Agra Smart City Mission

Improvements to Taj East Drain

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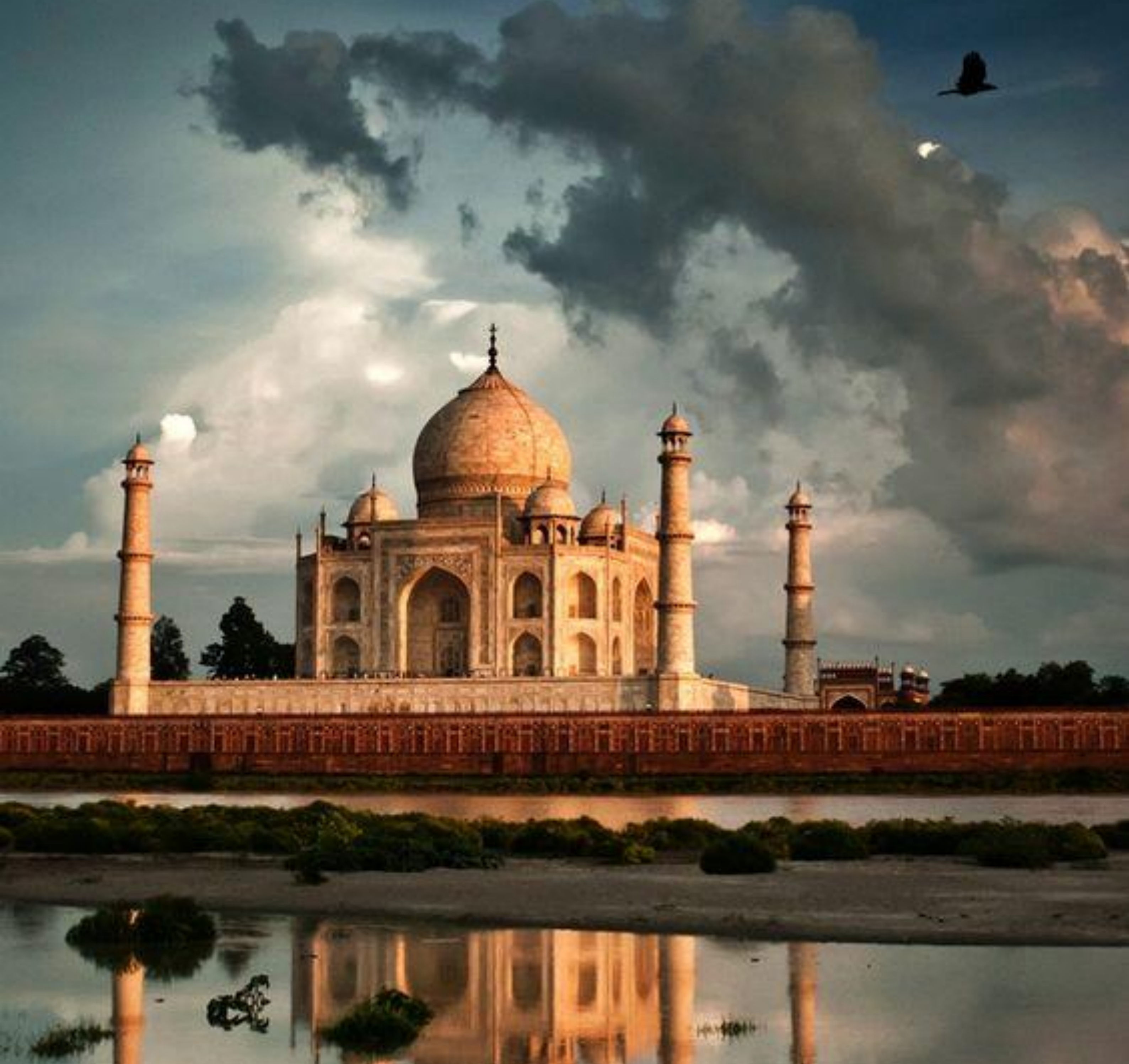

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EXECUTIVE SUMMARY

- **Introduction**

The smart city project for Agra is earmarked for about 22.50 Hectares covering both side of Fatebad road and Taj Ganj area around Taj Mahal. Taj East drain is one of major drain flows across the ABD area. It originates from Shamshabad road as a road side drain along Gobar Chowki road and crosses Fatebad road further merges as single drain near Nageena Masjid and further collecting the inflow from the catchment area crossed Taj east road and confluence at river Yamuna. The total length of drain is about 4000 mts.

- **Existing condition of Taj East Drain**

The storm water drain is slowly turned into sewage and solid waste disposal due to lack of adequate sewerage and solid waste infrastructure. The drain is also travels through thickly populated urban area. Part of the drain also passes through ABD area from ch.1520 to ch.4000

At present the drain during dry weather flow carries domestic sewage and solid waste. Though the catchment area is having sewerage facilities 100% house sewer connections are not yet commissioned. Due to this the public health of people living at vicinity of the drain are affected. As this drain crosses near to Taj Mahal it also affects aesthetics of Taj Mahal.

As these drain confluence to river Yamuna, the pollution level is so high that the river Yamuna lost its self-cleaning capacity and carries only sewage and effluents discharged from various industries. As a immediate measure to curb pollution to river Yamuna Jal Nigham has installed a sewage pumping station at Kolhai and the drain flow is diverted to SPS and further pumped to STP at Dandhupura for further treatment and disposal.

- **Proposed improvements to Taj east drain**

The total catchment area of the drain is about 2369 hectares covering within municipal limit and outside the limit. The total area is divided into 7 catchment zones. The drain is designed as per CPHEEO guidelines for its carrying capacity and improvement plan is proposed to improve the existing drain and constructing new drain from Taj east road junction at chainage 3215m to confluence point at river Yamuna chainage 4000m.

From chainage from 0m to 680m the existing drain size is adequate for hydraulic adequacy. The following works are proposed for strengthening of drain.

1. Rising of side wall
2. Plastering of exposed brickwork inside of drain
3. Providing RCC cover slab
4. Providing grating arrangements with rainwater harvesting structures

From chainage from 680m to 810m the existing drain size is closed with RCC slab and serving as road. So, no improvement works are proposed except desiglting and disposing of silt and solid waste.

From chainage from 810m to 1800 (R), 1520 (L) the existing drain size is inadequate for hydraulic adequacy. The following works are proposed for strengthening of drain

1. Construction of new RCC drain with cover slab and grating arrangement

From chainage from 2040m to 3120m the existing drain size is adequate for hydraulic adequacy. The following works are proposed for strengthening of drain

1. Rising of protection wall on both side of the drain with brickwork
2. Plastering of inside exposed brickwork
3. Providing cover slab with ventilation shaft for air ventilation
4. Providing grating arrangements with rain water harvesting structures

From chainage from 3120m to 3215m the existing drain size is adequate for hydraulic adequacy. The following works are proposed for strengthening of drain

1. Construction of new side wall
2. Plastering of inside exposed brickwork
3. Providing cover slab with ventilation shaft for air ventilation
4. Providing grating arrangements with rain water harvesting structures

From chainage from 3215m to 4000m new adequate drain size is proposed for hydraulic adequacy. The following works are proposed for construction of new drain

1. Construction of new RCC drain as per the hydraulic and structural design requirements with rain water harvesting structures

   Apart from above improvements screen chambers with screen arrangements are proposed at junctions where lateral drains join Taj East drain

- **Cost estimate**

  Detailed cost estimate has been prepared using Agra PWD schedule of rates and data has been worked out for non-schedule of rates as per market rates

  Total project cost worked out to be 17.20 Crores.

1.0. Preamble

Uttar Pradesh is urbanizing much more slowly than other parts of India. At 11.8%, its urban population is one third of the average urban population of India (31.6%, Census, 2011). Even though urban population may be growing slowly, Agra is one of the important city in Uttar Pradesh

Agra city is located on the southern bank of river Yamuna. It is a northern part of Uttar Pradesh, India. The state capital Lucknow is about 378 Km on east. Agra is near national capital New Delhi about 206 Kms northwest direction. The city is also well connected with National highways, rail networks to other major cities and district headquarters.

Agra is a major tourist destination because of its many Mughal-era buildings, most notably the Tāj Mahal, Agra Fort and Fatehpur Sikri, all three of which are UNESCO World Heritage Sites. Agra is included on the Golden Triangle tourist circuit, along with Delhi and Jaipur; and the Uttar Pradesh Heritage Arc, tourist circuit of UP state.

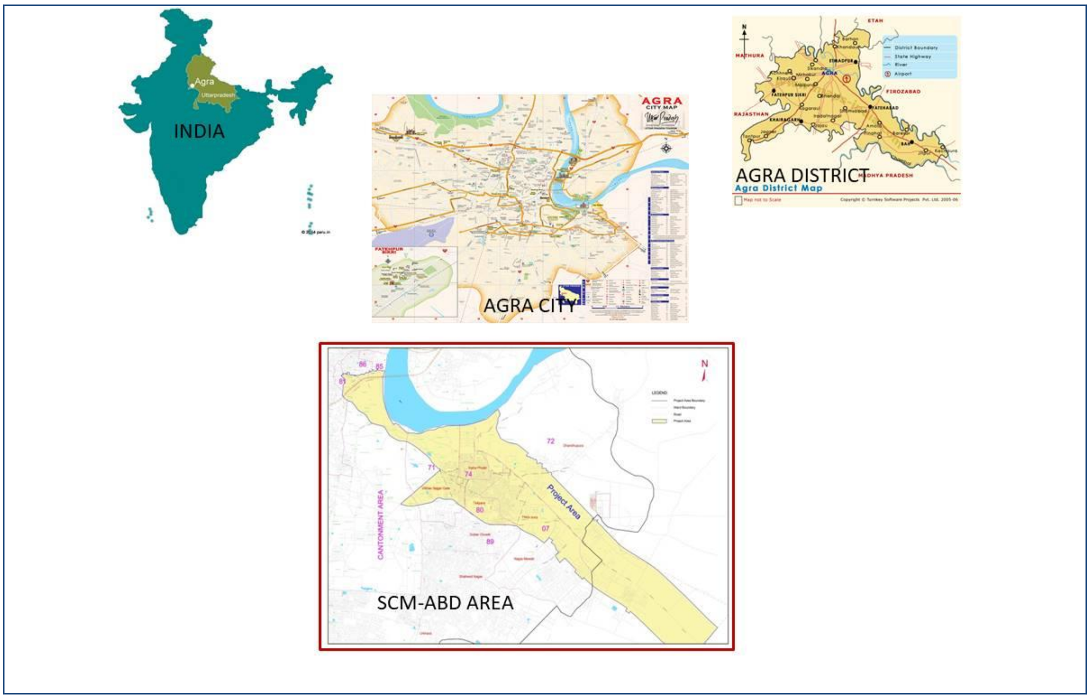


Figure 1: Location of Agra city and SCM-ABD area

The climate of Agra experiences mild winters, hot and dry summers and a monsoon season. Agra has a reputation of being one of the hottest towns in India. In summers the city witnesses a sudden surge in temperature and at times, mercury goes beyond the 46°C mark in addition to a very high level of humidity. During summer, the daytime temperature hovers around 46-50°C. Nights are relatively cooler and temperature lowers to a comfortable 30°C. Winters are bit chilly but are the best time to visit Agra. The minimum temperature sometimes goes as low as 2 or 3°C but usually hovers in the range of 6 to 8°C.

Agra is one of 13 cities selected for smart city mission by Govt. of India, ABD area is earmarked based on selection criteria as follows

- The city profile
- Citizen opinion and engagement
- Opinion of the elected representatives
- Discussion with the urban planners and sector experts
- Discussion with the suppliers/ partners

The ABD area covers about 2.40 % of total Municipal corporation area. Two villages Kalal Kheria and Mayapura is located adjacent to the Municipal limit is also added to ABD area.

Taj east drain is one of the primary storm water drain flowing within ABD area flows from south to north direction. It originates as road side drain at chainage 0 to confluence point at Yamuna

2.0. Demographics

Agra is a major tourist destination because of its historical Mughal-era buildings, three historical monuments are earmarked for UNESCO World Heritage sites.

1. Taj Mahal,
2. Agra Fort
3. Fatehpūr Sikrī,

Agra City with a total land area of 141 km^2 had a population of 2,22,943 in 2011. The growth rate of Agra varies from decade to decade and last three decade the growth rate is increasing. In last six decades the population has grown almost 4.75 folds, with increase in population from 3,33,530 in 1951 to 15,85,704 in year 2011. The growth pattern of the town is illustrated in the Table 1.

Table 1: Decadal Population and Growth Pattern

Sl. No.	Year	Population		Decadal Growth rate Population Variation %
		Population	Variation	
1	1951	333530		
2	1961	462020	128,490	39%
3	1971	591917	129,897	28%
4	1981	694191	102,274	17%
5	1991	891790	197,599	28%
6	2001	1275134	383,344	43%
7	2011	1585704	310,570	24%
8	2035	2396855	811,151	51%

Agra recorded an overall literacy rate of 60.10 % with female literacy of 40.96%, Thus Agra compares favourably in terms of literacy and sex ratio compared to state averages on these indicators.

3.0. Existing condition of Taj east drain

The drain originates from Shamshabad road junction at ch-0m and confluence to river Yamuna at Ch-4000m. Taj East drain carries storm water during monsoon season and domestic sewage during arid season. Almost 85% of all household toilets in the low- income settlements along the drain directly or through shallow surface drains discharge faecal matter directly into the drain. Trade waste both liquid and solid also flows through the drain. Besides creating highly unsanitary conditions, the drain floods every monsoon causing loss of life and property. Over the years, it has also silted reducing its carrying capacity and increasing the incidence of flooding.

There are 17 low- income settlements along the drain's edge. The area also has some of the most luxurious hotels in the city such as the Amar Vilas and Mughal Sheraton besides traditional Mughal residential areas or Katras. There are some middle- income residential areas also in the Tajganj area. Taj East drain is discharged with both solid and liquid waste water that is generated from these habitations. It is estimated that waste water in the drain must be generated from approximately in wards 70, 71, 74, 80 and parts of 72 and 89.

Sewer lines are being laid in the area but are expected to cover only about 60% of households in the area along the drain. These are however, yet to be made operational. There is a gap in providing house sewer connections in areas where sewer lines are laid. are provided and also many households didn't have toilet facilities.
The alignment of drain flows through the following global coordinates.

Figure 2: Taj East Drain

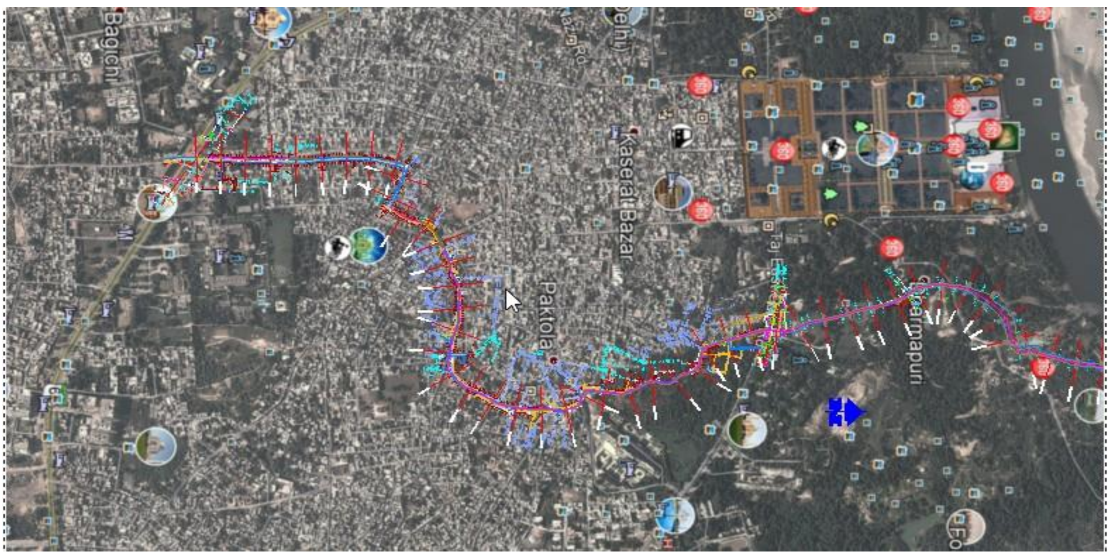


Figure 3: Photographic illustration on existing scenario of Taj East Drain

Left side-Chainage 0m to 60m
The drain is damaged and filled with soil. Needs desilting, raising of side walls and cover slab

Right side-Chainage 0m to 60m
The drain is open and filled with solid waste Needs desilting, raising of side walls and cover slab

Left side-Chainage 60m to 300m
The drain is open, silted and filled with solid waste. Needs desilting, raising of side walls and cover slab

Right side-Chainage 90m to 300m
The drain is open, silted. Needs desilting, raising of side walls and cover slab

 Left side-Chainage 300m to 520m The drain is open, silted and filled with solid waste	 Right side-Chainage300m to 520m The drain is open, silted
 Left side-Chainage 520m to 670m The drain cross from left to right	 Right side-Chainage 520m to 600m The drain is open, heavily silted &exposed brickwork

Right side-Chainage 600m to 680m
The drain is open, filled with solid waste, heavily silted & exposed brickwork

Chainage 680m to 810m
The drain is closed with RCC slab and serving as road

Chainage 810m to 1500m
The drain is open , silted & exposed brickwork

Chainage 1520m Fatebad road junction
The drain is open , silted & exposed brickwork

 Left side-Chainage1520m to 2040m Open drain with exposed brick work heavily silted and partially covered by residents	 Right side-Chainage 1520m to 2040m The drain is open, heavily silted & exposed brickwork
 Chainage 2040m to 2130m vulnerable for flooding The drain is open ,filled with solid waste, silted exposed brickwork without cover slab	 Chainage 2160m to 2190m road crossing The drain is open, heavily silted, no protection wall on sides and no cover slab

Chainage 2190m to 2340m
The drain is open, heavily silted, protection wall needs to be raised and uncovered

Chainage 2340m to 2430m
The drain is open, silted, protection wall needs to be raised and uncovered

Chainage 2420m to 2450m Road culvert crossing
Solid waste dumping yard drain is open, heavily silted, protection wall needs to be raised and uncovered

Chainage 2450m to 2820m
Open exposed brickwork drain, Desilting, Protection walls need to be raised, cover slab to be provided

 Chainage 2820m to 2910m Open drain without protection wall, soil from righside slides into drain, Protection walls need to be raised, cover slab to be provided	 Chainage 2910m to 3030m Open drain side retaining walls are damaged, silted and new retaining walls to be provided with cover slab
 Chainage 3030m to 3090m Open drain with weeds on side walls of drain, Protection wall to be raised and covered with slab	 Chainage 3090m to 3180m Open drain in damaged condition, needs desilting, new retining wall in briickwork and cover slab needs to be provided

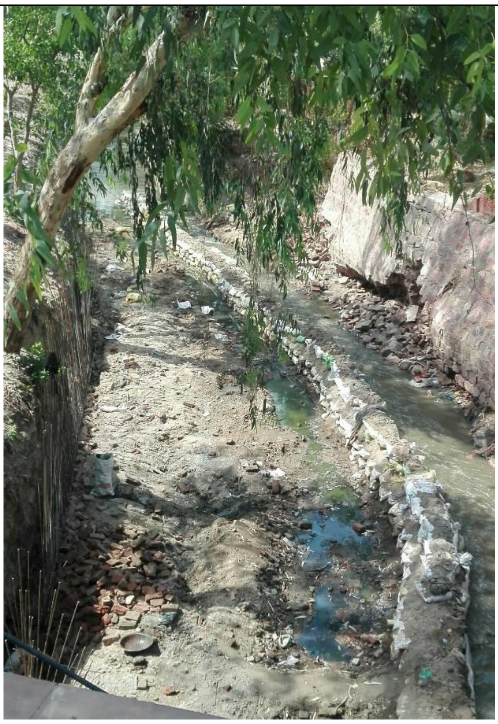
 Chainage 3210 crossing near Taj east gate road Open drain without side walls, heavily silted by sliding of soil and needs to be refurbished with brickwork and plasterin	 Chainage 3230 to 3480 after crossing near Taj east gate road Open drain partially damaged, silted without side protection wall, needs desilting, construction of damaged walls, plastering and cover slab

Table 2: Condition assessment and improvement matrix for Taj east drain

Condition assessment and improvement plan for Taj east drain from Shamshabad road to confluence point at River Yamuna													
Left side							**Right side**						
Chainage (m)	**Size of drain B (m) x D (m)**	**Construction material**	**Silt depth (m)**	**Condition assessment**	**Improvements**	**Remarks**	**Chainage (m)**	**Size of drain B (m) x D (m)**	**Construction material**	**Silt depth (m)**	**Condition assessment**	**Improvements**	**Remarks**
0-60				No drain is visible	Minimum size drain shall be provided		0-60	0.90 x 1.30	Exposed brick work	0.9	Side walls are lower than GL, Heavily silted, No cover slab	Desilting of drain, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab	At 60m rightside drain joins leftside drain by culvert crossing
60-520	1.50 x 1.50	Exposed brick work	1	Heavily silted with solid waste, side walls are lower than GL & no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab	At 520 the drain crosses to right and joins rightside drain	90-380	1.20 x 1.30	Concrete wall	1	Side walls are lower than GL, Heavily silted, No cover slab	Desilting of drain, rising of side walls for 0.45m above ground level, & providing cover slab	At 520 leftside drain joins right side drain
							380-520	1.2 x 1.8	Exposed brick work	1.3	Side walls are lower than GL, Heavily silted, No cover slab	Desilting of drain, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab	
							520-680	1.2 x 1.8	Exposed brick work	1	Heavily silted with solid waste, side walls are lower than GL & no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab	
							680-810		Closed drain		The drain is closed with RCC slab with manholes. Drain is serving as road	Desilting and disposal of silt & debris is required	The exact condition is not visible
810-930	1.0 x 1.50	Exposed brick work	1.1	Heavily silted with solid waste, side walls are lower than GL & no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab	at 810 confluence to side drain							
930-1140	1.2 x 1.3	Exposed brick work	0.9	Heavily silted with solid waste, side walls are lower than GL & no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering &								

Condition assessment and improvement plan for Taj east drain from Shamshabad road to confluence point at River Yamuna														
Left side								**Right side**						
Chainage (m)	**Size of drain B (m) x D (m)**	**Construction material**	**Silt depth (m)**	**Condition assessment**	**Improvements**	**Remarks**		**Chainage (m)**	**Size of drain B (m) x D (m)**	**Construction material**	**Silt depth (m)**	**Condition assessment**	**Improvements**	**Remarks**
					providing cover slab									
1140-1500	1.2 x 1.3	Exposed brick work	1	Heavily silted with solid waste, side walls are lower than GL & no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab			1450-1500	.90 x .50	Exposed brick work	0.3	Heavily silted with solid waste, side walls are lower than GL & no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab	
1550-1800	1.4 x 1.3	Stone boulders (RR masonery), Partially covered by shops	1	Heavily silted with solid waste, side walls are lower than GL & no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab			1500-2040	.90 x .80	Stone boulders (RR masonery), Partially covered by shops	1	Heavily silted with solid waste, side walls are lower than GL & no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab	At 2040 drain cross to left side and joins as major drain. The area is prone to flooding
1800-2040	.45 x .60	Exposed brick work	0.5	Heavily silted, side walls are lower than GL & no cover slab. The drain size is reduced	Desilting and disposal of silt & debris, rising of side walls for 0.45m above ground level, inside plastering & providing cover slab. Adequacy for carrying capacity to be checked									

Table 3: Conditional Assessment Survey

Chainage (m)	Size of drain B (m) x D (m)	Construction material	Silt depth (m)	Condition assessment	Improvements	Remarks
2040-2130	1.0 x 1.20	Brickwork drain with plastering	1	Heavily silted with solid waste, side walls are at GL and no cover slab	Desilting and disposal of silt & debris, rising of side walls for 0.60m above ground level & providing cover slab	
2160-2190	2.0 x .80	Closed drain in brickwork with plastering	0.5	Closed by road crossing culvert. Side walls of culvert are unplastered	Road culvert crossing	At 2190 mechanical screen may be provided to remove solid waste
2190-2270	2.0 x 1.0	Exposed brick work with side walls raised upto .45m	0.5	Silted with grit sludge. Side walls unplastered	Desilting and disposal of sludge and grit, rising of side walls uniformly to 0.60m above ground level & providing cover slab	
2270-2300	2.0 x 1.0	Closed drain	0.5	Silted with grit sludge. Side walls unplastered	Desilting and minor repair works needed	
2300-2430	2.0 x 1.0	Exposed brick work with side walls raised upto .60m	0.4	Silted with grit sludge. Side walls unplastered	Desilting, Side wall plastering required	At 2430 mechanical screen may be provided to remove solid waste
2430-2670	2.90 x 2.0	Exposed brick work with side walls raised upto .40m	0.6	Silted with grit sludge. Side walls unplastered	Desilting and disposal of sludge and grit, rising of side walls uniformly to 0.60m above ground level & providing cover slab	At 2670 major drain joins from right side 2.0 x 2.5
2670-2850	3 x 2.5	Exposed brick work with side walls raised upto .40m	0.75	Heavily silted with solid waste, left side side wall is good, right side sidewall needs to be raised for 2m to avoid soil sliding into drain	Right side sidewall to be raised, plastering of side walls with cover slab to be provided	

2850-2960	5 x 3	Exposed brick work	1	The side walls are collapsed during recent flood,	Both side walls to be constructed with cover slab	
2960-3060	5 x 3	Exposed brick work	0.8	The side walls partially damaged	Both side walls to be constructed with cover slab	
3060-3090	4 x 5	Exposed brick work	0.7	Both side walls are damaged	Both side walls to be constructed with cover slab	
3090-3210	6 x 5	Exposed brick work	0.7	Both side walls are partially damaged	Rehabilitation of walls and cover slab is needed	
3210-3480		Exposed brick work		Side walls are partially damaged	Rehabilitation of side walls, rising above GL for o.60m and cover slab is needed	
3480-4000		Earthern drain		Wide earthern drain of 26m wide	New drain to be constructed	

Condition assessment survey for the entire stretch from chainage 0 to 4000 has been carried out and improvement plan has been worked out

4.0. Need of the project

The storm water drain is slowly turned into sewage and solid waste disposal due to lack of adequate sewerage and solid waste infrastructure. The drain is also travels through thickly populated urban area. Part of the drain also passes through ABD area from ch.1520 to ch.4000. At present the drain during dry weather flow carries domestic sewage and solid waste. Though the catchment area is having sewerage facilities 100% house sewer connections are not yet commissioned. Due to this the public health of people living at vicinity of the drain are affected. As this drain crosses near to Taj Mahal it also affects aesthetics of Taj Mahal. So there is an urgent need for this project and bring the drain to its original condition.

During the heavy rains and floods, the infrastructure (roads, drains etc,) are being damaged and needs repairs and re-strengthening works. A huge amount is being spent on this account. In addition the floods are also having impact on human health (spreading of water borne diseases and Vector Borne diseases).

As these drain confluence to river Yamuna, the pollution level is so high that the river Yamuna lost its self-cleaning capacity and carries only sewage and effluents discharged from various industries. As a immediate measure to curb pollution to river Yamuna and bring back the drain to its original condition this project is vial.

5.0. Sewage pumping station at Kolhai

As a immediate preventive measure to curb discharge of sewage into Yamuna river UP Jal Nigham installed a Sewage Pumping Station (SPS) adjoining to drain at chainage 2700 Km at Kolhai Shutter provision with screen arrangements are provided across the drain to divert the flow sewage pumping station and further it is pumped to Sewerage Treatment Plant (STP) at Dhanadupura. At present about 18 MLD of sewage is pumped from this pumping station to STP. However sewage from downstream of this pumping station sewage infalls into the drain from 2 large settlement settlements, 2 katras at the south gate of Taj Mahal, and a few middle income residential area is flowing untreated into Yamuna river.

6.0. Objectives of the assignment

The project shall have two key objectives:

1. To check the hydraulics of the drain to discharge storm water effectively without inundations into river Yamuna.
2. To bring back the drain to its original form by curbing discharge of domestic sewage and solid wastes into the drain thereby the pollution caused by this drain to Yamuna can be stop sewage and solid waste pollution discharged into Yamuna by improving the sewage infrastructure for Agra especially to the catchment areas of the drain.
3. To study and improve the Taj east drain infrastructure to achieve effective storm water drainage system of Taj ganj area.

7.0. Survey and investigations

7.1. Reconnaissance Survey

The reconnaissance survey shall cover the entire Taj east drain system and shall form the basis for identification of the extent of the field surveys, studies / investigation. As a minimum, the following features shall be identified.

- Location of obstructions – types, cause etc.
- Location of encroachments
- Location of low-lying areas extent, general ground level, type of establishment etc.
- Locations of culverts / bridges / pedestrian crossings etc.
- Location of existing wastewater / sewage disposal points to open drain

7.2. Topographical Survey & Investigations

The following survey & investigations have been carried out which are required for the design activity and will be carried out through our experienced surveyors with sophisticated survey equipment.

7.3. Site Survey:

- Site Plans (drawn to suitable scales) showing sufficient details including location, levels, high flood levels and ground water table, approaches, existing buildings, encroachments etc. for following components:

7.4. Alignment survey:

Alignment survey along the entire proposed alignment for drainage collection system, natural drains (nallas), with levels cross sectional details survey of natural nalla's will be conducted. Bearings along the alignment to be recorded and L-sections showing following features are plotted:

- Plan of the alignment
- Cross drainage works (bed level, size of culvert, width of cross drainage)
- Drain crossings with levels along bed, river width, high flood level, details of adjacent existing bridges
- Road and railways Crossings
- Details of roads adjacent to the alignment
- Details of encroachments, structures, power & telephone lines etc. along and across the alignment
- High flood levels and ground water tables recorded at every 500m along the course of the natural drains.

8.0. Approach & Methodology

- Based on the water sheds, the carrying capacities of the existing drains are being assessed and analysed for hydraulic adequacy with help of Bentley StormCAD V8i software's.
- Following improvement of existing hydraulic adequate road side drain will be proposed
  - Desilting and safe disposal of silt and solid waste from the drain
  - Raising of side wall to avoid in fall of soil from road into drains
  - Plastering of drain side wall with SRC cement to prevent corrosion from sulphate attack
  - Providing cover slab to protect the drain from solid waste fill
  - Providing grating arrangements at regular interval to allow rain water to flow into drain
- Following improvement of existing hydraulic adequate major open drain will be proposed

- The protection wall on both side of the drain shall be raised to safeguard the residents adjoining to drain
- Plastering of drain inside with SRC cement mortar to protect the structure from sulphate attack
- Providing cover slab to protect the drain from solid waste fill
- Providing grating arrangements at regular interval to allow rain water to flow into drain
- Wherever the side walls are damaged, new side walls with brickwork shall be proposed
- Wherever side walls are partially damaged retrofitting the walls with new brickwork shall be proposed
- Wherever earthen drains are identified, new drain with RCC walls shall be proposed

8.1. Design criteria for Strom Water Drains

General specification for Construction Material Proposed for new drain / Channel/Culvert as recommended by IS 456-2000 and other codes

Cement : The cement shall be Ordinary Portland Cement of 43 grade conforming to IS:8112. It is proposed to use sulphate resisting cement (SRC) to prevent corrosion of structure due to sulphate attack. Other specifications for storage, testing etc. shall be as per the relevant IS codes.

Aggregate: All the aggregate (coarse and fine) shall conform to the technical specification laid down under relevant IS code 383-1987. Unless otherwise specified, well graded coarse aggregate of 20mm size shall be used in reinforced cement concrete for drain wall, base slab and cover slab. For plain cement concrete too, graded 20mm size aggregate shall be used.

Water: Clean water for mixing and curing shall be free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to the concrete and steel and should confirm to the specifications laid IS:456 - 2000.

Admixtures: If required, chemical admixture in concrete shall be used as specified in IS:456-1978.

Reinforcement: Epoxi coated Mild steel and high tensile steel bars and hard drawn steel conforming to IS:432 (Pt-I)-1982. Cold twisted worked bars conforming to IS:1786- 1985 and hard drawn steel wire and fabric conforming to IS:1566-1982 shall be used and structural steel section conforming to IS:226-1975 shall be used.

8.2. Structural design of Drains

The engineer shall specify the material type to be used in the conduit for the underground drainage system. The material type shall be Reinforced concrete Drain of M-25 Grade, Density of concrete used 25KN/ m^3, Fe 415 Grade Steel used.

The drains are designed for two conditions

1. Drain full of water and no earth pressure from outside
2. Earth pressure from outside and no water in the drain

Drains Section to be provided Bottom sand filling 100mm, Levelling course using M 10 concrete 100mm thick and Bottom slab with RCC M25 concrete.

Drains have been provided with cover slab, Pre cast RCC Slabs are provided at regular intervals of 15 m to facilitate for cleaning purpose.

Gratings have also been provided at every 15m interval. The cover slab has been designed for live load and dead load.

Culvert

The Culverts are proposed at every road junctions and for crossing from one side to other side of the roads . The minimum size of the culverts is 2.0m x 2.0m Box culverts are suggested for adoption. It has been designed as RCC box culvert of M 25 concrete with live load (superimposed load) considered IRC Class AA loading, Density of concrete used 25KN/m^3, Fe 415 Grade Steel used.

Box culvert wall has been designed for the following four conditions

1. Culvert full of water and no earth pressure from outside

2. Earth pressure from outside and no water in the culver

3. Dead load and live load with no water in the culvert

Code References: IS:426-2000, IS 3370 Part III, IRC SP 6 and SP 13

9.0. Rainfall Analysis / Interpretation

The most important factor determining the size of storm water drain is the intensity of rainfall, which varies inversely to the duration. For any drain section, the intensity of rainfall corresponding to a duration equal to the time of concentration (time taken for storm water from the extreme end of the catchments to reach the point under consideration) at that section only will give the maximum flow.

- Time of Concentration also decides the economical section of the drain.
- The inadequate design factors and inadequate size of the drains will lead to either inundation or further damage to the existing storm water drainage system as well as the structures on the banks.
- Rainfall intensities and its return period are the critical factors in the design of any storm water drainage system.
- The size of the drain for a particular section needs to be designed to carry the runoff contributed by the respective catchment area.
- The topography of the contributing area also plays a major role.

The rainfall data available for Agra for 24 hour rainfall depth for a period of 30 years (1981 to 2012) were collected from the Indian Meteorological Department (IMD), Pune. The yearly maximum precipitation for past 30 years is furnished below:

Table 4 : Rainfall data for 30 years period

S.No	Year	Maximum Annual One Day Rainfall (mm)	Total Annual Rainfall (mm)
1	1981	365	511.5
2	1982	191.5	1086.2
3	1985	285	1011.2
4	1986	60	118.8
5	1987	500	500.5
6	1988	69.2	440.6
7	1989	85.6	285.1
8	1990	15	38.6
9	1991	8.1	34.2
10	1992	51	289.2
11	1993	204	452
12	1994	55	160.7
13	1995	49	329.7
14	1996	180	407
15	1997	34	78.8

S.No	Year	Maximum Annual One Day Rainfall (mm)	Total Annual Rainfall (mm)
16	1998	54	101.6
17	1999	60	169
18	2000	27	123.7
19	2001	16.1	79.3
20	2002	66.2	200.3
21	2003	55	184.9
22	2004	32	179.8
23	2005	68	228
24	2006	44	187.4
25	2007	52	75
26	2008	70	194
27	2009	12.6	22.5
28	2010	64	186
29	2011	58	170.4
30	2012	160	560
	Average	**99.71**	**280**

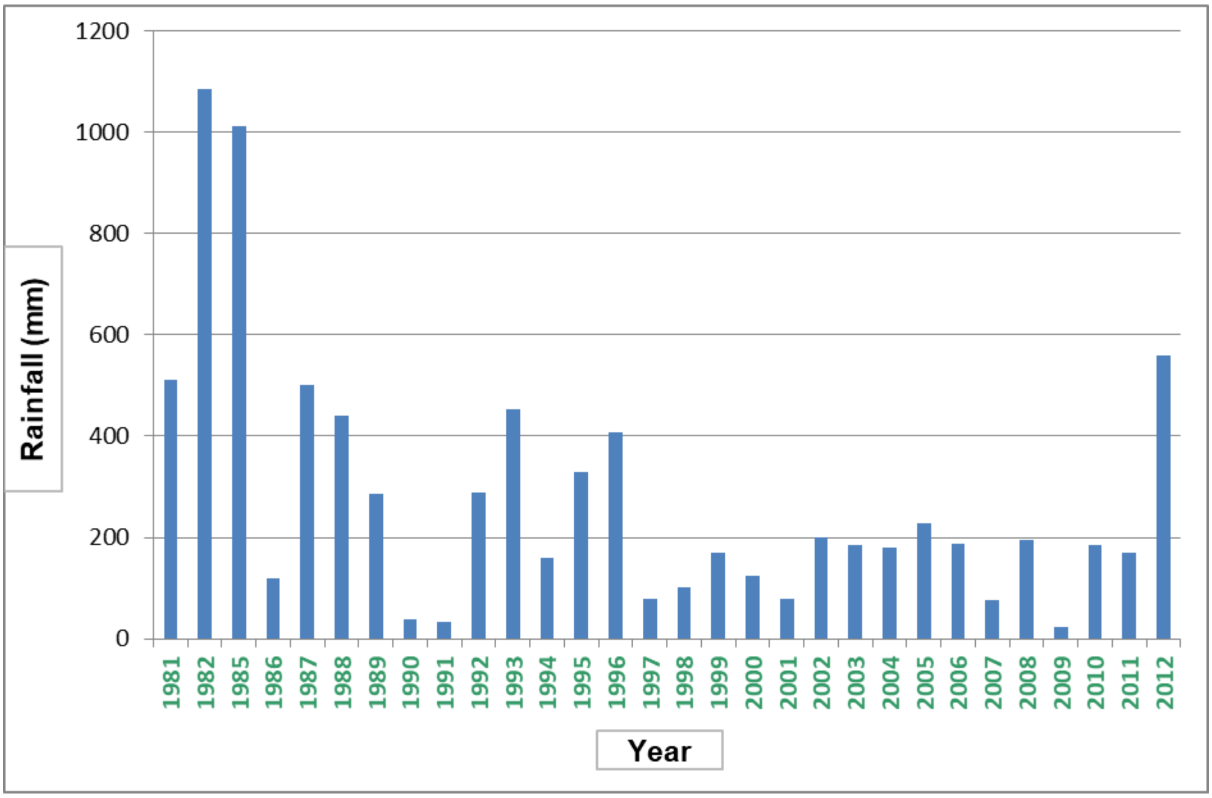


Figure 4: Graph showing the Maximum Total Annual rainfall for 30 years period

Rain fall has exceeded the average rain fall for about 9 years and for major periods the annual rain fall is below average.

To generate IDF curves and for forecasting the rain fall intensities for various return periods, the following statistical methods are adopted.

- Method based on Least Squares Principle
- Annual exceedance with IMD 1/3rd Rule Method & Gumbel's equation

9.1. Method based on Least Squares Principle

This is a statistical method used to determine a line of best fit by minimizing the sum of squares created by a mathematical function. A "square" is determined by squaring the distance between a data point and the regression line.

The least square equation for linear regression is **Y = A + BX**

Where,

Y = Dependent variable computed by the equation

A = y intercept, *B* = Slope of the line, *X* = Time period

The least square method tries to fit the line to the data that minimize the sum of the sum of the squares of the vertical distance between each data point and its corresponding point on the line.

In the least square method, the equations for '*A*' and '*B*' are

$$A = \bar{y} - B\bar{x}$$

and

$$B = \frac{\sum \bar{x}\bar{y} - n\,\bar{x}\bar{y}}{\sum x^2 - n\,x^2}$$

As far as the rainfall data are concerned,

Y = Max annual one day rainfall mm/day

$$X = \log\left(\log\frac{T}{T-1}\right)$$

Recurrence Interval in years T = (N+1)/m

N = number of years = 27

m = ranking number

Table 5 : Rainfall analysis by Least Square Method

Ranking "m"	Year	Max annual one day rainfall mm/day "y"	Total annual rainfall (mm)	Recurrence Interval in years T=(N+1)/m	x = loglogT/T-1	xy	x^2
1	1987	500	500.5	30.0	-1.832	-915.998	3.356
2	1981	365	511.5	15.0	-1.523	-556.045	2.321
3	1985	285	1011.2	10.0	-1.340	-381.768	1.794
4	1993	204	452	7.5	-1.207	-246.141	1.456
5	1982	191.5	1086.2	6.0	-1.101	-210.914	1.213
6	1996	180	407	5.0	-1.014	-182.454	1.027
7	1989	85.6	285.1	4.3	-0.938	-80.277	0.880
8	2008	70	194	3.8	-0.871	-60.945	0.758
9	1988	69.2	440.6	3.3	-0.810	-56.048	0.656
10	2005	68	228	3.0	-0.754	-51.290	0.569
11	2002	66.2	200.3	2.7	-0.703	-46.507	0.494
12	2010	64	186	2.5	-0.654	-41.852	0.428
13	1986	60	118.8	2.3	-0.608	-36.473	0.370
14	1999	60	169	2.1	-0.564	-33.830	0.318
15	2011	58	170.4	2.0	-0.521	-30.241	0.272
16	1994	55	160.7	1.9	-0.480	-26.410	0.231
17	2003	55	184.9	1.8	-0.440	-24.193	0.193
18	1998	54	101.6	1.7	-0.400	-21.610	0.160
19	2007	52	75	1.6	-0.361	-18.761	0.130
20	1992	51	289.2	1.5	-0.321	-16.390	0.103
21	1995	49	329.7	1.4	-0.282	-13.798	0.079
22	2006	44	187.4	1.4	-0.241	-10.607	0.058
23	1997	34	78.8	1.3	-0.199	-6.775	0.040
24	2004	32	179.8	1.3	-0.156	-4.977	0.024

Ranking "m"	Year	Max annual one day rainfall mm/day "y"	Total annual rainfall (mm)	Recurrence Interval in years T=(N+1)/m	x = loglogT/T-1	xy	x^2
25	2000	27	123.7	1.2	-0.109	-2.941	0.012
26	2001	16.1	79.3	1.2	-0.058	-0.933	0.003
27	1990	15	38.6	1.1	0.000	0.000	0.000
28	2009	12.6	22.5	1.1	0.070	0.888	0.005
29	1991	8.1	34.2	1.0	0.169	1.372	0.029
N = 29	**Sum**					**- 3075.919**	**16.978**
	Mean	97.6	270.6		-0.595		

Mean y = 97.6
Mean x = -0.595

Sc

$$B = \frac{\sum x\,y - N\,\bar{x}\,\bar{y}}{\sum x^2 - N\,\bar{x}^2}$$

0.3536

B = -207.088

$$A = \bar{y} - B\,\bar{x}$$

A = -25.520

$$F = A + B \log\left(\log \frac{T}{T-1}\right)$$

$$I_0 = \frac{F}{T}\left[\frac{T+1}{t_c+1}\right]$$

F - Maximum rainfall in T hours (Here, 24 hours)
T = 24 hours
t_c - Time of concentration in hours

T = 1.1	**-29.16746034**		**-Io = 15.19**	
T = 1.5	**F = 41.03**	mm	**Io = 21.37**	mm/hr
T = 2	**F = 82.45**	mm	**Io = 42.94**	mm/hr
T = 2.5	**F = 109.90**	mm	**Io = 57.24**	mm/hr
T = 3	**F = 130.68**	mm	**Io = 68.06**	mm/hr
T = 3.5	**F = 147.45**	mm	**Io = 76.80**	mm/hr
T = 4	**F = 161.54**	mm	**Io = 84.14**	mm/hr
T = 4.5	**F = 173.70**	mm	**Io = 90.47**	mm/hr
T = 5	**F = 184.39**	mm	**Io = 96.04**	mm/hr
T = 10	**F = 251.88**	mm	**Io = 131.19**	mm/hr
T = 20	**F = 316.62**	mm	**Io = 164.91**	mm/hr
T = 50	**F = 400.42**	mm	**Io = 208.55**	mm/hr
T = 100	**F = 463.22**	mm	**Io = 241.26**	mm/hr

Based on the above equations the rain fall intensity for various return periods is arrived.

Table 6: Critical Rainfall intensity be Least Square Method

Minutes	Critical Rainfall Intensity (mm/hr)				
	2 Year	5 Year	10 Year	50 Year	100 Year
5	79.30	177.30	242.20	385.00	445.40
10	73.60	164.60	224.90	357.50	413.60
15	68.70	153.70	209.90	333.70	386.00
20	64.40	144.10	196.80	312.80	361.90
25	60.60	135.60	185.20	294.40	340.60
30	57.30	128.00	174.90	278.10	321.70
35	54.20	121.30	165.70	263.40	304.70
40	51.50	115.20	157.40	250.30	289.50
45	49.10	109.80	149.90	238.30	275.70
50	46.80	104.80	143.10	227.50	263.20
55	44.80	100.20	136.90	217.60	251.70
60	**42.9**	**96**	**131.2**	**208.6**	**241.3**

The IDF curve for various return periods for a duration of 60 minutes has been given below:

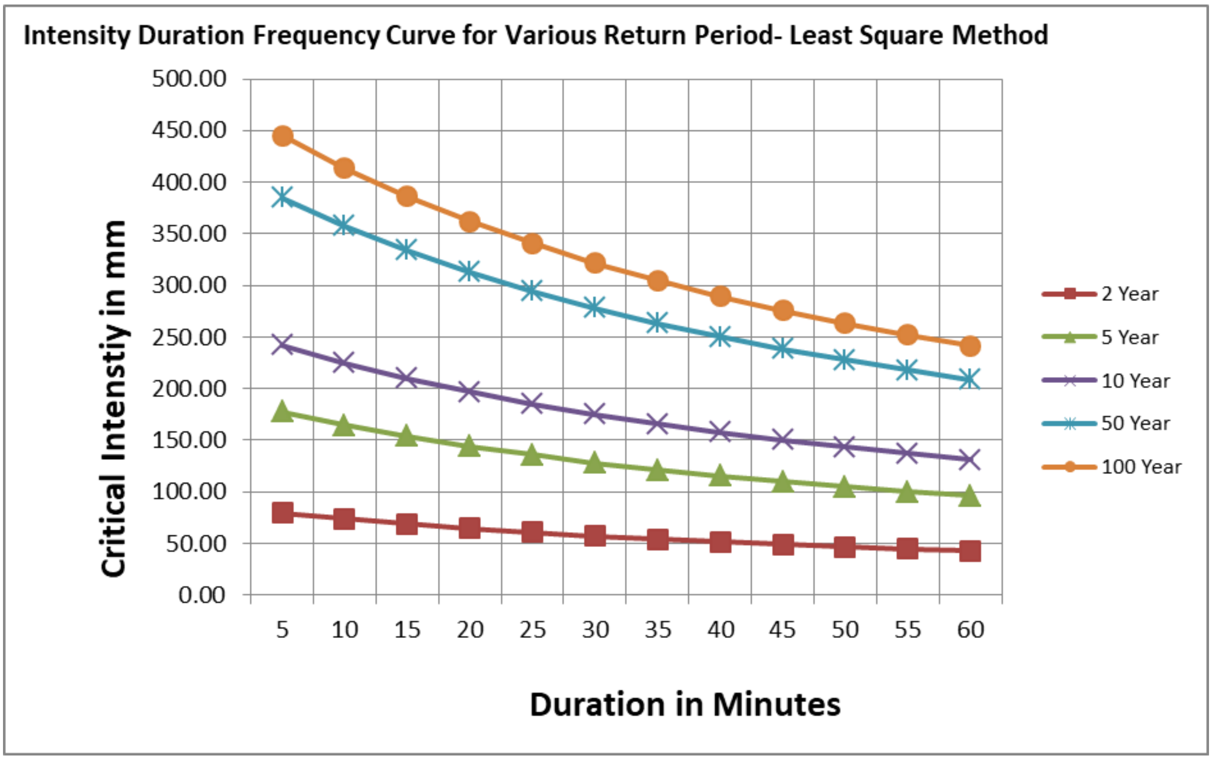


Figure 5: IDF Curve generation in Least Square Method

9.2. IMD 1/3rd Rule Method of Rainfall Intensity

Rainfall data being a random probability distribution, fit well with the theories of probability. Therefore, Gumbel's Extreme Value distribution can be ideally used to represent the rainfall Intensity Duration Frequency (IDF) relation.

The basic data required consists of rainfall details of the area under consideration for a substantial period. The rain fall details for 30 years period, obtained in respect of Agra region from the IMD has been used as the basic data.

IMD has suggested the 1/3rd rule for obtaining hourly rainfall from 24 hour data.

To generate shorter duration series (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, hour series) the following IMD formula has been used.

$P_t = P_{24} (t / 24)^{1/3}$

Where
Pt = Rainfall of t hours duration in mm
P24 = Daily Rainfall value in mm
t = Shorter duration in hours (1, 2, 3…)

The above Equation is used to generate the extreme value series of duration 1 to 12 hours in steps of 1 hour. The resulting series are given below:

Table 7: Rainfall intensity by IMD 1/3rd Rule

Year	Hours					Year	Hours				
	1	2	6	12	24		1	2	6	12	24
1981	126.50	159.40	229.90	289.70	365.00	1998	18.70	23.60	34.00	42.90	54.00
1982	66.40	83.60	120.60	152.00	191.50	1999	20.80	26.20	37.80	47.60	60.00
1985	98.80	124.50	179.50	226.20	285.00	2000	9.40	11.80	17.00	21.40	27.00
1986	20.80	26.20	37.80	47.60	60.00	2001	5.60	7.00	10.10	12.80	16.10
1987	173.30	218.40	315.00	396.90	500.00	2002	23.00	28.90	41.70	52.50	66.20
1988	24.00	30.20	43.60	54.90	69.20	2003	19.10	24.00	34.60	43.70	55.00
1989	29.70	37.40	53.90	67.90	85.60	2004	11.10	14.00	20.20	25.40	32.00
1990	5.20	6.60	9.40	11.90	15.00	2005	23.60	29.70	42.80	54.00	68.00
1991	2.80	3.50	5.10	6.40	8.10	2006	15.30	19.20	27.70	34.90	44.00
1992	17.70	22.30	32.10	40.50	51.00	2007	18.00	22.70	32.80	41.30	52.00
1993	70.70	89.10	128.50	161.90	204.00	2008	24.30	30.60	44.10	55.60	70.00
1994	19.10	24.00	34.60	43.70	55.00	2009	4.40	5.50	7.90	10.00	12.60
1995	17.00	21.40	30.90	38.90	49.00	2010	22.20	28.00	40.30	50.80	64.00
1996	62.40	78.60	113.40	142.90	180.00	2011	20.10	25.30	36.50	46.00	58.00
1997	11.80	14.90	21.40	27.00	34.00	2012	55.50	69.90	100.80	127.00	160.00
Average							**34.577**	**43.550**	**62.800**	**79.143**	**99.710**
Average Per Hour							**34.577**	**21.775**	**10.467**	**6.595**	**4.155**

The rainfall (P_T) corresponding to a specific return period (T) using **the Gumbel's extreme value distribution** is given by:

$P_T = \sigma + K_T s$

Where 'σ' is the mean value of the original series and 's' its standard deviation.

K_T, the frequency factor given by:

KT values are calculated for different return periods using Gumbel's distribution

$$K_T = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left[\ln\left(\frac{T}{T-1}\right)\right]\right\}$$

T (years)	2	5	10	20	50	100
K_T	-0.164	0.719	1.305	1.866	2.592	3.137

Based on the above equation rainfall intensities for various return periods are calculated and furnished below:

Table 8: Rainfall intensity for various return periods by Gumbel's Method

Minutes	RETURN PERIODS				
	2 Year	5 Year	10 Year	50 Year	100 Year
5	145.5	326.73	447.01	711.17	823.03
10	91.6	205.72	281.46	447.79	518.23
15	69.93	157.02	214.82	341.76	395.51
20	57.73	129.63	177.35	282.15	326.53
25	49.75	111.72	152.84	243.16	281.41
30	44.05	98.92	135.33	215.31	249.17
35	39.74	89.25	122.1	194.26	224.82
40	36.37	81.66	111.71	177.72	205.68
45	33.63	75.51	103.31	164.35	190.2
50	31.34	70.37	96.28	153.18	177.27
55	29.41	66.05	90.36	143.76	166.37
60	27.77	62.32	85.25	135.61	156.94

The IDF curve has been generated for various return periods.

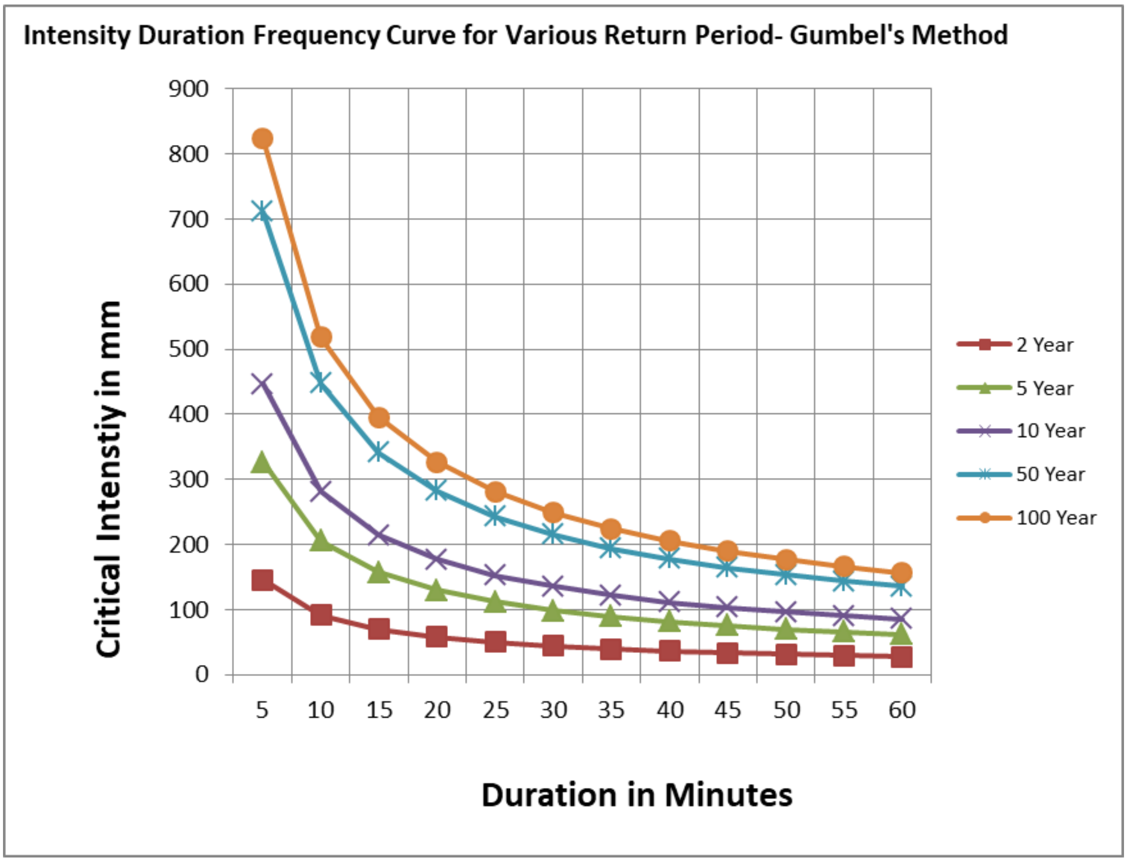


Figure 6: IDF Curve generation by Gumbel's Method

9.3. Comparison of values

The rainfall intensity for various return periods arrived by least square method and Gumbel's method are compared and the comparative table is given below.

Table 9: Comparison of Rainfall Intensity

Intensity of rain fall in MM/HOUR					
Method	**RETURN PERIOD IN YEARS**				
	2	**5**	**10**	**50**	**100**
Gumbel's Method	**28.20**	**62.55**	**85.34**	**135.41**	**156.61**
Least Square Method	**42.90**	**96.00**	**131.20**	**208.60**	**241.30**

Based on the above values a chart is drawn and shown below:

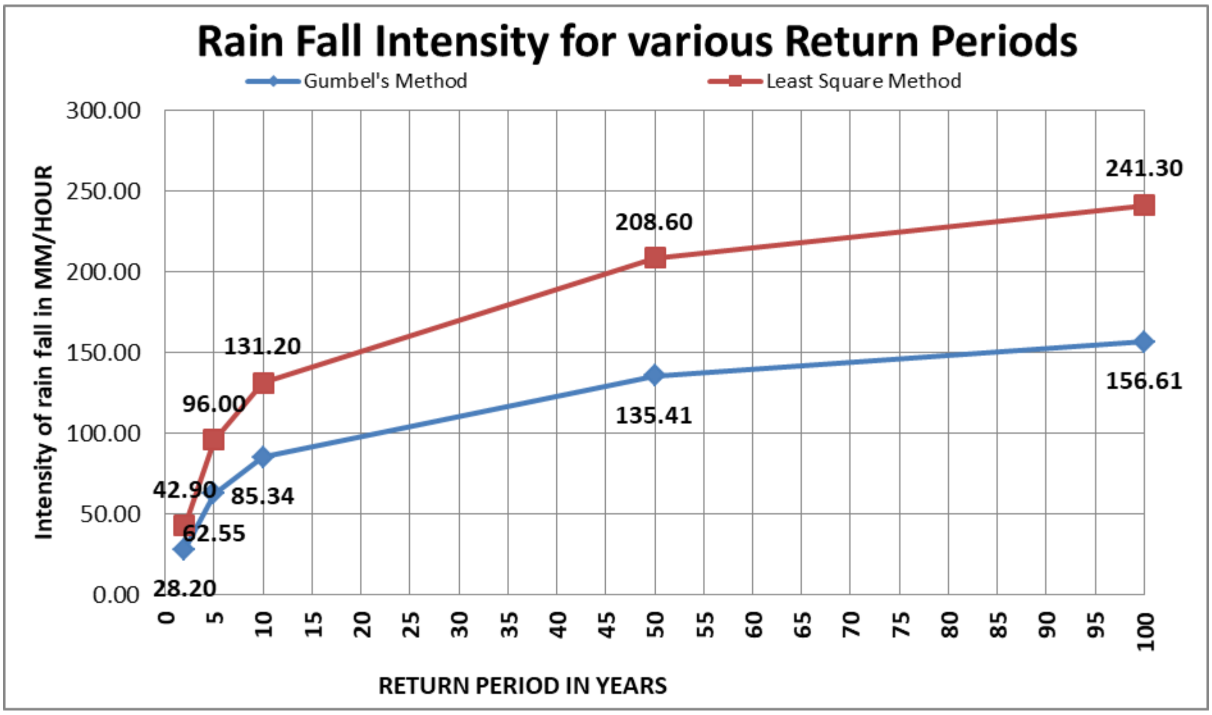


Figure 7: Graph showing the comparison of Rainfall Intensity by LSM and IMD 1/3rd Rule

9.4. Comparison of values

As already mentioned, it is seen that the rain fall data, obtained from IMD, has exceeded the average rain fall only for 9 years, and for major periods the annual rain fall are below average.

Therefore the values, as given below, arrived from Annual exceedance 1/3rd rule with Gumbel's method, suits to Agra region, are adopted for calculating the storm water flow and for designing the Storm water drainage system.

Table 10: Rainfall Intensity recommended for the designs for various Return Periods

Return Period in Years	Intensity of rain fall in mm / hr.
2	28.20

10.0 Delineation of Strom Water Drainage Zones

The whole catchment area of Taj east drain has been divided into 7 storm water drainage catchment zones.

The total catchment area considered for this project is about 2369 Hect (or) 23.69.Sq.km.. The details of the catchments, drainage plus flow accumulation are shown in the figure 7.

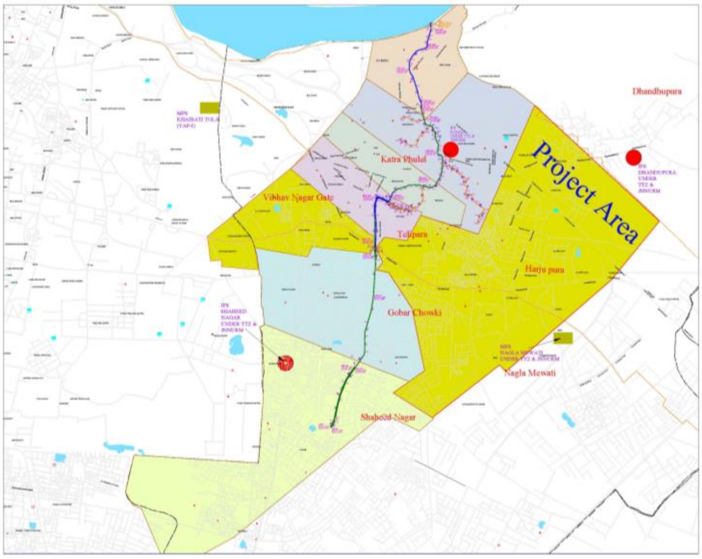


Figure 8: Details of catchment and flow details

The objective is to assess the problems and to identify with the aid of modern hydrological and hydraulic modelling techniques, measures to alleviate the problems along the drain. These catchments have different characteristic of their own have different types of land use pattern that affected the discharges. They have different soil characteristics; different permeability and flood absorption characteristic.

Table 11: Left Side Drain

Chainage Number	Label	Start Node	Stop Node	Length (Scaled) (m)	Flow (m^3/s)	Capacity (Full Flow) (m^3/s)	Flow / Capacity (Design) (%)	System CA (ha)
0 to 60	CO-1082	CH-0	CH-60	55.06	0.30	0.87	34.10	2.09
60 to 520	CO-1080	CH-60	CH-270	210.27	0.74	1.05	70.90	5.60
	CO-1077	CH-270	CH-390	122.47	0.75	2.55	29.50	6.60
	CO-1074	CH-390	CH-520	130.38	0.86	1.42	60.50	7.77
520 to 520-1 (Cul)	CO-1096	CH-520	CH-520-1	8.92	0.93	16.27	5.70	8.86
810 to 930	CO-1091	CH-810	CH-930	118.73	1.43	1.67	85.80	14.58
930 to 1140	CO-1097	CH-930	CH-1140	211.8	1.57	1.24	126.60	16.28
1140 to 1500	CO-1101	CH-1140	CH-1500	358.27	1.67	2.87	58.00	17.84
1500 to 1520	CO-1183	CH-1500	CH-1520	25.57	1.69	6.29	26.90	18.65
1520 to 1532	CO-1107	CH-1520	CH-1532	12.66	2.09	6.37	32.80	23.05
1532 to 1800	CO-141	CH-1532	CH-1800	261.56	2.58	6.30	40.90	28.44
1800 to 2040	CO-147	CH-1800	CH-1940	144.1	2.66	4.03	66.10	29.74
	CO-151	CH-1940	CH-1950	9.36	2.72	4.03	67.50	30.66
	CO-152	CH-1950	CH-2040	97.67	2.77	4.03	68.90	31.32
							Total	**241.474**

Table 12: Right Side Drain

Chainage Number	Label	Start Node	Stop Node	Length (Scaled) (m)	Flow (m^3/s)	Capacity (Full Flow) (m^3/s)	Flow / Capacity (Design) (%)	System CA (ha)
0-1 to 60-1	CO-1072	CH-0-1	CH-60-1	58.55	0.30	0.42	71.90	2.13
60-1 to 60 (Cul)	CO-1086	CH-60-1	CH-60	8.45	0.32	4.92	6.50	2.42
90-1 to 380-1	CO-189	CH-90-1	CH-380-1	291.46	0.12	1.99	6.20	0.87
380-1 to 520-1	CO-193	CH-380-1	CH-520-1	141.67	0.24	2.74	8.90	2.05
520-1 to 680	CO-1071	CH-520-1	CH-680	160.10	1.23	1.31	93.40	11.70
680 to 810	CO-1090	CH-680	CH-810	125.54	1.32	3.29	40.10	13.20
1440-1 to 1500-1	CO-1196	CH-1440-1	CH-1500-1	59.69	0.02	1.47	1.3	0.1385
1500-1 to 1520-1	CO-1185	CH-1500-1	CH-1520-1	22.2	0.02	5.66	0.4	0.1679
1520-1 to 1532-1	CO-1108	CH-1520-1	CH-1532-1	12.00	0.85	2.10	40.40	9.36
1532-1 to 2010-1	CO-1110	CH-1532-1	CH-1800-1	265.05	2.18	2.98	73.30	24.23
	CO-1116	CH-1800-1	CH-1830-1	140.97	2.21	2.98	74.30	25.03
	CO-1121	CH-1830-1	CH-2010-1	90.79	2.20	2.98	73.90	25.15
2010-1 to 2040	CO-1120	CH-2010-1	CH-2040	7.79	2.25	2.98	75.60	25.91
							Total	**142.36**

Table 13: Single Drain

Chainage Number	Label	Start Node	Stop Node	Length (Scaled) (m)	Flow (m^3/s)	Capacity (Full Flow) (m^3/s)	Flow / Capacity (Design) (%)	System CA (ha)
2040 to 2130	CO-155	CH-2040	CH-2130	88.42	5.01	2.21	227.10	57.69
2130 to 2190	CO-158	CH-2130	CH-2190	60.18	5.04	5.52	91.20	58.42
2190 to 2270	CO-159	CH-2190	CH-2270	84.02	5.09	16.70	30.50	59.21
2270 to 2340	CO-160	CH-2270	CH-2340	120.45	5.14	9.32	55.20	59.95
2340 to 2430	CO-1146	CH-2340	CH-2430	35.68	5.24	26.46	19.80	61.45
2430 to 2700	CO-162	CH-2430	CH-2460	29.6	5.28	57.09	9.20	61.92
	CO-163	CH-2460	CH-2520	59.27	5.33	33.86	15.70	62.60
	CO-164	CH-2520	CH-2580	59.93	5.38	11.52	46.70	63.37
	CO-165	CH-2580	CH-2610	32.12	5.43	41.52	13.10	64.16

Chainage Number	Label	Start Node	Stop Node	Length (Scaled) (m)	Flow (m^3/s)	Capacity (Full Flow) (m^3/s)	Flow / Capacity (Design) (%)	System CA (ha)
	CO-166	CH-2610	CH-2670	58.32	5.45	32.71	16.70	64.48
	CO-167	CH-2670	CH-2700	30.36	5.46	54.68	10.00	64.74
2700 to 2850	CO-1143	CH-2700	CH-2730	30.93	5.73	74.14	7.70	68.04
	CO-1144	CH-2730	CH-2790	58.4	5.76	52.42	11.00	68.47
	CO-169	CH-2790	CH-2850	60.88	5.77	55.64	10.40	68.69
2850 to 2970	CO-170	CH-2850	CH-2910	60.07	5.81	68.26	8.50	69.30
	CO-171	CH-2910	CH-2940	29.43	5.84	78.17	7.50	69.81
	CO-172	CH-2940	CH-2970	28.64	5.91	73.36	8.10	70.79
2970 to 3030	CO-173	CH-2970	CH-3000	29.34	6.04	92.90	6.50	72.35
	CO-174	CH-3000	CH-3030	38.46	6.08	220.94	2.80	73.05
3030 to 3120	CO-175	CH-3030	CH-3120	76.97	6.30	67.81	9.30	75.67
3120 to 3215	CO-176	CH-3120	CB-3215	95.69	6.41	179.55	3.60	77.35
3215 to 3225	CO-177	CB-3215	CH-3225	11.07	6.44	17.49	36.80	78.01
3225 to 4000	CO-178	CH-3225	CH-3300	74.53	6.47	9.28	69.70	78.59
	CO-1193	CH-3300	CH-3390	90.09	6.48	10.38	62.40	79.25
	CO-180	CH-3390	CH-3540	150.27	6.46	10.38	62.30	79.96
	CO-1191	CH-3540	CH-3600	58.8	6.40	10.38	61.70	80.51
	CO-1177	CH-3600	CH-3630	29.72	6.41	10.38	61.80	81.12
	CO-182	CH-3630	CH-3750	120.03	6.46	10.38	62.20	81.91
	CO-183	CH-3750	CH-3810	59.92	6.43	10.38	61.90	82.59
	CO-184	CH-3810	CH-3870	61.01	6.43	10.38	61.90	83.14
	CO-185	CH-3870	CH-3900	30.1	6.42	10.38	61.80	83.54
	CO-186	CH-3900	CH-3990	90.07	6.43	10.38	61.90	83.99
	CO-187	CH-3990	OF-3	15.17	6.41	10.38	61.80	84.59
							Total	**2,368.68**

11.0 Hydraulic Analysis of Taj East drain

The Runoff flow from these catchment drains into Taj east drains during rainy season only, the drains may flooded / overtopped during rainy season, this may be due to

- The change in the land use,
- Change in the rainfall pattern
- Reduction in the carrying capacity of drains due to dumping of solid wastes, vegetation growths, silting up of the beds and

The existing Land use detail has been used to arrive at the probable run off co-efficient for the calculations of discharges in the Macro drains. The cross sectional and longitudinal sectional details of drain have been carried out

For the analysis and adequacy check of the Taj east drain Bentley's StormCAD software has been used and the results are furnished in Annexure- II

12.0 Flood occurrence under various scenarios

The adequacy of the proposed sections, in respect of Taj east drain have been checked for the storm return periods of 2 year, and analysed. As per the analysis, the flooding will occur at the reaches that are indicated in RED colour, in the figures furnished below:

Figure 9:Legend

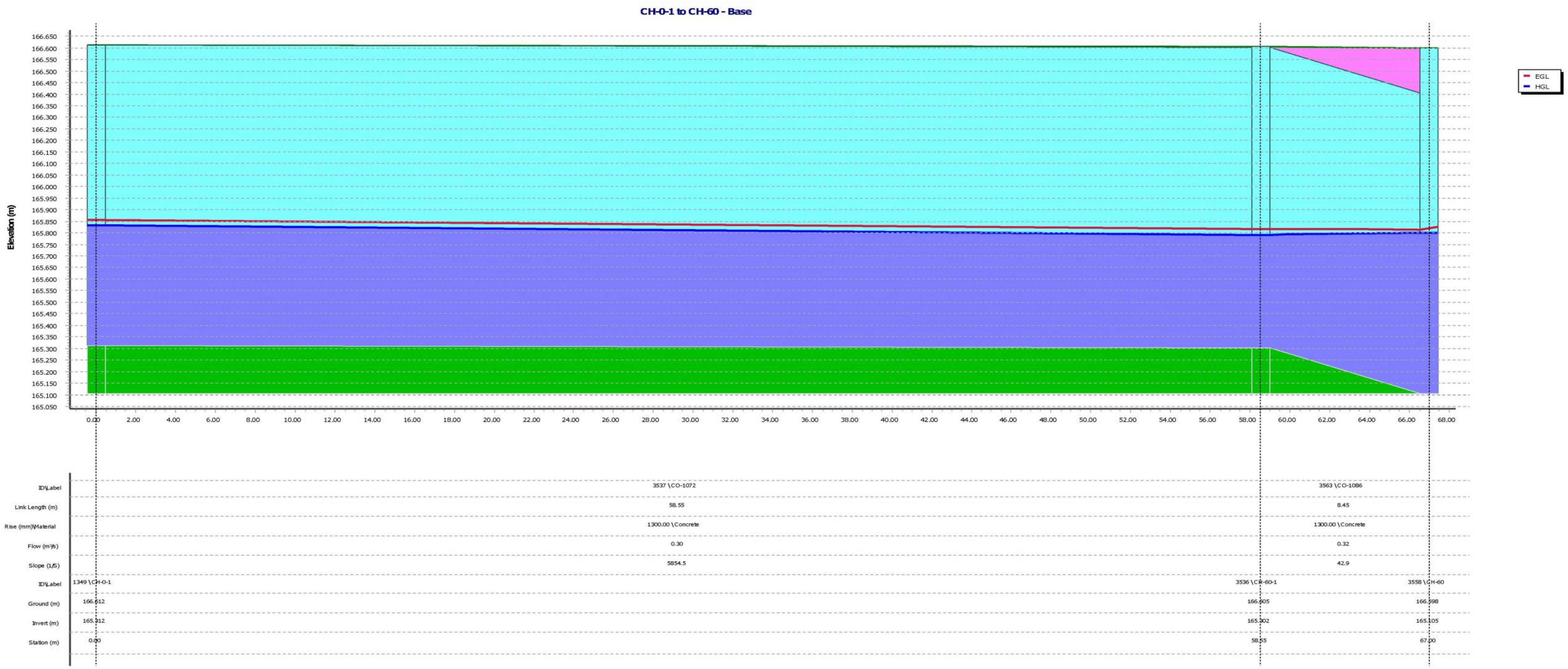
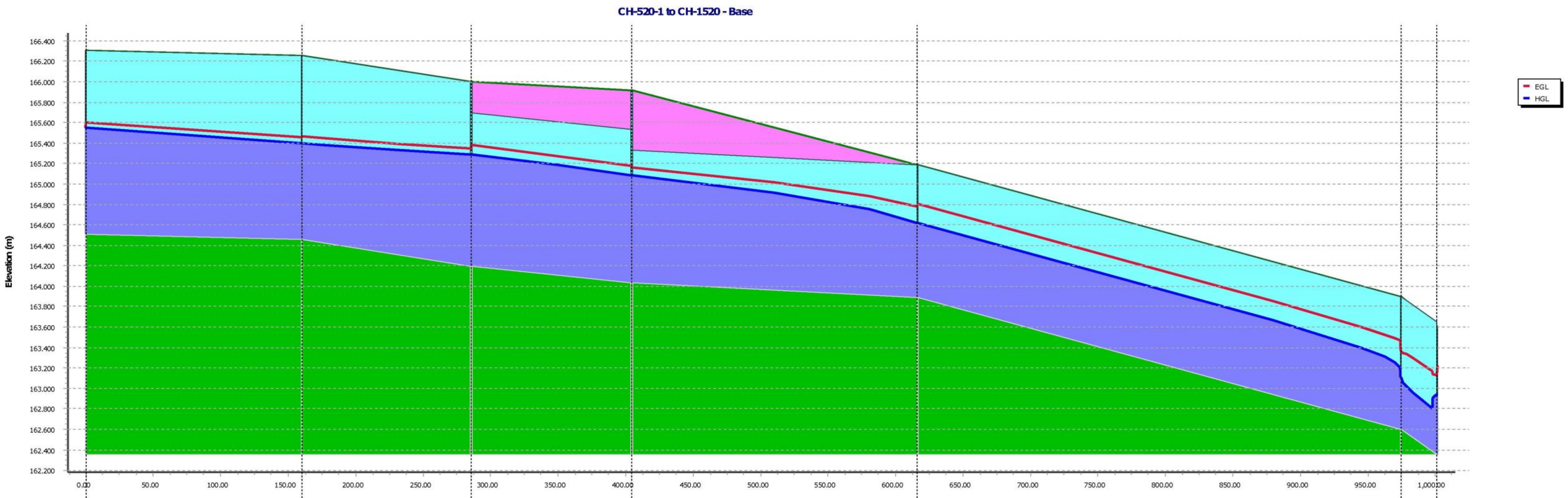


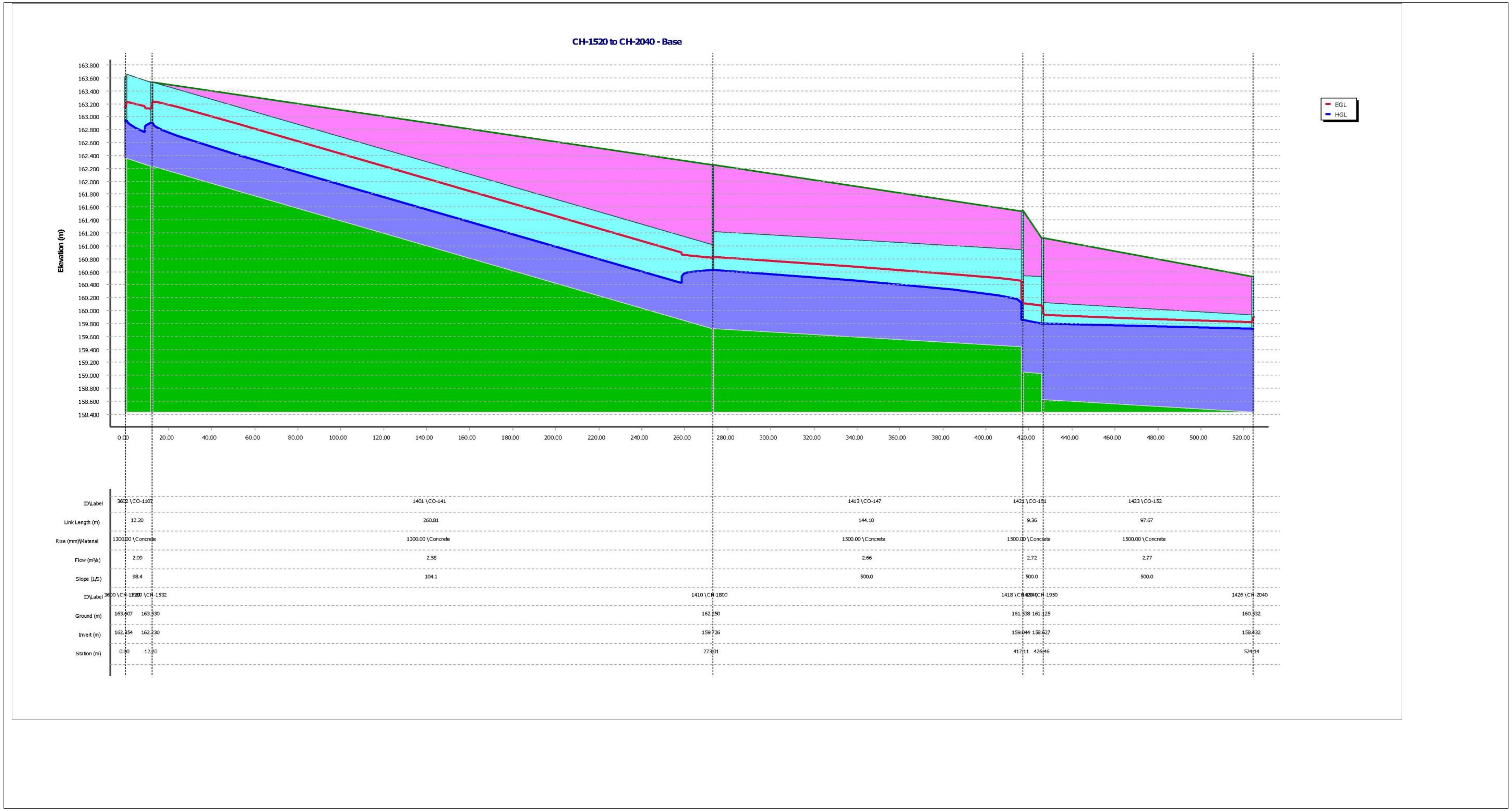
Figure 10: Flood occurring reaches for 2 years return period

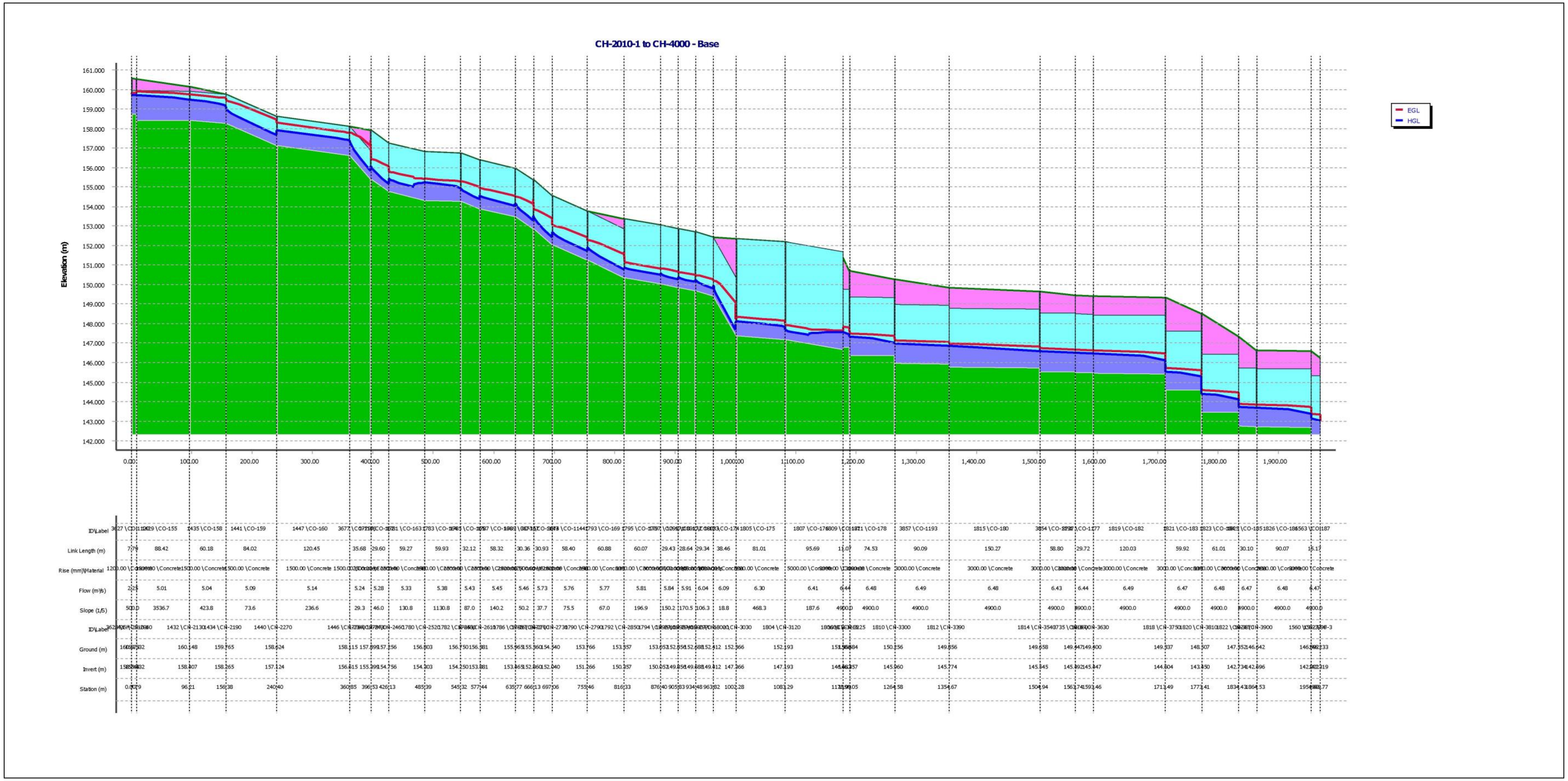

CH-90-1 to CH-520-1 - Base
Elevation (m)
166.700
166.600
166.500
166.400
166.300
166.200
166.100
166.000
165.900
165.800
165.700
165.600
165.500
165.400
165.300
165.200
165.100
165.000
164.900
164.800
164.700
164.600
164.500
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
240.00
260.00
280.00
300.00
320.00
340.00
360.00
380.00
400.00
420.00
EGL
HGL
ID\Label
1353 \CO-189
1361 \CO-193
Link Length (m)
291.46
141.67
Rise (mm)\Material
1300.00 \Concrete
1800.00 \Concrete
Flow (m³/s)
0.12
0.24
Slope (1/S)
578.3
708.3
ID\Label
1350 \CH-90-1
1358 \CH-380-1
1360 \CH-520-1
Ground (m)
166.660
166.505
166.305
Invert (m)
165.209
164.705
164.505
Station (m)
0.00
291.46
433.13



ID\Label	3535 \CO-1071	3572 \CO-1090	3573 \CO-1091	3583 \CO-1097	3591 \CO-1101	3836 \CO-1183
Link Length (m)	160.10	125.54	118.73	211.80	358.27	26.76
Rise (mm)\Material	1800.00 \Concrete	1800.00 \Concrete	1500.00 \Concrete	1300.00 \Concrete	1300.00 \Concrete	1300.00 \Concrete
Flow (m³/s)	1.23	1.32	1.43	1.57	1.67	1.69
Slope (1/S)	3078.9	490.4	719.6	1481.1	277.5	109.7

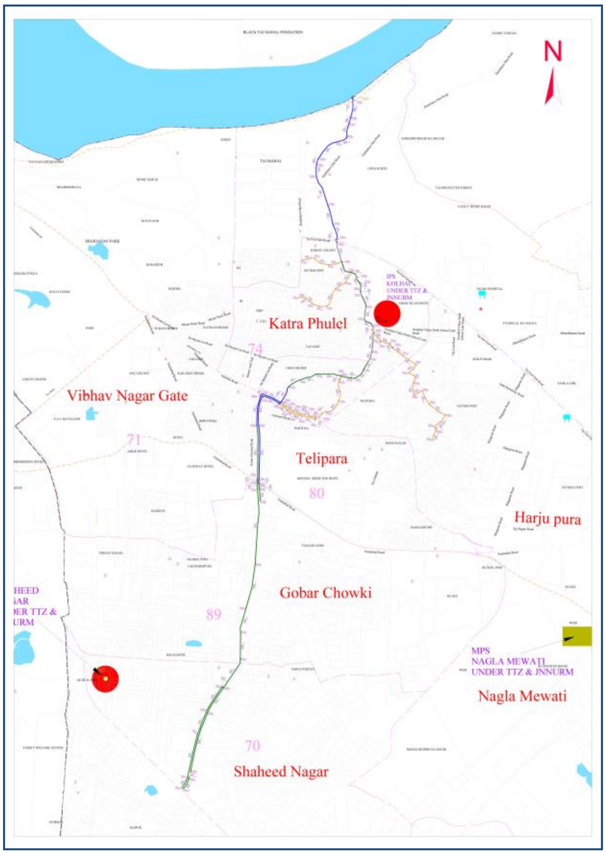
ID\Label	1360 \CH-520-1	1366 \CH-680	3571 \CH-810	1370 \CH-930	3588 \CH-1140	3834 \CH-15[illegible]	3600 \CH-1520
Ground (m)	166.305	166.253	165.997	165.913	165.189	163.898	163.607
Invert (m)	164.505	164.453	164.197	164.032	163.889	162.598	162.354
Station (m)	0.00	160.10	285.64	404.37	616.17	974.44	1001.20


CH-1520 to CH-2040 - Base
Elevation (m)
EGL
HGL


CH-2010-1 to CH-4000 - Base
Elevation (m)
EGL
HGL
ID\Label
Link Length (m)
Rise (mm)\Material
Flow (m³/s)
Slope (1/S)
ID\Label
Ground (m)
Invert (m)
Station (m)

13.0 Improvements of Taj east drain

This drain originate from Shamshabad road and traverse through and terminates at river Yamuna. Length of Taj east drain is 4000 m and width of the channel varies from 0.90 m to 6 m. The following settlements fall in the Taj east drain catchment area Rajpur, Shamshabad Road, Vashistpuram, KalindiVihar Road, Bank Colony, Bagh Rajpur, Pakki Sarai,Lacchipura, Shaheed nagar, Kareem Nagar, GobarChauki, M.P. Pura, Harjupura, Gummat, PuraniMandi, sanjay colony, Taj Ganj, Navada, Patiram ki Bagichi, Sheik Bulakhi, Paak Tola, Basai Kalan, Marutam Nagar, Billochpura, Tajganj, Telipada, Kohai and Taj East Gate Road (Source: City Sanitation Plan, Agra, 2011) .



The adequacy of drain section for various scenarios 2 years return periods have been analysed and the section of channel for 2 years return period has been modified and tabulated below:

Table 14: Left Side Drain

Chainage Number	Label	Start Node	Stop Node	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Invert (Start) (m)	Invert (Stop) (m)	Length (Scaled) (m)	Conduit Description	Slope (Calculated) (1/S)	Velocity (m/s)	Flow (m^3/s)	Capacity (Full Flow) (m^3/s)	Flow / Capacity (Design) (%)
0 to 60	CO-1082	CH-0	CH-60	166.612	166.598	166.012	165.105	55.06	SS-0.60 x 0.60	60.70	2.18	0.30	0.87	34.10
60 to 520	CO-1080	CH-60	CH-270	166.598	166.567	165.105	165.067	210.27	SS-1.50 x 1.50	5533.40	0.51	0.74	1.05	70.90
	CO-1077	CH-270	CH-390	166.567	166.436	165.067	164.936	122.47	SS-1.50 x 1.50	934.90	0.98	0.75	2.55	29.50
	CO-1074	CH-390	CH-520	166.436	166.393	164.936	164.893	130.38	SS-1.50 x 1.50	3032.20	0.66	0.86	1.42	60.50
520 to 520-1 (Cul)	CO-1096	CH-520	CH-520-1	166.393	166.305	164.893	164.505	8.92	SS-1.50 x 1.50	23.00	3.58	0.93	16.27	5.70
810 to 930	CO-1091	CH-810	CH-930	165.997	165.913	164.197	164.032	118.73	SS-1.00 x 1.50	719.60	1.23	1.43	1.67	85.80
930 to 1140	CO-1097	CH-930	CH-1140	165.913	165.189	164.032	163.889	211.8	SS-1.20 x 1.30	1481.10	1.01	1.57	1.24	126.60
1140 to 1500	CO-1101	CH-1140	CH-1500	165.189	163.898	163.889	162.598	358.27	SS-1.20 x 1.30	277.50	1.91	1.67	2.87	58.00
1500 to 1520	CO-1183	CH-1500	CH-1520	163.898	163.607	162.598	162.354	25.57	SS-1.50 x 1.30	104.80	2.71	1.69	6.29	26.90
1520 to 1532	CO-1107	CH-1520	CH-1532	163.607	163.53	162.354	162.23	12.66	SS-1.50 x 1.30	102.10	2.91	2.09	6.37	32.80
1532 to 1800	CO-141	CH-1532	CH-1800	163.53	162.25	162.23	159.726	261.56	SS-1.50 x 1.30	104.40	3.06	2.58	6.30	40.90
1800 to 2040	CO-147	CH-1800	CH-1940	162.25	161.538	159.726	159.438	144.1	SS-1.50 x 1.50	500.00	1.91	2.66	4.03	66.10
	CO-151	CH-1940	CH-1950	161.538	161.125	159.044	159.025	9.36	SS-1.50 x 1.50	500.00	1.92	2.72	4.03	67.50
	CO-152	CH-1950	CH-2040	161.125	160.532	158.627	158.432	97.67	SS-1.80 x 1.50	500.00	1.93	2.77	4.03	68.90

Table 15: Right Side Drain

Chainage Number	Label	Start Node	Stop Node	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Invert (Start) (m)	Invert (Stop) (m)	Length (Scaled) (m)	Conduit Description	Slope (Calculated) (1/S)	Velocity (m/s)	Flow (m³/s)	Capacity (Full Flow) (m³/s)	Flow / Capacity (Design) (%)
0-1 to 60-1	CO-1072	CH-0-1	CH-60-1	166.612	166.605	165.312	165.302	58.55	SS-0.90 x 1.30	5,854.50	0.39	0.30	0.42	71.90
60-1 to 60 (Cul)	CO-1086	CH-60-1	CH-60	166.605	166.598	165.302	165.105	8.45	SS-0.90 x 1.30	42.90	2.37	0.32	4.92	6.50
90-1 to 380-1	CO-189	CH-90-1	CH-380-1	166.660	166.505	165.209	164.705	291.46	SS-1.20 x 1.30	578.30	0.68	0.12	1.99	6.20
380-1 to 520-1	CO-193	CH-380-1	CH-520-1	166.505	166.305	164.705	164.505	141.67	SS-1.20 x 1.80	708.30	0.80	0.24	2.74	8.90
520-1 to 680	CO-1071	CH-520-1	CH-680	166.305	166.253	164.505	164.453	160.10	SS-1.20 x 1.80	3,078.90	0.68	1.23	1.31	93.40
680 to 810	CO-1090	CH-680	CH-810	166.253	165.997	164.453	164.197	125.54	SS-1.20 x 1.80	490.40	1.45	1.32	3.29	40.10
1440-1 to 1500-1	CO-1196	CH-1440-1	CH-1500-1	164.723	163.782	164.223	162.582	59.69	SS-0.90 x 0.50	36.4	0.9	0.02	1.47	1.3
1500-1 to 1520-1	CO-1185	CH-1500-1	CH-1520-1	163.782	163.607	162.582	161.742	22.2	SS-0.90 x 1.20	26.4	1.06	0.02	5.66	0.4
1520-1 to 1532-1	CO-1108	CH-1520-1	CH-1532-1	163.607	163.530	161.742	161.730	12.00	SS-1.50 x 1.20	1,000.00	1.10	0.85	2.10	40.40
1532-1 to 2010-1	CO-1110	CH-1532-1	CH-1800-1	163.530	162.227	160.957	160.427	265.05	SS-1.50 x 1.20	500.00	1.83	2.18	2.98	73.30
	CO-1116	CH-1800-1	CH-1830-1	162.227	161.303	159.785	159.503	140.97	SS-1.50 x 1.20	500.00	1.83	2.21	2.98	74.30
	CO-1121	CH-1830-1	CH-2010-1	161.303	160.573	158.954	158.773	90.79	SS-1.50 x 1.20	500.00	1.83	2.20	2.98	73.90
2010-1 to 2040	CO-1120	CH-2010-1	CH-2040	160.573	160.532	158.748	158.732	7.79	SS-1.80 x 1.20	500.00	1.84	2.25	2.98	75.60

Table 16: Single Drain

Chainage Number	Label	Start Node	Stop Node	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Invert (Start) (m)	Invert (Stop) (m)	Length (Scaled) (m)	Conduit Description	Slope (Calculated) (1/S)	Velocity (m/s)	Flow (m^3/s)	Capacity (Full Flow) (m^3/s)	Flow / Capacity (Design) (%)
2040 to 2130	CO-155	CH-2040	CH-2130	160.532	160.148	158.432	158.407	88.42	SS-2.00 x 1.50	3,536.70	1.67	5.01	2.21	227.10
2130 to 2190	CO-158	CH-2130	CH-2190	160.148	159.765	158.407	158.265	60.18	SS-2.00 x 1.50	423.80	2.15	5.04	5.52	91.20
2190 to 2270	CO-159	CH-2190	CH-2270	159.765	158.624	158.265	157.124	84.02	SS-2.40 x 1.50	73.60	3.99	5.09	16.70	30.50
2270 to 2340	CO-160	CH-2270	CH-2340	158.624	158.115	157.124	156.615	120.45	SS-2.40 x 1.50	236.60	2.66	5.14	9.32	55.20
2340 to 2430	CO-1146	CH-2340	CH-2430	158.115	157.899	156.615	155.399	35.68	SS-2.40 x 1.50	29.30	5.50	5.24	26.46	19.80
2430 to 2700	CO-162	CH-2430	CH-2460	157.899	157.256	155.399	154.756	29.6	SS-3.00 x 2.50	46.00	4.50	5.28	57.09	9.20
	CO-163	CH-2460	CH-2520	157.256	156.803	154.756	154.303	59.27	SS-3.00 x 2.50	130.80	3.19	5.33	33.86	15.70
	CO-164	CH-2520	CH-2580	156.803	156.75	154.303	154.25	59.93	SS-3.00 x 2.50	1,130.80	1.51	5.38	11.52	46.70
	CO-165	CH-2580	CH-2610	156.75	156.381	154.25	153.881	32.12	SS-3.00 x 2.50	87.00	3.68	5.43	41.52	13.10
	CO-166	CH-2610	CH-2670	156.381	155.965	153.881	153.465	58.32	SS-3.00 x 2.50	140.20	3.14	5.45	32.71	16.70
	CO-167	CH-2670	CH-2700	155.965	155.36	153.465	152.86	30.36	SS-3.00 x 2.50	50.20	4.43	5.46	54.68	10.00
2700 to 2850	CO-1143	CH-2700	CH-2730	155.36	154.54	152.86	152.04	30.93	SS-3.40 x 2.50	37.70	4.78	5.73	74.14	7.70
	CO-1144	CH-2730	CH-2790	154.54	153.766	152.04	151.266	58.4	SS-3.40 x 2.50	75.50	3.82	5.76	52.42	11.00
	CO-169	CH-2790	CH-2850	153.766	153.357	151.266	150.357	60.88	SS-3.40 x 2.50	67.00	3.98	5.77	55.64	10.40
2850 to 2970	CO-170	CH-2850	CH-2910	153.357	153.052	150.357	150.052	60.07	SS-5.00 x 3.00	196.90	2.53	5.81	68.26	8.50
	CO-171	CH-2910	CH-2940	153.052	152.856	150.052	149.856	29.43	SS-5.00 x 3.00	150.20	2.76	5.84	78.17	7.50
	CO-172	CH-2940	CH-2970	152.856	152.688	149.856	149.688	28.64	SS-5.00 x 3.00	170.50	2.66	5.91	73.36	8.10
2970 to 3030	CO-173	CH-2970	CH-3000	152.688	152.412	149.688	149.412	29.34	SS-5.00 x 3.00	106.30	2.70	6.04	92.90	6.50
	CO-174	CH-3000	CH-3030	152.412	152.366	149.412	147.366	38.46	SS-5.00 x 3.00	18.80	6.50	6.08	220.94	2.80
3030 to 3120	CO-175	CH-3030	CH-3120	152.366	152.193	147.366	147.193	76.97	SS-4.00 x 5.00	444.90	2.11	6.30	67.81	9.30
3120 to 3215	CO-176	CH-3120	CB-3215	152.193	151.36	147.193	146.683	95.69	SS-6.00 x 5.00	187.60	2.53	6.41	179.55	3.60

Chainage Number	Label	Start Node	Stop Node	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Invert (Start) (m)	Invert (Stop) (m)	Length (Scaled) (m)	Conduit Description	Slope (Calculated) (1/S)	Velocity (m/s)	Flow (m³/s)	Capacity (Full Flow) (m³/s)	Flow / Capacity (Design) (%)
3215 to 3225	CO-177	CB-3215	CH-3225	151.36	150.684	146.776	146.77	11.07	SS-6.00 x 5.00	1,727.00	0.91	6.44	17.49	36.80
3225 to 4000	CO-178	CH-3225	CH-3300	150.684	150.256	146.354	146.342	74.53	SS-6.00 x 5.00	6,137.40	0.91	6.47	9.28	69.70
	CO-1193	CH-3300	CH-3390	150.256	149.856	145.96	145.942	90.09	SS-6.00 x 5.00	4,900.00	0.91	6.48	10.38	62.40
	CO-180	CH-3390	CH-3540	149.856	149.658	145.774	145.744	150.27	SS-6.00 x 5.00	4,900.00	0.91	6.46	10.38	62.30
	CO-1191	CH-3540	CH-3600	149.658	149.447	145.545	145.533	58.8	SS-6.00 x 5.00	4,900.00	0.91	6.40	10.38	61.70
	CO-1177	CH-3600	CH-3630	149.447	149.4	145.492	145.486	29.72	SS-6.00 x 5.00	4,900.00	0.91	6.41	10.38	61.80
	CO-182	CH-3630	CH-3750	149.4	149.337	145.447	145.423	120.03	SS-6.00 x 5.00	4,900.00	0.91	6.46	10.38	62.20
	CO-183	CH-3750	CH-3810	149.337	148.507	144.604	144.592	59.92	SS-6.00 x 5.00	4,900.00	0.91	6.43	10.38	61.90
	CO-184	CH-3810	CH-3870	148.507	147.352	143.45	143.438	61.01	SS-6.00 x 5.00	4,900.00	0.91	6.43	10.38	61.90
	CO-185	CH-3870	CH-3900	147.352	146.642	142.734	142.728	30.1	SS-6.00 x 5.00	4,900.00	0.91	6.42	10.38	61.80
	CO-186	CH-3900	CH-3990	146.642	146.592	142.696	142.678	90.07	SS-6.00 x 5.00	4,900.00	0.91	6.43	10.38	61.90
		CH-3990	OF-3	146.592	146.233	142.322	142.319	15.17	SS-6.00 x 5.00	4,900.00	0.91	6.41	10.38	61.80

Replacement / Proposed drains

14.0 Proposals

- From chainage from 0m to 680m the existing drain size is adequate for hydraulic adequacy. The following works are proposed for strengthening of drain

    1. Rising of side wall
    2. Plastering of exposed brickwork inside of drain
    3. Providing RCC cover slab
    4. Providing grating arrangements with rain water harvesting structures

- From chainage from 680m to 810m the existing drain size is closed with RCC slab and serving as road. So, no improvement works are proposed except desilting and disposing of silt and solid waste.

- From chainage from 810m to 1800 (R), 1520 (L) the existing drain size is inadequate for hydraulic adequacy. The following works are proposed for strengthening of drain

    1. Construction of new RCC drain with cover slab and grating arrangement with rain water harvesting structures

- From chainage from 2040m to 3120m the existing drain size is adequate for hydraulic adequacy. The following works are proposed for strengthening of drain

    1. Rising of protection wall on both side of the drain with brickwork
    2. Plastering of inside exposed brickwork
    3. Providing cover slab with ventilation shaft for air ventilation
    4. Providing grating arrangements with rain water harvesting structures

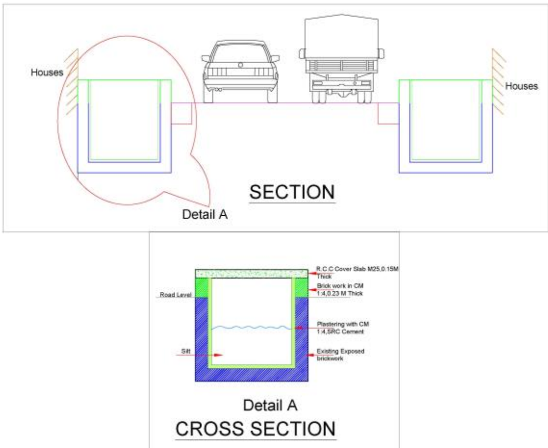
- From chainage from 3120m to 3215m the existing drain size is adequate for hydraulic adequacy. The following works are proposed for strengthening of drain

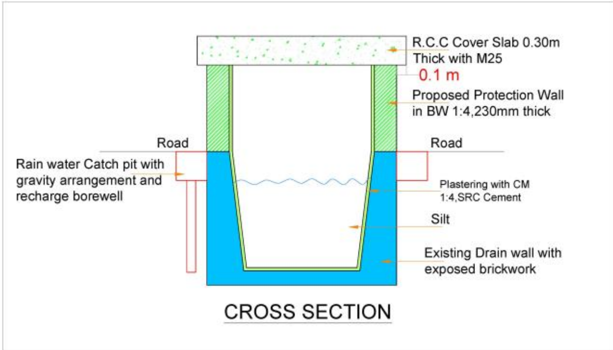
    5. Construction of new side wall
    6. Plastering of inside exposed brickwork
    7. Providing cover slab with ventilation shaft for air ventilation
    8. Providing grating arrangements with rain water harvesting structures

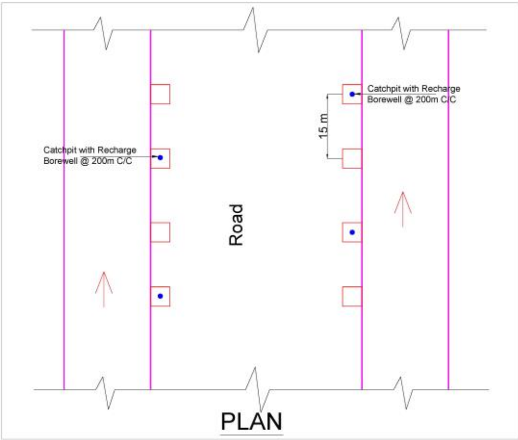
- From chainage from 3215m to 4000m new adequate drain size is proposed for hydraulic adequacy. The following works are proposed for construction of new drain

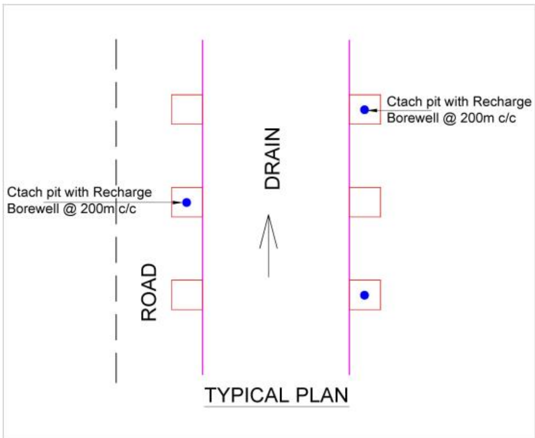
    1. Construction of new RCC drain as per the hydraulic and structural design requirements with rain water harvesting structures

- Apart from the above proposal wherever lateral drains join the main drain screen chamber is proposed to avoid mixing of solid waste into main drain


Houses
Houses
SECTION
Detail A
R.C.C Cover Slab M25,0.15M Thick
Brick work in CM 1:4,0.23 M Thick
Road Level
Plastering with CM 1:4,SRC Cement
Silt
Existing Exposed brickwork
Detail A
CROSS SECTION


R.C.C Cover Slab 0.30m Thick with M25
0.1 m
Proposed Protection Wall in BW 1:4,230mm thick
Road
Road
Rain water Catch pit with gravity arrangement and recharge borewell
Plastering with CM 1:4,SRC Cement
Silt
Existing Drain wall with exposed brickwork
CROSS SECTION


Catchpit with Recharge Borewell @ 200m C/C
15 m
Catchpit with Recharge Borewell @ 200m C/C
Road
PLAN


Ctach pit with Recharge Borewell @ 200m c/c
DRAIN
Ctach pit with Recharge Borewell @ 200m c/c
ROAD
TYPICAL PLAN

15.0 Way forward

Improving the structural stability of the drain by refurbishment of civil structures, as per the physical condition assessment carried out. Rehabilitation works such as construction of drain side retaining wall, raising of drain side wall above ground level to prevent dumping of solid waste and enable safety of adjoining residents. Wherever drain wall doesn't exist new RCC drain side walls are proposed

The sewerage improvement plan for ABD area is under progress. By implementing the smart city project the 100% coverage of sewerage facilities for Taj east drain will be covered. House sewer connections for newly laid pipes and gap in sewer connections shall be ensured to combat sewage inflow into Taj east drain. Over the period of time after completing Smart City Project zero discharge of sewage into Taj east drain shall be ensured

The comprehensive solid waste management is also part of Smart City project and by implementation of this project effective door to door solid waste collection will be implemented. Hence dumping of solid waste into drain will be nullified

So, over a period of time after completion of Smart city mission project the Taj east drain will be free from pollutants from domestic sewage and solid waste and only carry storm water discharge into river Yamuna.

DARASHAW
1926
ALL ABOUT TRUST
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