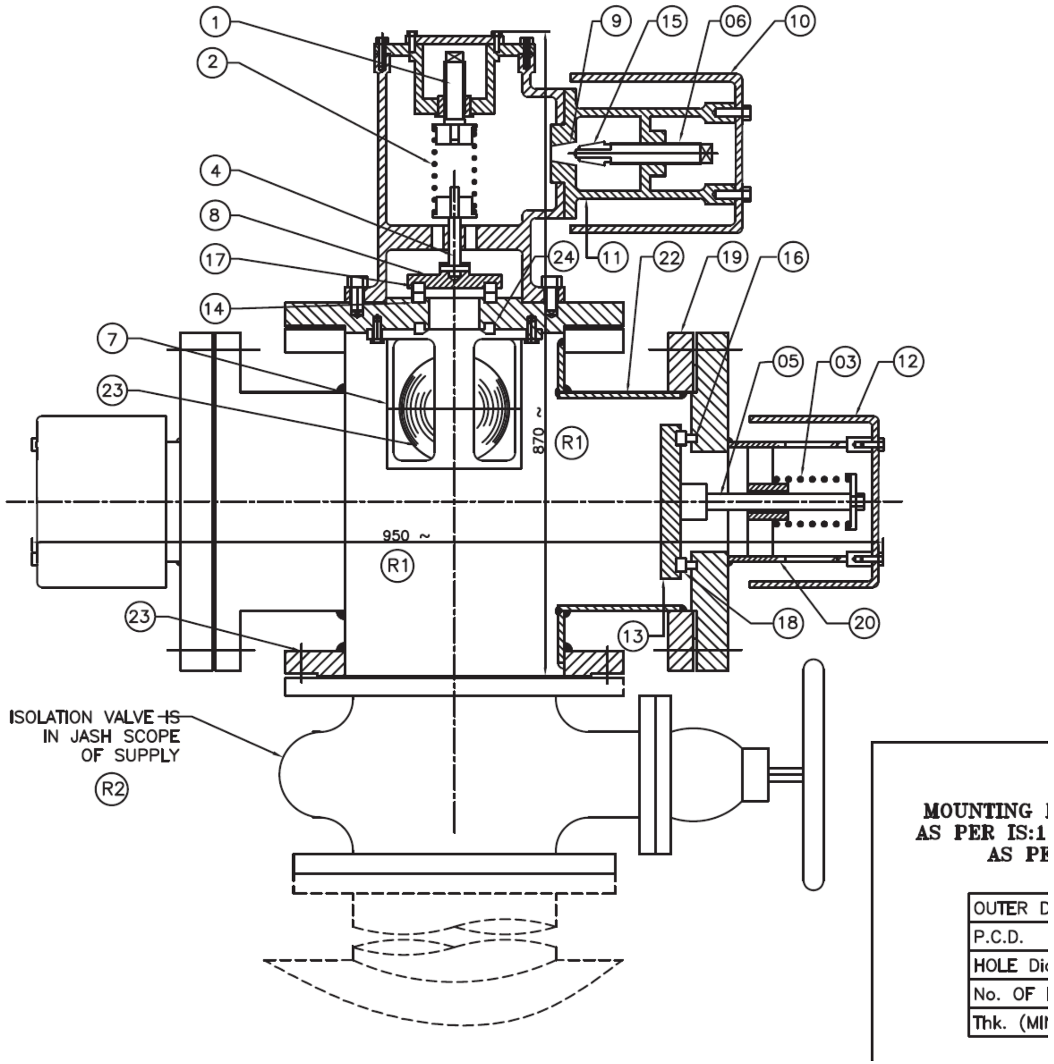
5. Kinetic Air Valve

Kinetic Air Valves are commonly used in air venting / air admission services in water pipelines Designed to operate with the floats inside.



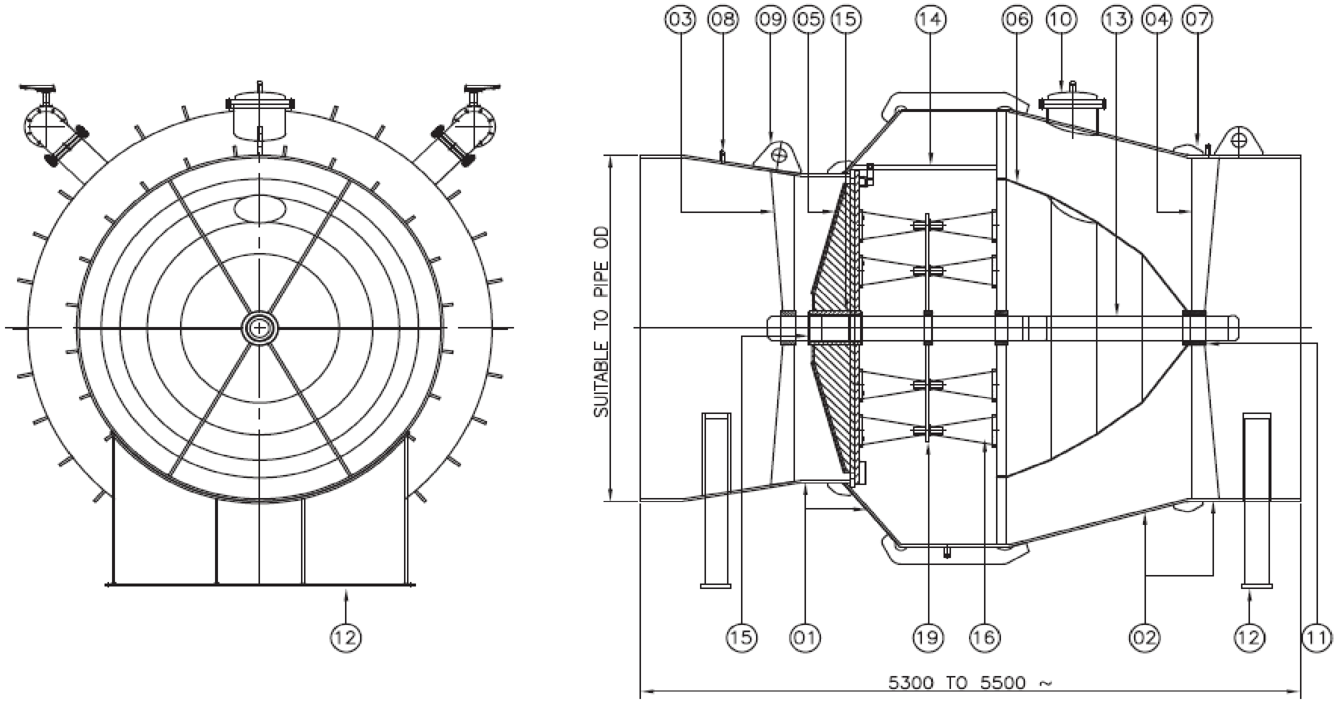
6. Air Cushion Valve

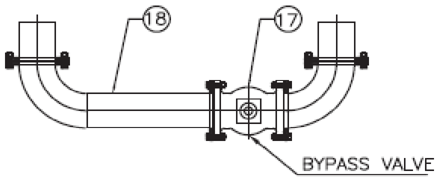
These Valves are commonly used for surge protection. Allowing suction of large volumes of air venting in the system through its inlet port and controlled expulsion of air from the system to dampen the effect of surge.



7. <u>Zero Velocity Valve</u>

These Valves are self acting valve which prevents reverse flow by closing the path before zero velocity is attained through spring action. It is used for surge protection.

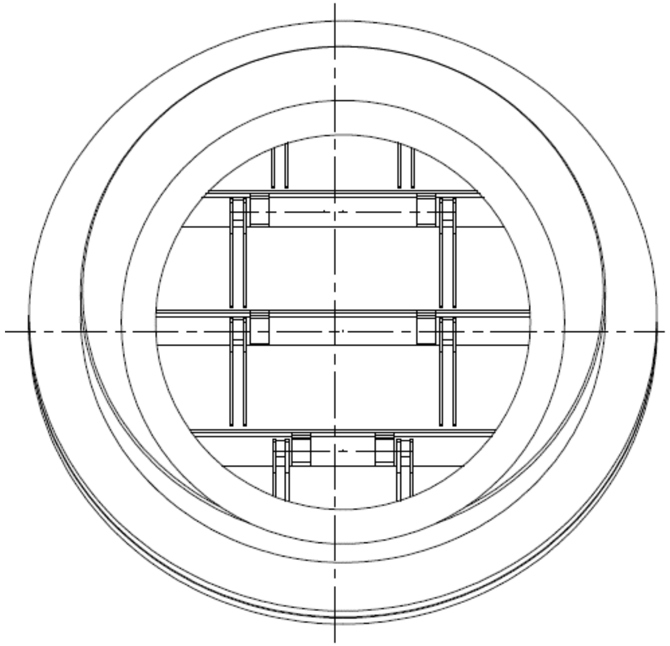


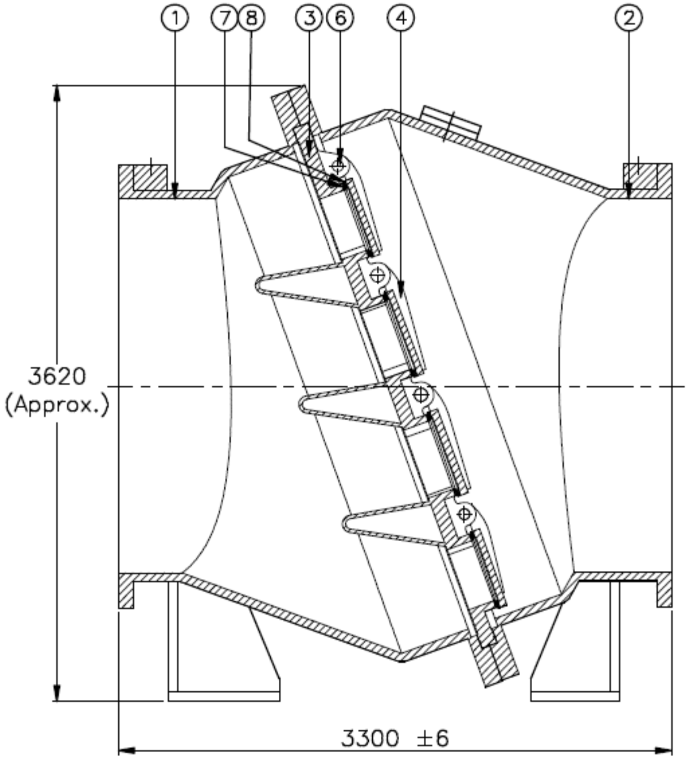


BY PASS ARRANGEMENT

7. <u>Swing Check Valve (Multi Door Type)</u>

Multi-Door Non Return Valves are used in pipelines to reduce water hammer and to prevent back flow of water to the pump from rising mains. These valves are suitable for clear water having turbidity up to 5000 ppm and temperature upto 45 Deg.C





thank you