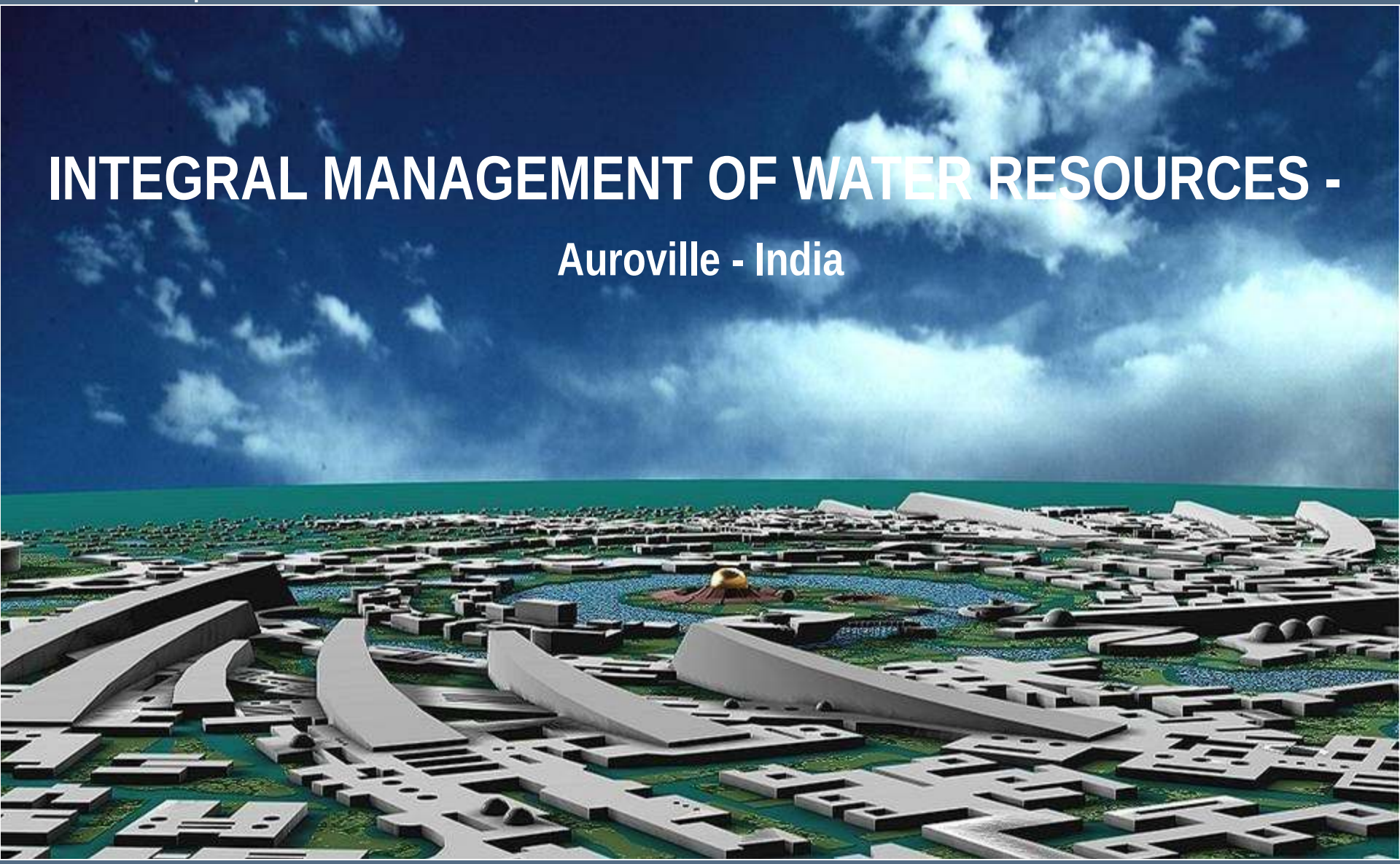
INTEGRAL MANAGEMENT OF WATER RESOURCES -

Auroville - India



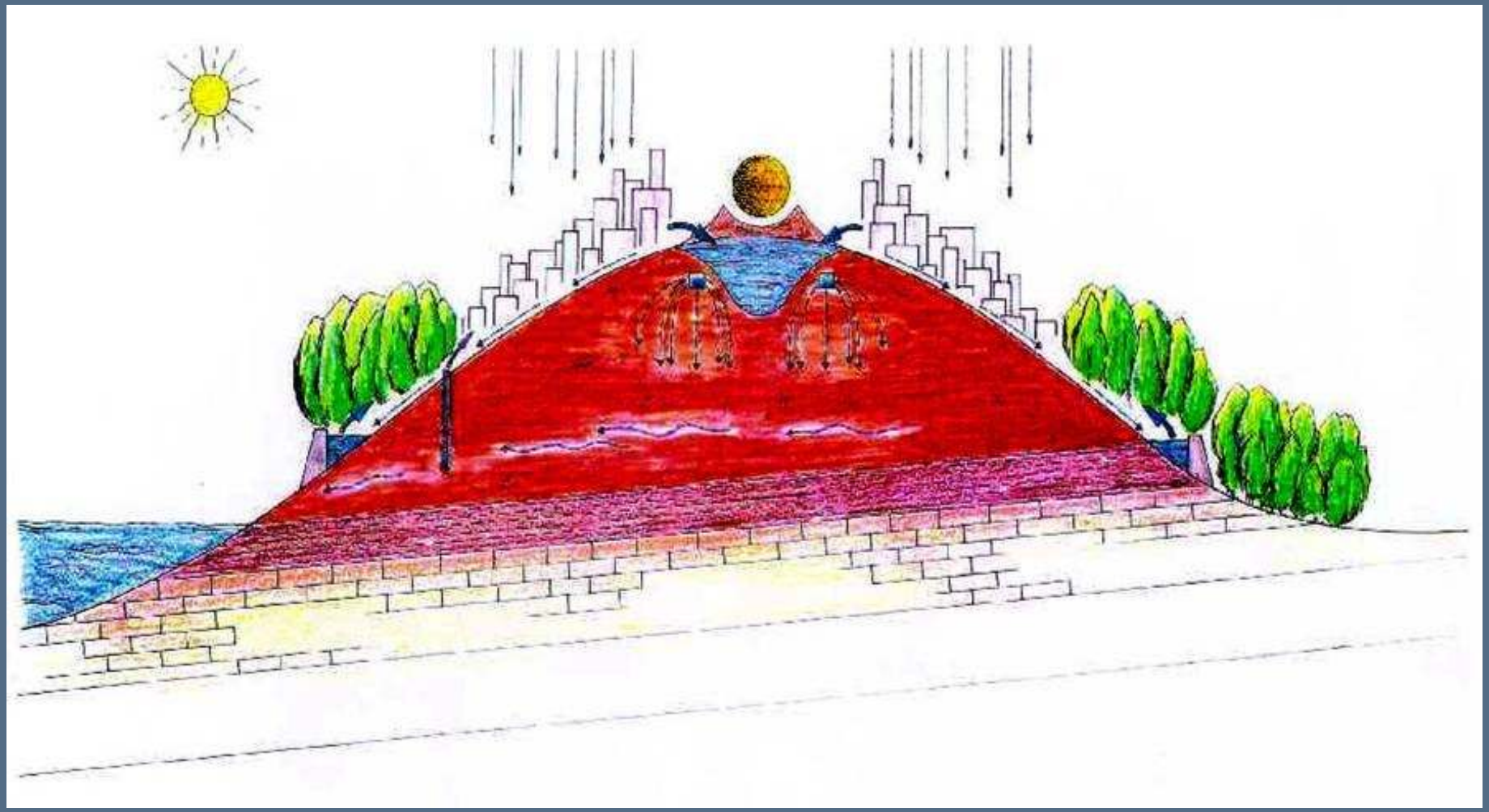
International City Auroville, India, 1992 - 2003

Water Management Conzept 1992

The following estimates are based on the use of rainwater :

Total Rainfall – 19,63 km2 25,5 Mio m3/a
Full DW Requirement - 3,7 Mio m3 14,5 %
Min DW Supply - 1,8 Mio m3 = 7,0%

City - 5 km2 – 25% of Surface 6,4 Mio m3/a
Full DW Requirement - 3,7 Mio m3 58 %
Min Drinking Water Supply - 1,8 Mio m3 28 %



Area: 19,6 km², 14,7 ha green belt, 4,9 km² city area, 50.000 inhabitants, 1.200 mm Ø-rain, zero-runoff, rainwater management and reuse, wastewater treatment und reuse for irrigation

Pre Feasibility Study 2003
Water Balance

Month	Precipitation Average Year [mm]	Precipitation Wet Year [mm]	Precipitation Dry Year [mm]
January	36	88	25
February	18	48	18
March	19	0	0
April	22	47	0
May	45	1098	38
June	45	67	17
July	68	28	26
August	118	157	56
September	145	139	5
October	263	367	202
November	350	234	25
December	162	331	214
Annual	**1.293**	**2.604**	**626**

The runoff from the proposed surfaces have been calculated for a rainfall intensity of

r = 300 l/s·ha

The runoff factor has been estimated to be:

main roads $\Psi_{MR} = 0{,}8$
green space, parks $\Psi_{G} = 0{,}4$
internal roads $\Psi_{IR} = 0{,}8$

Rainfall data

Monthly Potential Evapotranspiration (mm) at Cuddalore

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Okt.	Nov.	Dec.	Annual
1981	NA	NA	NA	158,1	197,7	392,1	209,9	184,4	129,1	102,4	86,7	89,2	1.549,6
1982	128,9	133,7	183,1	191,7	232,0	118,9	160,4	195,0	165,5	145,2	63,8	89,2	1.807,4
1983	99,7	111,2	116,4	109,5	156,6	212,0	140,1	98,7	74,4	106,0	108,3	113,2	1.446,1
Mean	114,3	122,5	149,8	153,1	195,4	211,0	176,1	159,4	123,0	117,9	86,3	97,2	1.706,0

Mean Monthly Potential Evapotranspiration at Auroville Station

Details		Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Okt.	Nov.	Dec.	Annual
Mean Temperature	°C	23,5	24,9	26,9	29,3	31,1	31,4	30,4	29,5	28,5	27,6	25,6	23,8	27,7
Potential Evapo-transpiration	mm	92	101	142	162	183	183	182	170	156	145	122	94	1732,0

Table 2.5: Mean monthly relative humidity at 08.00 hours and 18.00 hours

Details		Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Okt.	Nov.	Dec.
Rel. Humidity %	at 08	80	82	81	78	73	66	74	75	81	86	88	87
Rel. Humidity %	at 18	70	71	71	77	77	64	67	70	79	83	80	76

Mean monthly relative humidity at 08.00 hours and 18.00 hours

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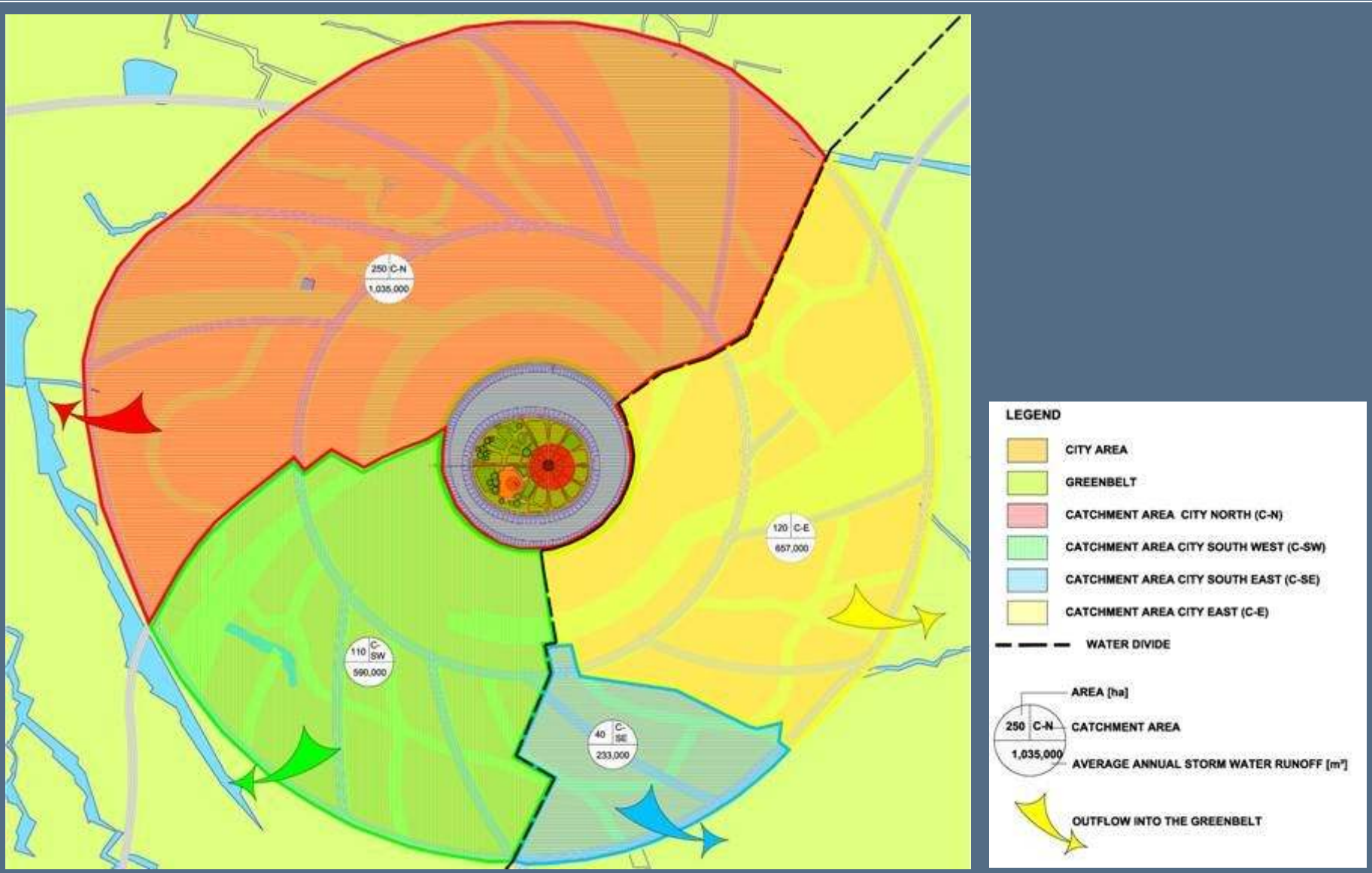
Location	Drainage Area
Residential Zone	160 ha
International Zone	63 ha
Industrial Zone	95 ha
Cultural Zone	91 ha
City Center	82 ha
Total of drainage city area	491 ha (25%)

The greenbelt covers an area of 1.472 ha

The total drainage area of Auroville covers a surface of 1.963 ha

Drainage Area of Auroville City



Layout Plan: general overview, city areas, catchment areas, annual storm water runoff

Water Demand

Population

According to the Master Plan Auroville is separated into 6 Zones of different water demands (see drawing 42.01/1.1.1).:

Residential Zone	40.000 inhabitants
International Zone	600 inhabitants
Industrial Zone	1.800 inhabitants
Cultural Zone	600 inhabitants
City Center	5.000 inhabitants
Green Belt	2.000 inhabitants
Total	50.000 inhabitants

Additional water demand for commercial or industrial uses can be estimated as follows:

Residential Zone	500 PE (Population Equivalent)
International Zone	1.500 PE (Population Equivalent)
Industrial Zone	10.000 PE (Population Equivalent)
Cultural Zone	3.500 PE (Population Equivalent)
City Center	1.500 PE (Population Equivalent)
Total	17.000 PE (Population Equivalent)

The water demand of Auroville has to be estimated for a population of 50.000 and 17.000 PE (Population Equivalent) in total **67.000 P/PE** (see Annex 1.1).

Drinking water demand

Drinking water demand of each inhabitant or population equivalent is estimated according to the general daily water consumption for different uses. This is generally known to be:*

Cooking and Drinking	**3-5 l/cap.d**
Dish Washing	**10-20 l/cap.d**
Personnel Hygiene	**10-15 l/cap.d**
Shower, Bath	**50-100 l/cap.d**
Toilet Flushing	**40-50 l/cap.d**
Laundry	**15-30 l/cap.d**
Garden, Car	**9-15 l/cap.d**
Total	**147-250 l/cap.d**

All further estimates are based on the water consumption of 150 l/person and day

The daily water consumption can therefore be estimated to be

67.000 PE x 150 l/PE = 10.050 m³/d.

The annual water consumption can thus be estimated to be

365 d x10.050 m³/d = 3.668.250 m³/a.

Water for:

Cooking and Drinking	3-5 l/cap.d
Dish Washing	10-20 l/cap.d
Personal Hygiene	10-15 l/cap.d
Shower, Bath	50-100 l/cap.d
Total	**73-140 l/cap.d**

has to be met from water of drinking water quality.

Water demand for:

House Cleaning	10-15 l/cap.d
Laundry	15-30 l/cap.d
Total	**25-45 l/cap.d**

can be met from the use of harvested rainwater collected from roof tops.

Water demand for:

Toilet Flushing	40-50 l/cap.d
Gardening, Car Washing	9-15 l/cap.d
Total	**49-65 l/cap.d**

can be met from the use of wastewater or harvested storm water runoff.

* „Taschenbuch der Wasserwirtschaft“, Page 30

The following estimates are based on the use of groundwater for:

Cooking and Drinking	5 l/cap.d
Dish Washing	10 l/cap.d
Personal Hygiene	10 l/cap.d
Shower, Bath	50 l/cap.d
Total	75 l/cap.d

The daily and annual groundwater demand for the drinking water supply can therefore be estimated to be:

67.000 PE x 0,075 m³/d	=	**5.025 m³/d**
5.025 m³/d x 365 d	=	**1.834.125 m³/a**

Irrigation Water Supply

Year	irrigation demand at ET (50 % of PET)	irrigation demand at PET
[--]	[m³/a]	[m³/a]
average year	4.504.472	13.411.105
wet year	3.166.374	9.580.058
dry year	7.906.406	18.931.417

In an average year the irrigation requirement ranges between 4,5 M m³ and 13,4 M m³. In the wet year the irrigation demand is reduced to 3,1 M m³ up to 9,6 M m³. The highest demand has to be met in a dry year. It ranges between 7,9 M m³ and 18,9 M m³.

Average 122 % of DW-Demand to 360 %
Wett 84 % of DW-Demand to 260 %
Dry 214 % of DW-Demand to 510 %
IRRIGATION DEMAND = 1,2 to 5 x DW - Demand

Irrigation demand at Actual and Potential Evapotranspiration

Irrigation water supply

The water demand irrigation has to been estimated (see 4.1.4) in a average year to be

QId = 4.504.472 m³/a

This water requirement can be supplied by treated wastewater up to

QWW = **3.368.250 m³/a**

and from groundwater sources

QGW= 1.136.222 m³/a

In a dry year the water demand for irrigation is estimated to be

QId = 7.906.406 m³/a

This water requirement can be supplied by treated wastewater up to

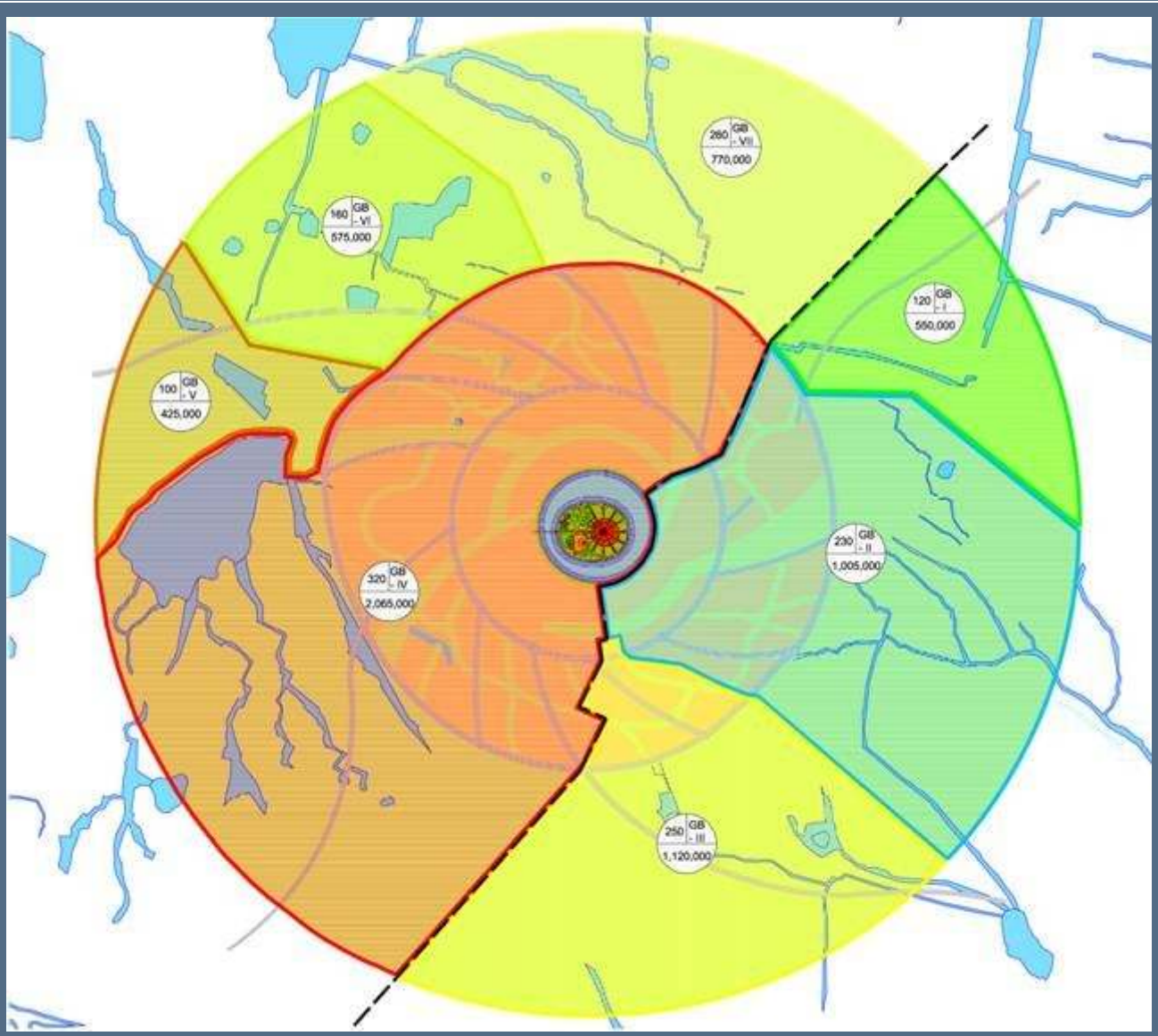
QWW = 3.368.250 m³/a

and from groundwater sources

QGW= 4.538.156 m³/a

The water demand will be met in the city trough a water supply network which runs parallel to the drinking water network. Every consumer in the city will be reached through this pipe system. This system will be fed by booster pumps from tree intakes, from the Wastewater Treatment Plants in the West and the East of the township, as well as from the Water Works, where raw groundwater can be fed into the system. In a dry year the water demand in the greenbelt cannot be met through the system. Individual tub wells have to be used to supply the peak flow.

Water Resources



Layout Plan: general overview, catchment areas, annual storm water runoff

The total rooftop area in Auroville has been estimated to be

AR = **1.066.500** m²

The total annual runoff from this rooftop area has been estimated for a dry, a mean and a wet year at

Qdry = 852.923 m³/a
Qmean = **1.227.648 m³/a**
Qwet = *1.858.941 m³/a*

The required storage volume for the rainwater harvesting has been estimated to be:

Vdry = 279.386 m³
Vmean = 469.977 m³
Vwet = 845.829 m³

For this storage volume a population of 50.000 can be supplied with harvested rainwater at a rate per capita and day of

qdry = 46,7 l/cap·d
qmean = 67,3 l/cap·d
qwet = 101,9 l/cap·d

Annual Stormwater Runoff from the City and the Greenbelt

Selected Year	Storm Water Runoff Catchment Area I	Storm Water Runoff Catchment Area II	Storm Water Runoff Catchment Area III	Storm Water Runoff Catchment Area IV	Storm Water Runoff Catchment Area V	Storm Water Runoff Catchment Area VI	Storm Water Runoff Catchment Area VII	Total Storm Water Runoff to Greenbelt Storage Tanks
	[m³]	[m³]	[m³]	[m³]	[m³]	[m³]	[m³]	**[m³]**
Average Year	548.425	1.004.367	1.118.214	2.065.574	425.433	577.964	771.630	**6.511.607**
Dry Year 1952	244.032	424.797	490.215	912.734	187.208	249.734	316.308	**2.825.029**
Wet Year 1943	765.324	1.184.862	1.488.458	2.831.369	573.456	734.718	815.796	**8.375.983**

Water Balance

Annual water demand		annual water resource	
[--]	[m³/a]	[--]	[m³/a]
drinking water supply	1.834.125	Groundwater	1.834.125
harvested rainwater reuse	1.589.575	Harvested rainwater (Roof top)	579.584
Irrigation	7.906.406	Wastewater reuse	3.368.250
Total	**11.330.106**		**5.781.959**

Water Balance	
	[m³/a]
drinking water supply	± 0
harvested rainwater reuse	-1.009.992
Irrigation	- 4.538.156
Total	**- 5.548.148**

Water balance in a Dry Year

Annual water demand		annual water resource	
[--]	[m³/a]	[--]	[m³/a]
drinking water supply	1.834.125	groundwater	1.834.125
harvested rainwater reuse	1.589.575	harvested rainwater (Roof top)	1.195.850
Irrigation	4.504.472	wastewater reuse	3.368.250
Total	**7.928.172**		**6.398.225**

Water Balance	
	[m³/a]
drinking water supply	± 0
harvested rainwater reuse	- 393.726
Irrigation	-1.136.222
Total	**- 1.529.948**

Water balance in an Average Year

Annual water demand		annual water resource	
[--]	[m³/a]	[--]	[m³/a]
drinking water supply	1.834.125	groundwater	1.834.125
harvested rainwater reuse	1.589.575	harvested rainwater (Roof top)	2.408.818
Irrigation	3.166.374	wastewater reuse	3.368.250
Total	**6.590.074**		**7.611.193**

Water Balance	
	[m³/a]
drinking water supply	± 0
harvested rainwater reuse	819.243
Irrigation	201.876
Total	**1.021.119**

Water balance in a Wet Year

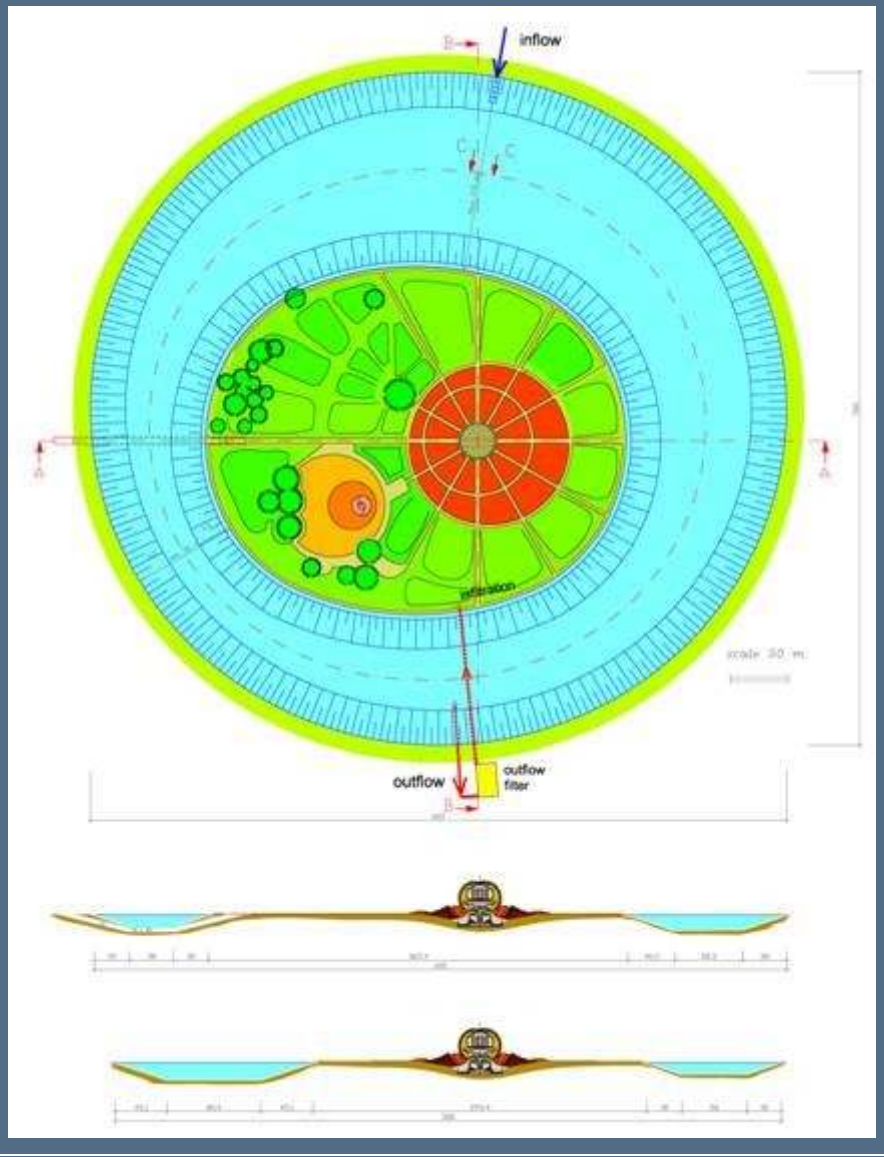
Water resources (wet year)

Water resources (average year)

Water resources (dry year)

Water demand

Water resources and water demand in Auroville



Layout Plan and Section: rainwater lake; alternative 1

Alternative	Mean Depth tM	Maximum Depth tMax	Surface Area Ao	Volume V
	m	m	m²	m³
1	5,71	10	89.322	510.250
2	6,90	10	137.027	945.610
3	7,60	10	181.102	1.376.280
4	7,67	10	186.000	1.426.000
5	8,93	15	186.000	1.660.000

Optional Morphological Parameter for the Matrimandir Lake

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THANK YOU FOR YOUR ATTENTION