CE 3372 WATER SYSTEMS DESIGN

DRINKING WATER STORAGE PART 2 (FALL 2020)

STORAGE

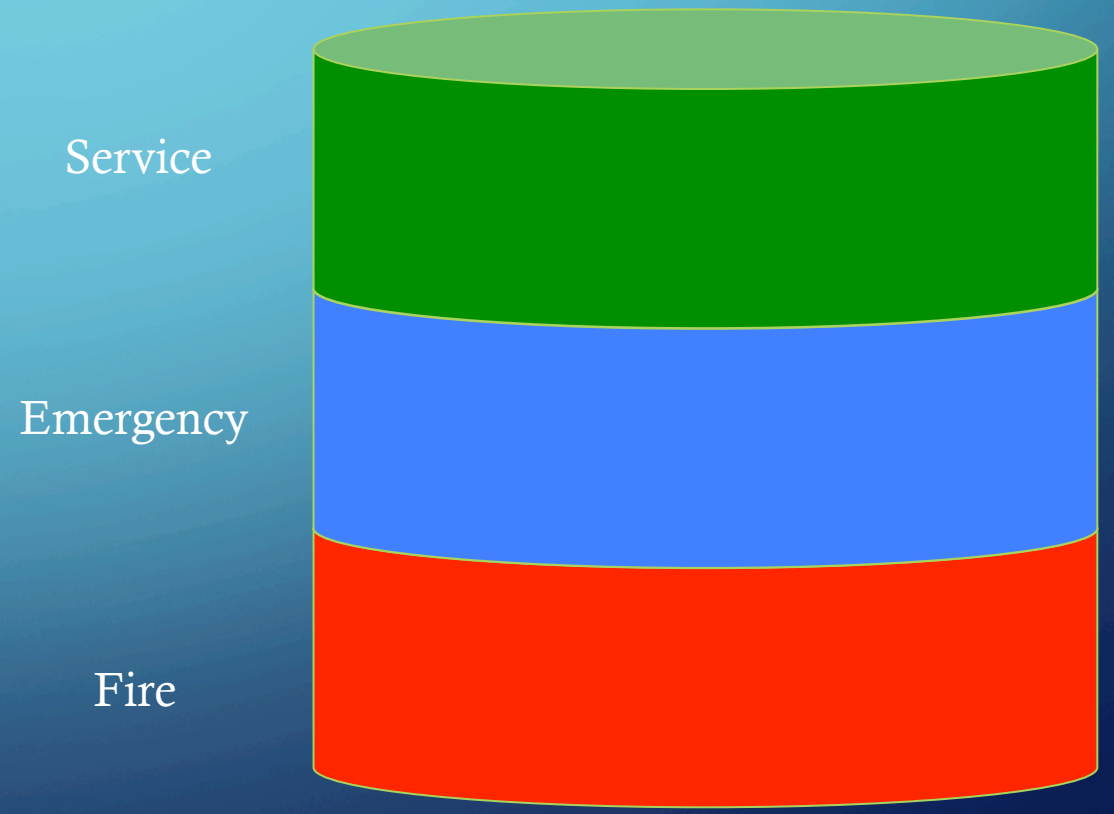
- Purpose of storage reservoirs
- Types of reservoirs
- Calculating storage requirements

STORAGE RESERVOIRS

- Equalizing or Operating Storage
  - Equalize pumping rate into reservoirs
  - Provide storage for peak demand times
  - Provide system pressure without booster pumping
- Fire and emergency pressures
- Types
  - Surface reservoirs
  - Standpipes
  - Elevated tanks

STORAGE COMPARTMENTS

- Service storage
- Emergency storage
- Fire Storage



FLOW-EQUALIZATION

- Flow-equalization storage is sufficient storage to account for peak demands in the system without having to exceed supply capacity.
  - A desirable volume is 1-2 days of average daily demand.

FIRE STORAGE

- Fire storage is sufficient storage to allow the system to meet routine uses plus substantial fire flow.
  - The desirable volume is based on expected fire flow rates multiplied by the required fire flow duration.

EMERGENCY STORAGE

- Emergency storage to allow the system to operate without external supply sources for a period of time to allow for repairs or other unusual circumstances.
  - Without emergency storage, every upset will lead to a ”boil-water” order or substantial interruption of service — these kinds of interruptions should be rare if the system is well engineered.
  - A desirable volume is 1-2 days of average daily demand.

HOW MUCH?

- Engineering would tend to choose for the larger volumes
- Economics will argue for the smaller volumes
  - The engineer will have to balance these competing choices in a design.

RESIDENCE TIME

- Additionally, residence times in any storage reservoir for TREATED water should not exceed a reasonable amount disinfection residual contact time.
  - For chlorine/chloramine disinfection time is on the order of 6-10 days
  - Hydraulic retention time of any such reservoir should be no longer than 8 days (as a reasonable rule of thumb).

HYDRAULIC RETENTION TIME

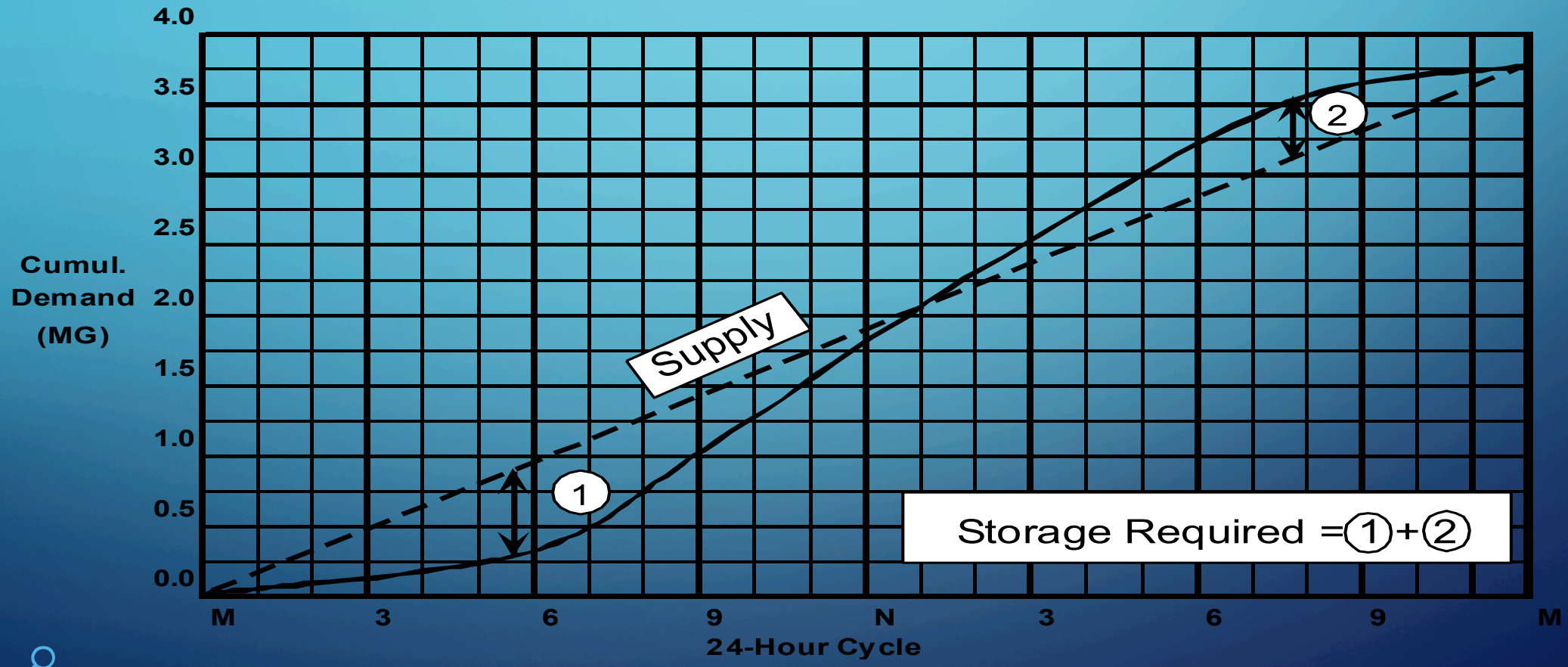
- Hydraulic retention time is the ratio of storage volume to average discharge through the reservoir

$$HRT = \frac{V_{tank}}{Q_{average-daily}}$$

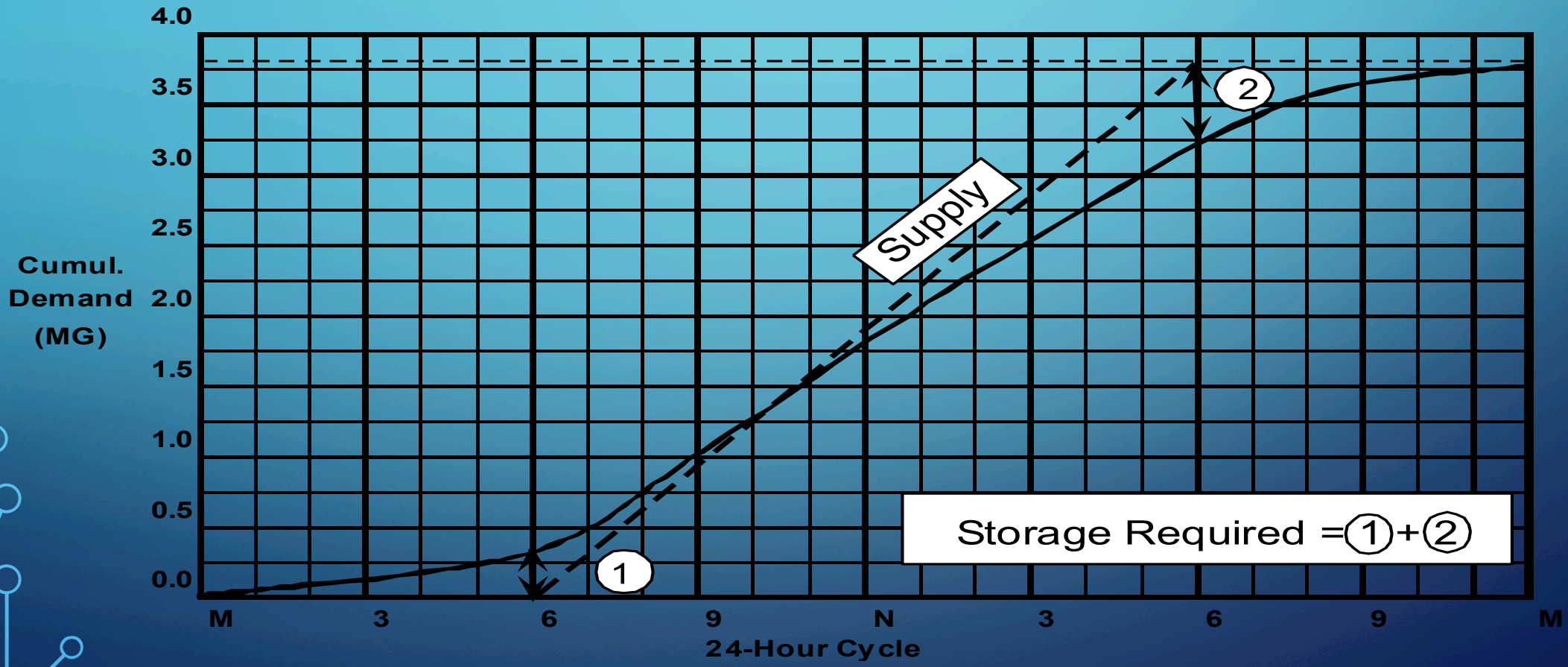
OPERATING STORAGE

- Determine hourly demand for design day
- Calculate cumulative draft
- Plot cumulative draft vs. time (24 hr)
- Draw diagonal line representing constant pumping
- Read required storage as sum of two maximum ordinates

MASS DIAGRAM (24-HR PUMPING)



MASS DIAGRAM (12-HR PUMPING)

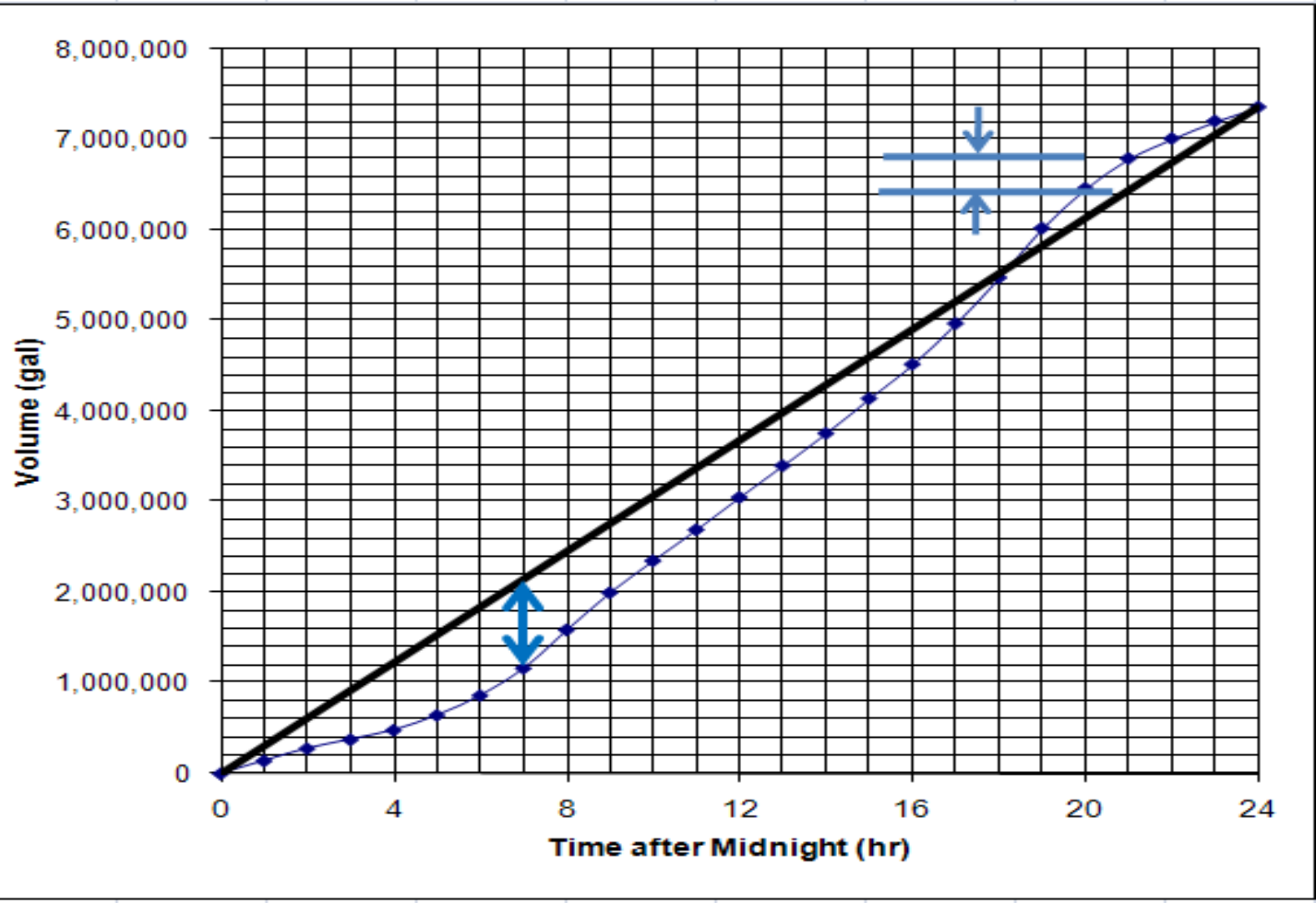


Example Service Storage Problem

1. Given: Average hourly demands in the table below.
   Find: Uniform pumping rate (gpm) and required storage (gallons).

Time (hr)	Time after midnight (hr)	Hourly Demand (gpm)	Cumulative Demand (gal)	Uniform Supply (gal)	Difference (gal)
12:00 AM	0	0	0	0	0
1:00 AM	1	2370	142206	306627	164421
2:00 AM	2	2252	277343	613253	335910
3:00 AM	3	1644	375983	919880	543897
4:00 AM	4	1740	480377	1226506	746129
5:00 AM	5	2745	645106	1533133	888027
6:00 AM	6	3644	863758	1839759	976002
7:00 AM	7	5020	1164938	2146386	981447
8:00 AM	8	7053	1588104	2453012	864908
9:00 AM	9	6850	1999104	2759639	760535
10:00 AM	10	5877	2351742	3066266	714524
11:00 AM	11	5699	2693694	3372892	679198
12:00 PM	12	5960	3051264	3679519	628255
1:00 PM	13	5844	3401929	3986145	584216
2:00 PM	14	5946	3758677	4292772	534095
3:00 PM	15	6384	4141729	4599398	457669
4:00 PM	16	6302	4519849	4906025	386176
5:00 PM	17	7521	4971127	5212651	241524
6:00 PM	18	8428	5476822	5519278	42456
7:00 PM	19	9105	6023123	5825904	-197218
8:00 PM	20	7330	6462893	6132531	-330362
9:00 PM	21	5494	6792515	6439158	-353357
10:00 PM	22	3669	7012646	6745784	-266862
11:00 PM	23	3217	7205652	7052411	-153241
12:00 AM	24	2556	7359037	7359037	0

Uniform flow rate =		5110	gpm			
Storage volume =		981447	+	353357	=	1334805 gal



2. Given: Same data

Find: Uniform pumping rate (gpm) and required storage (gallons) for the following:

[a] Pumping from 6 AM to 6 PM only

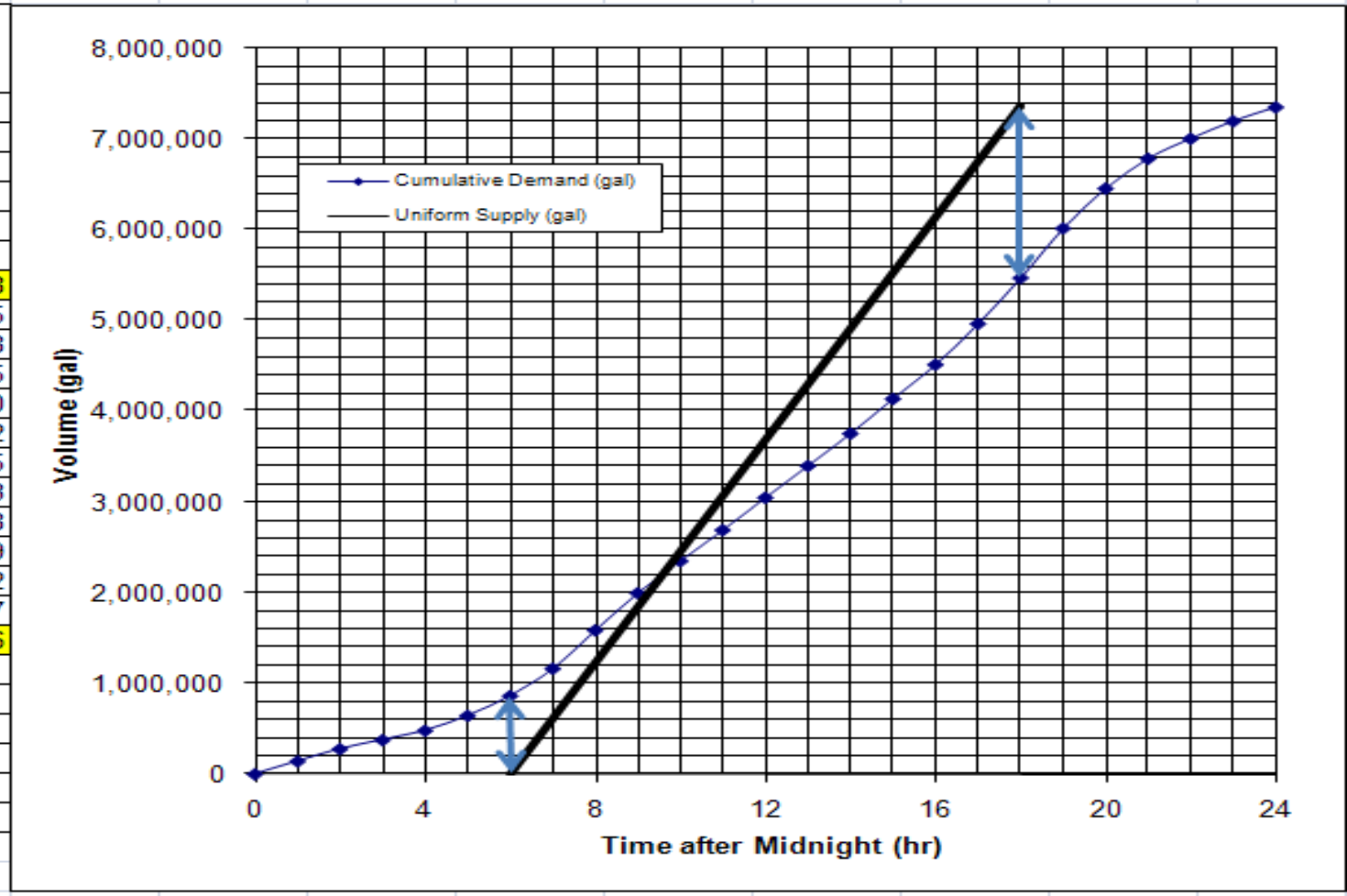
[b] Pumping from 6 PM to 6 AM only

[a]

Time (hr)	Time after Midnight (hr)	Hourly Demand (gpm)	Cumulative Demand (gal)	Uniform Supply (gal)	Difference (gal)
12:00 AM	0	0	0		
1:00 AM	1	2370	142206		
2:00 AM	2	2252	277343		
3:00 AM	3	1644	375983		
4:00 AM	4	1740	480377		
5:00 AM	5	2745	645106		
6:00 AM	6	3644	863758	0	-863758
7:00 AM	7	5020	1164938	613253	-551685
8:00 AM	8	7053	1588104	1226506	-361598
9:00 AM	9	6850	1999104	1839759	-159345
10:00 AM	10	5877	2351742	2453012	101270
11:00 AM	11	5699	2693694	3066266	372572
12:00 PM	12	5960	3051264	3679519	628255
1:00 PM	13	5844	3401929	4292772	890843
2:00 PM	14	5946	3758677	4906025	1147348
3:00 PM	15	6384	4141729	5519278	1377549
4:00 PM	16	6302	4519849	6132531	1612682
5:00 PM	17	7521	4971127	6745784	1774657
6:00 PM	18	8428	5476822	7359037	1882216
7:00 PM	19	9105	6023123		
8:00 PM	20	7330	6462893		
9:00 PM	21	5494	6792515		
10:00 PM	22	3669	7012646		
11:00 PM	23	3217	7205652		
12:00 AM	24	2556	7359037		

Uniform flow rate = 10221 gpm in 12 hours

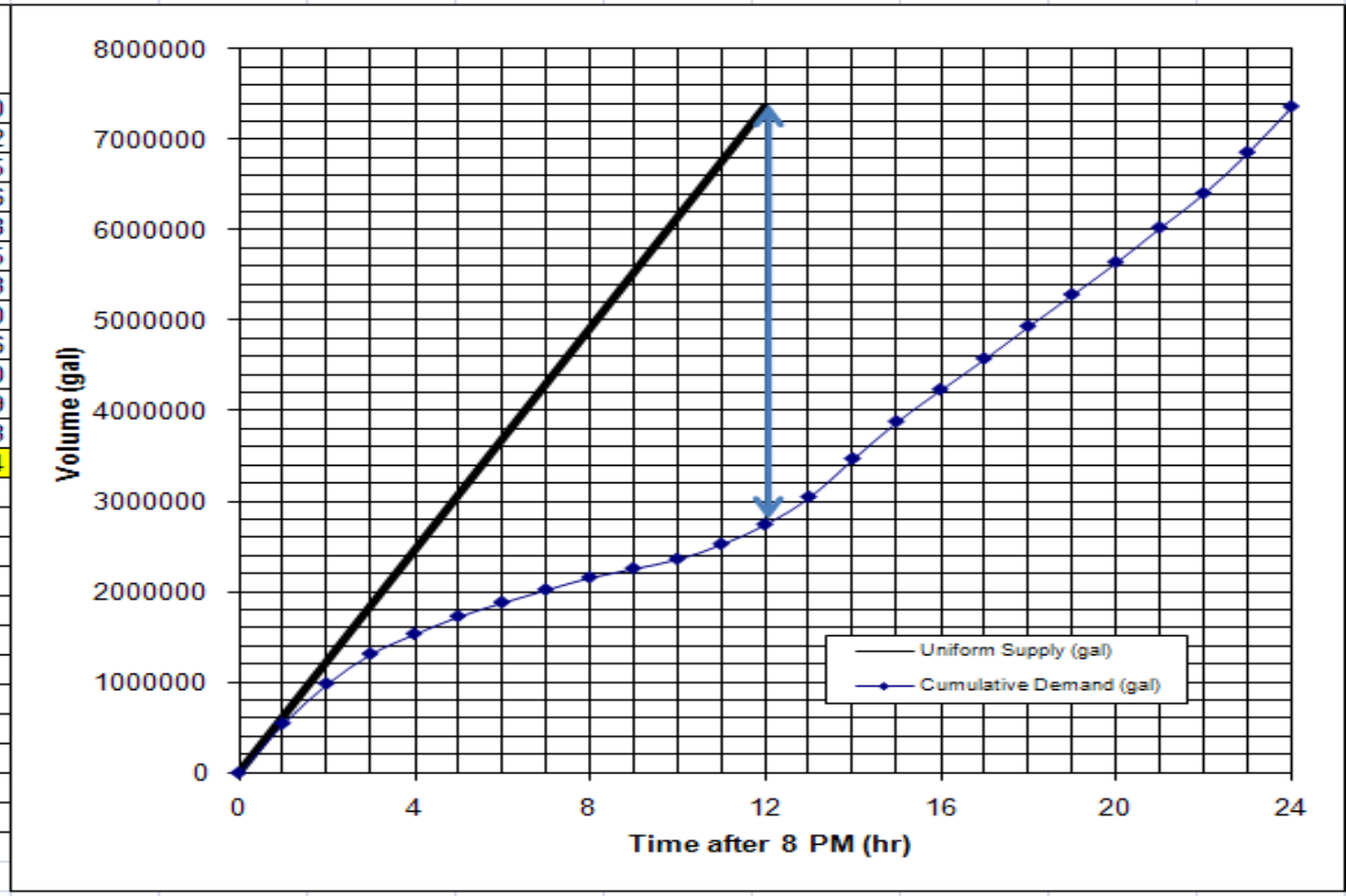
Storage volume = 863758 + 1882216 = 2745973 gal



[b]

Time (hr)	Time after 6 PM (hr)	Hourly Demand (gpm)	Cumulative Demand (gal)	Uniform Supply (gal)	Difference (gal)
6:00 PM	0	0	0	0	0
7:00 PM	1	9105	546301	613253	66952
8:00 PM	2	7330	986071	1226506	240435
9:00 PM	3	5494	1315693	1839759	524066
10:00 PM	4	3669	1535825	2453012	917188
11:00 PM	5	3217	1728830	3066266	1337435
12:00 AM	6	2556	1882216	3679519	1797303
1:00 AM	7	2370	2024422	4292772	2268350
2:00 AM	8	2252	2159558	4906025	2746466
3:00 AM	9	1644	2258198	5519278	3261080
4:00 AM	10	1740	2362592	6132531	3769939
5:00 AM	11	2745	2527321	6745784	4218463
6:00 AM	12	3644	2745973	7359037	4613064
7:00 AM	13	5020	3047154		
8:00 AM	14	7053	3470320		
9:00 AM	15	6850	3881320		
10:00 AM	16	5877	4233958		
11:00 AM	17	5699	4575910		
12:00 PM	18	5960	4933480		
1:00 PM	19	5844	5284145		
2:00 PM	20	5946	5640893		
3:00 PM	21	6384	6023945		
4:00 PM	22	6302	6402065		
5:00 PM	23	7521	6853343		
6:00 PM	24	8428	7359037		

Uniform flow rate =	10221	gpm in 12 hours
Storage volume =	4613064	gal



FLOW EQUALIZATION

- The engineer needs to decide which demand to use:
  - Daily
  - Peak
- These volumes are added to that needed for emergency and fire flow.
- Determines the tank volume required
- Tank type (elevated, at-grade, buried) determines shape – elevation, diameter, min-level, max-level.
  - Elevated tanks have substantial structural considerations