Using Equivalent Max.-day Cap to determine the Approved Cap of Sources/WTPs

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"Components" of Surface, Water-supply Sources

- River or Stream,
- Natural lake,
- Source-water storage
  - On-stream storage,
  - Off-stream storage,
- Intake,
- Source-water pumping (e.g., pumping upstream of off-stream storage, or pumping directly to the WTP), and
- Combinations of the above.

“Components” of Ground, Water-supply Sources

- Aquifer and/or Wellfield (component capacity to be defined),
- Well pumping (e.g., for vertical wells, for horizontal collector wells, etc.)
- Source-water storage,
- Source-water pumping (e.g., pumping upstream of source-water storage, or pumping directly to the WTP), and
- Combinations of the above.

"Components" of Water Treatment Plants (WTPs)

- A unit-treatment process (e.g., pre-sedimentation, rapid-mix, flocculation, sedimentation, filtration, stabilization, etc.);
- Essential chemical storage-and-feed facilities;
- Disinfection (e.g., chorine, chloramines, chlorine dioxide, ozone or UV generation and/or contacting facilities); and
- WTP pumping (e.g., intermediate pumping between components within the WTP, finished-water pumping to convey finished water to the distribution system, etc.).

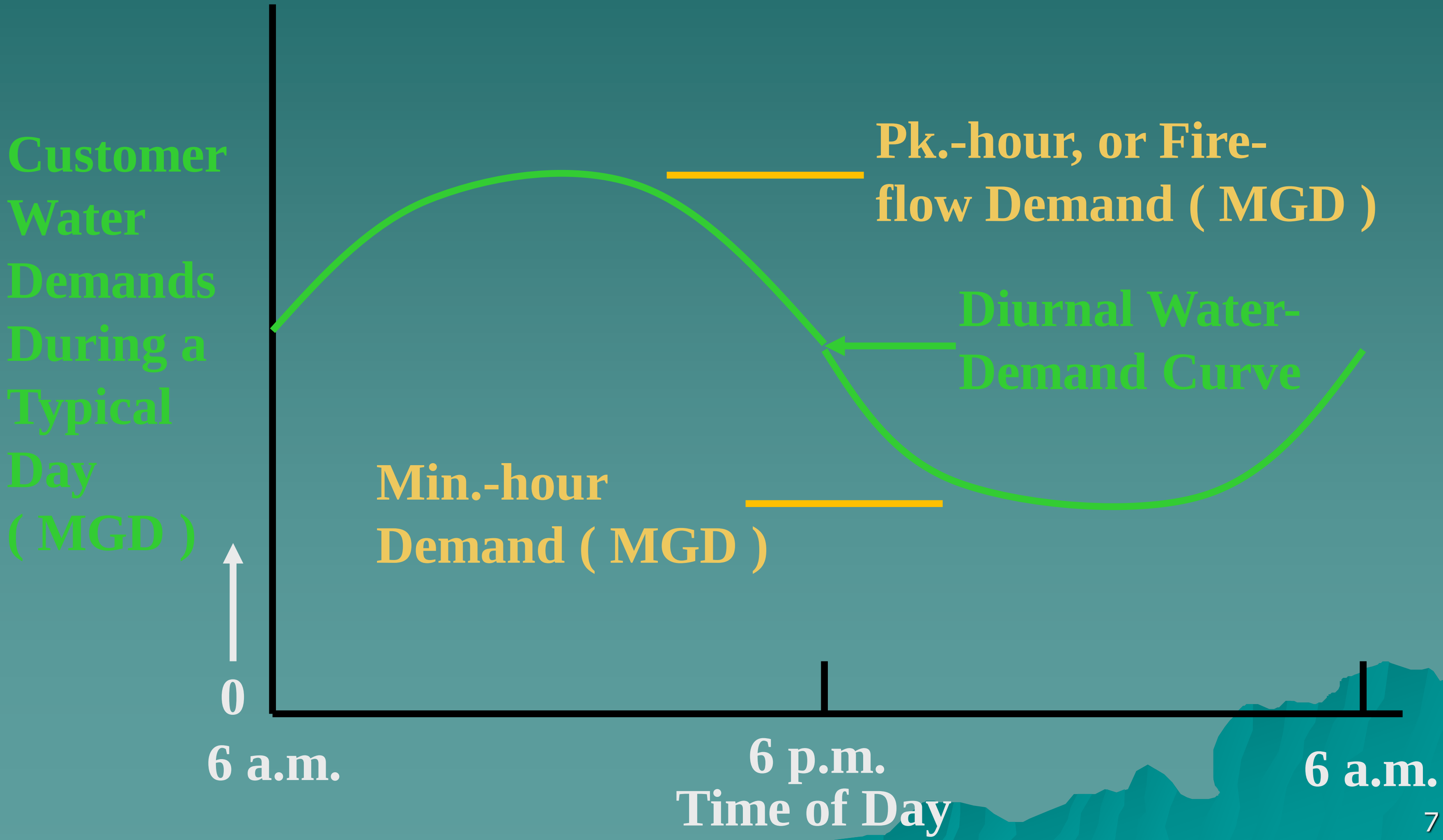
"Production" is the rate at which finished water leaves the WTP to supply Customer water demands, and to account for Other items

- "Customer water demands" are:
  - Commercial and Industrial (Large users)
  - Residential
  - Public use (Billed or Unbilled)
- Most of the difference between Demands and Production is contributed to or supplied by distribution storage

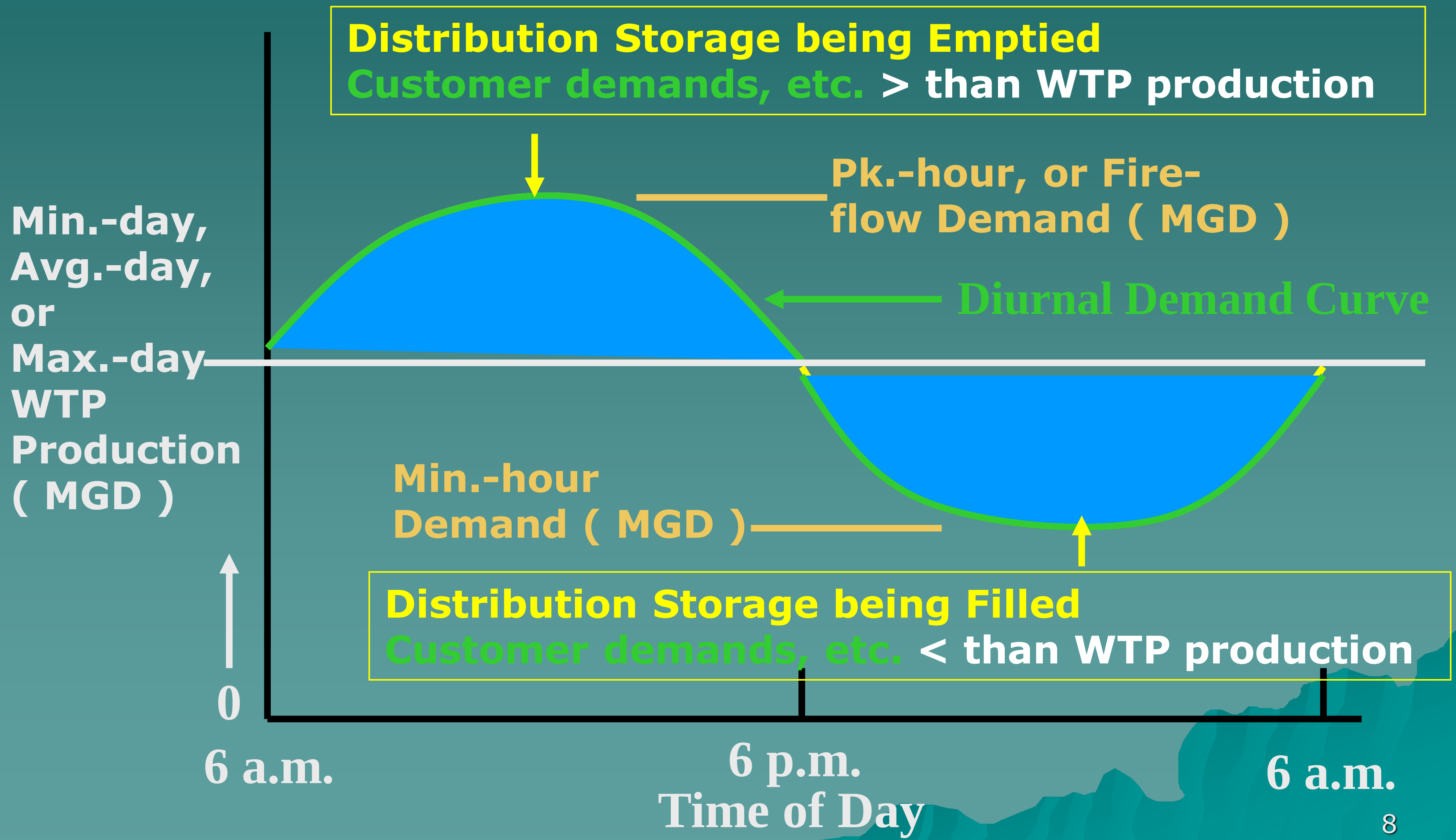
“Production” . . . (cont)

- “Other items” that cause a difference between WTP Production and Customer Demands are:
  - Accounted-for and Unaccounted-for Water losses
  - Inaccurate meters
  - Etc.

Customer Water Demands Vary during the Day



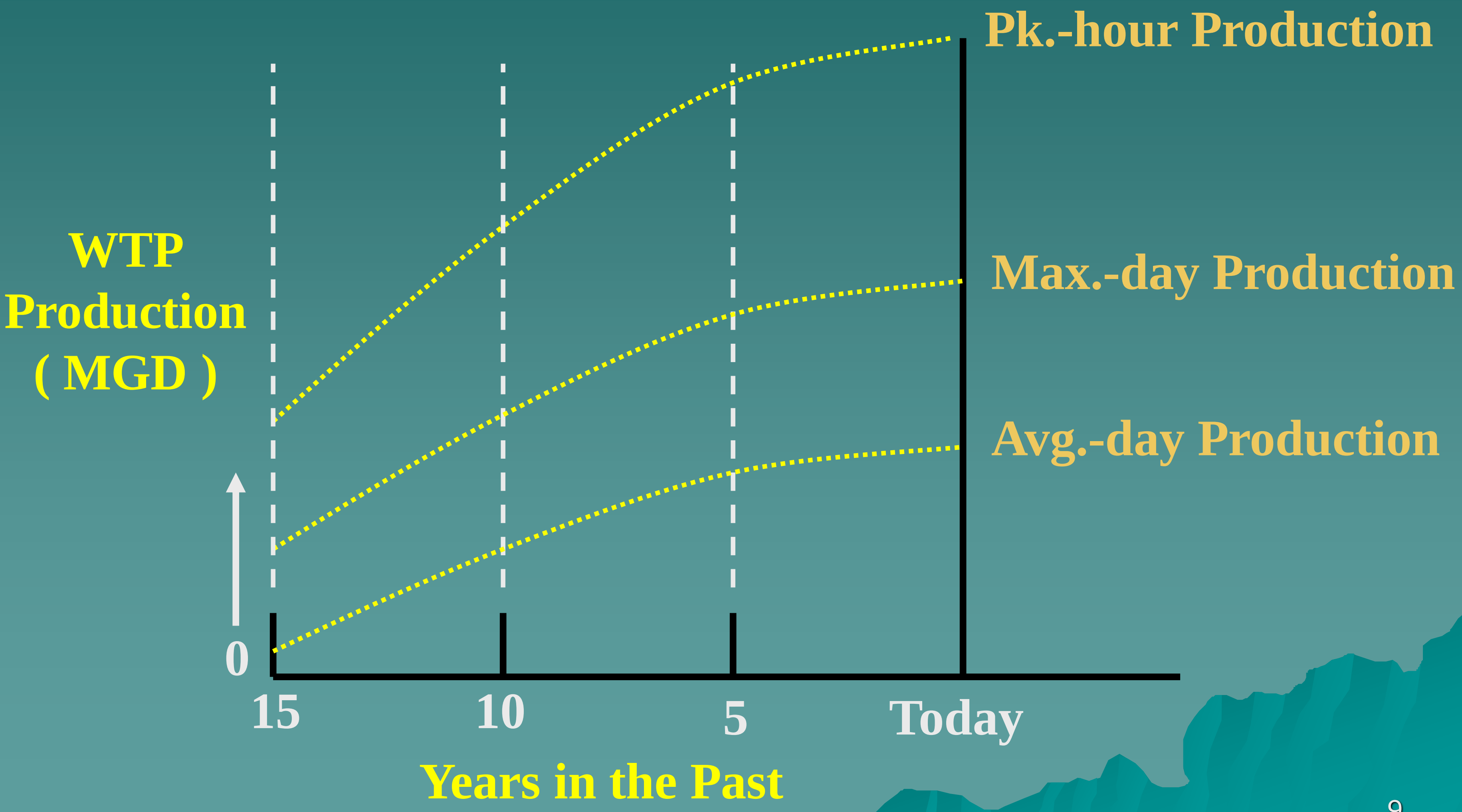
WTP Production, with Distribution Storage, supply Demands, etc.



Distribution Storage being Emptied
Customer demands, etc. > than WTP production

Distribution Storage being Filled
Customer demands, etc. < than WTP production

Historic WTP Production for a Rapidly-growing Water System



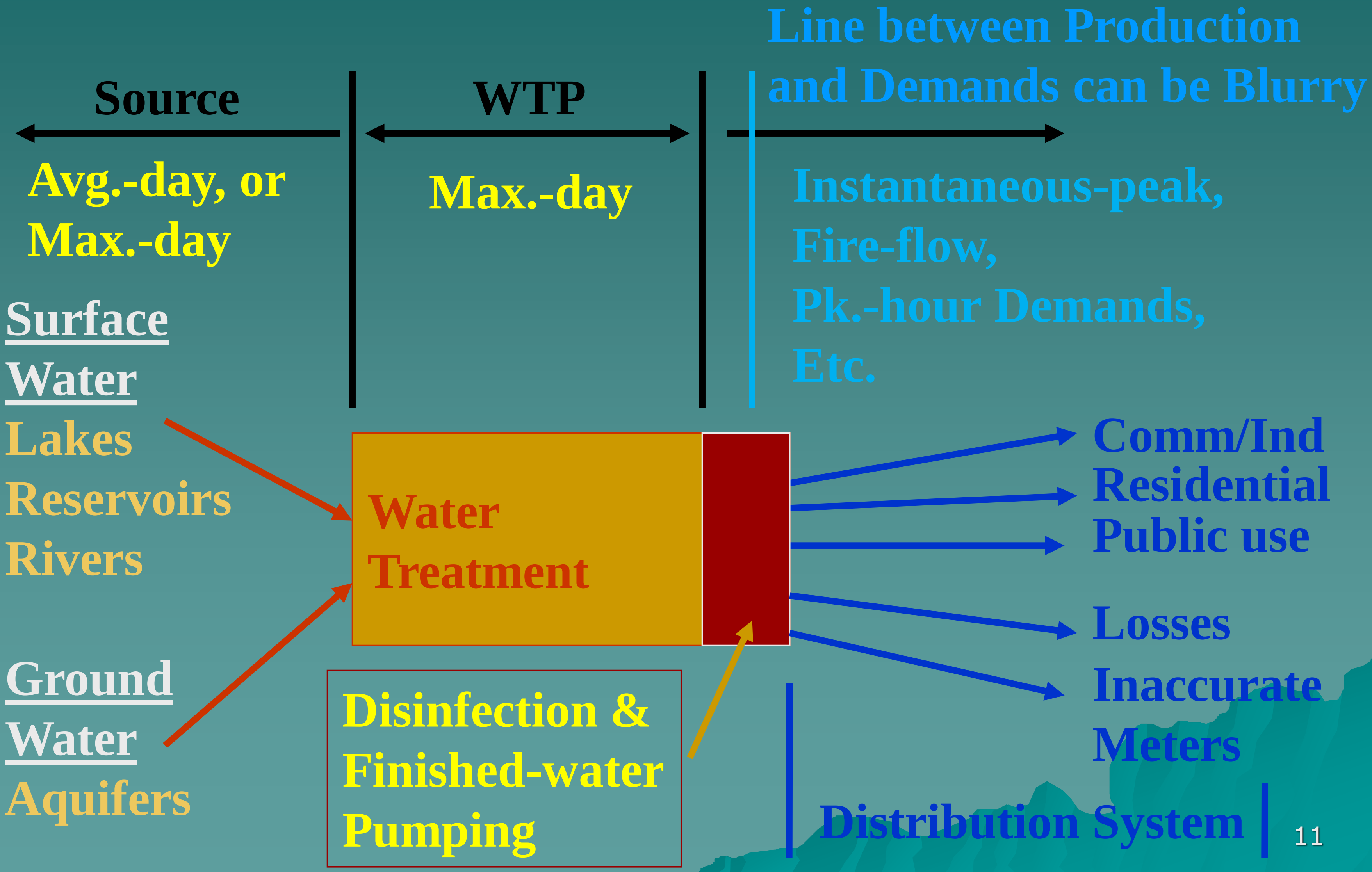
Typical Ratios of WTP Production to supply Customer Demands, etc.

- Avg.-day
  Min.-day = 1.2 - 1.5

- Avg.-day, MM
  Avg.-day = 1.2 - 1.5
  MM = max. month
- Max.-day
  Avg.-day = 1.2 - 2.5

- Pk.-hour
  Max.-day = 1.3 - 2.0

Each "Part" of a Water System Plays a Role in Supplying Customer Demands, etc.



Line between Production and Demands can be Blurry

Source

WTP

Avg.-day, or
Max.-day

Max.-day

Instantaneous-peak,
Fire-flow,
Pk.-hour Demands,
Etc.

Surface Water
Lakes
Reservoirs
Rivers

Ground Water
Aquifers

Water Treatment

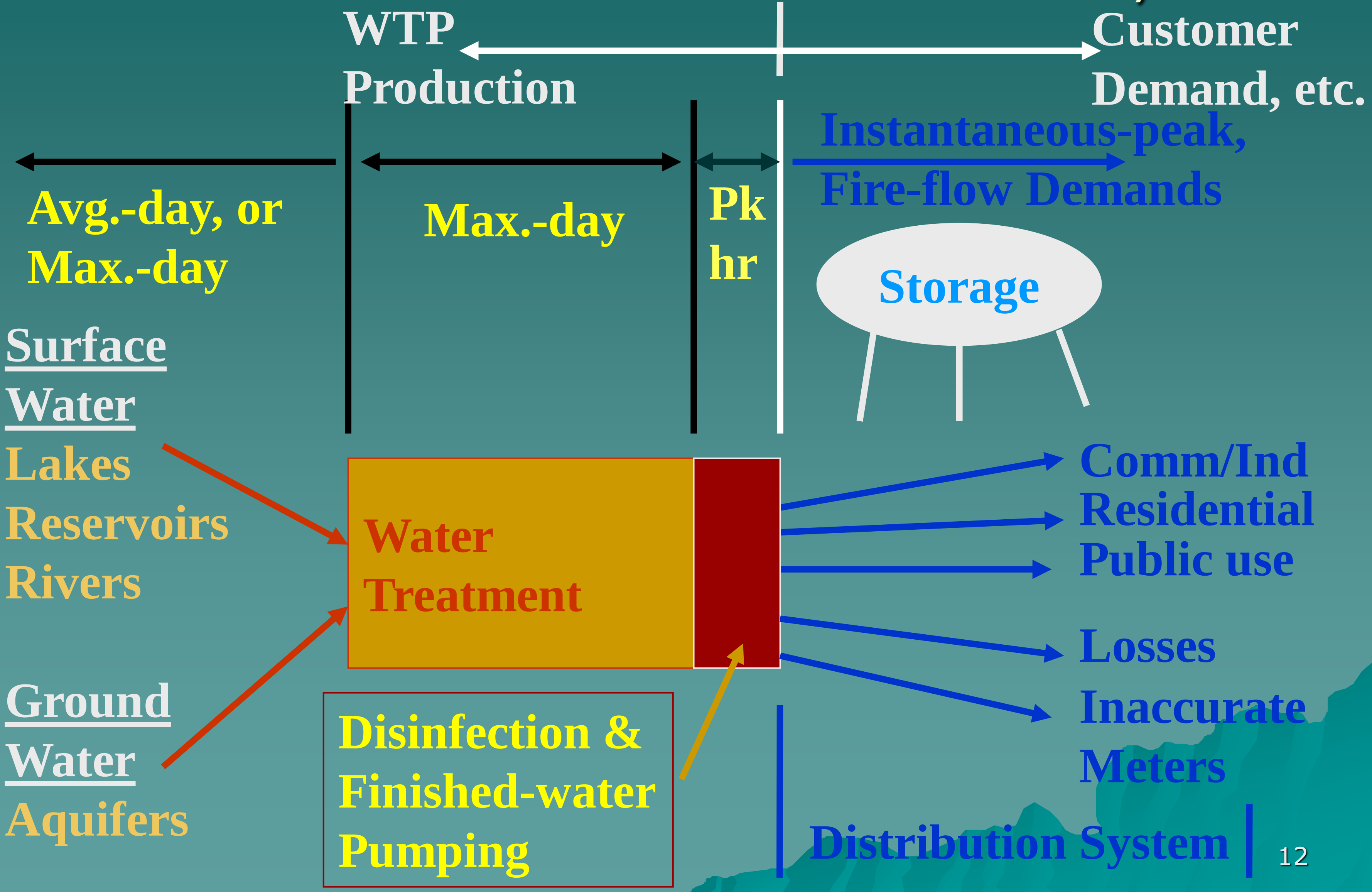
Disinfection & Finished-water Pumping

Comm/Ind
Residential
Public use

Losses
Inaccurate Meters

Distribution System

Distribution Storage is the Buffer Between Production and Demand, etc.



Typical Ratios of Customer Demand to WTP Production

- Avg.-day Demand
  Avg.-day Production = 1

- Max.-day Demand
  Max.-day Production = approx. 1

- Pk.-hour Demand
  Pk.-hour Production = > 1

Most of the difference between Demand and Production is contributed to or supplied by distribution-system storage

In Essence:
Distribution-system Storage . . .

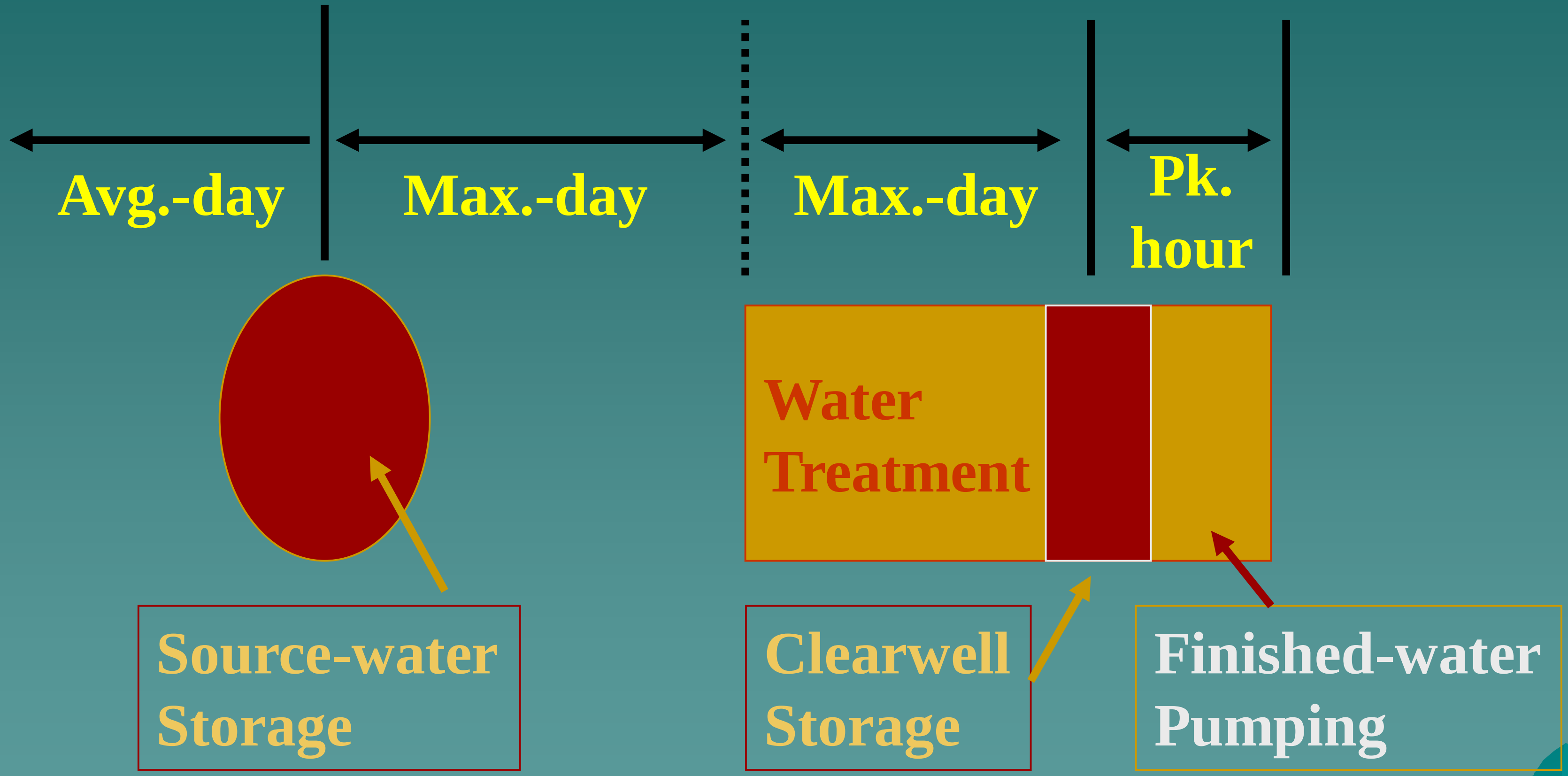
. . . Provides the difference between:

◆ The large, customer demands (e.g., Pk.-hour, Instantaneous-peak and Fire-flow), etc.

AND

◆ The smaller, more constant, flow rate at which water is produced on any given day at the WTP (i.e., Production) to supply these various Customer Min.-day, Avg.-day, or Max.-day demands

Storage between Components Buffers Other Up- & Down-stream Flow Rates



"Source-water storage" allows upstream Water-supply source components to be designed to meet Avg.-day production (not Max.-day rates). Likewise, "Clearwell storage" allows upstream WTP components to be designed to meet Max.-day production (not Pk.-hour rates).

Determining the Limiting Component using Equivalent, Max.-day Capacity

The Approved Capacity of a "Water-supply source" . . .

. . . is based on the Limiting Component (i.e., the Water-supply source component with the smallest Equiv., Max.-day capacity)

- Aquifer and/or Wellfield,
- River, Stream, Natural lake,
- On-stream storage, Off-stream storage,
- Intake,
- Source-water pumping (e.g., pumping upstream of off-stream storage, or pumping directly to the WTP), and
- Well pumping (e.g., vertical wells, horizontal collector wells - upstream of off-stream storage, or directly to the WTP)

The Approved Capacity of a “WTP” . . .

. . . is based on the Limiting Component (i.e., the WTP component with the smallest Equiv., Max.-day capacity)

- A unit-treatment process (e.g., pre-sedimentation, rapid-mix, flocculation, sedimentation, filtration, stabilization, etc.);
- Essential chemical storage-and-feed facilities;
- Disinfection (e.g., chorine, chloramines, chlorine dioxide, ozone or UV generation and/or contacting facilities); and
- WTP pumping (e.g., intermediate pumping between components within the WTP, finished-water pumping to convey finished water to the distribution system, etc.).

The Approved Capacity of a "Source/WTP System"

. . . is the lesser of the Approved Capacity for the Water-supply source and the WTP

The Limiting Component is Determined Based on Equiv., Max.-day Capacity

- **The limiting:**
  - 1) Water-supply Source component (e.g., river, aquifer, etc.), or
  - 2) WTP component (e.g., rapid-mix unit, finished-water pump station, etc.),

  can only be determined by comparing components on a common "numerical" basis

- Therefore, the component capacity of each component is converted to an **"Equivalent Max.-day Capacity"** so the numerical values for components can be compared on a common and equal basis (i.e., a common denominator)

Equiv. Max.-day Capacity can be thought of as . . .

. . . The equivalent Max.-day Production that particular component could help support based on the water system’s production ratios of:

- $\frac{\text{Max.-day}}{\text{Avg.-day}}$

and

- $\frac{\text{Pk.-hour}}{\text{Max.-day}}$

“Production” is the rate at which finished water leaves the WTP to supply Customer water demands, and to account for Other items

- “Customer water demands” are:
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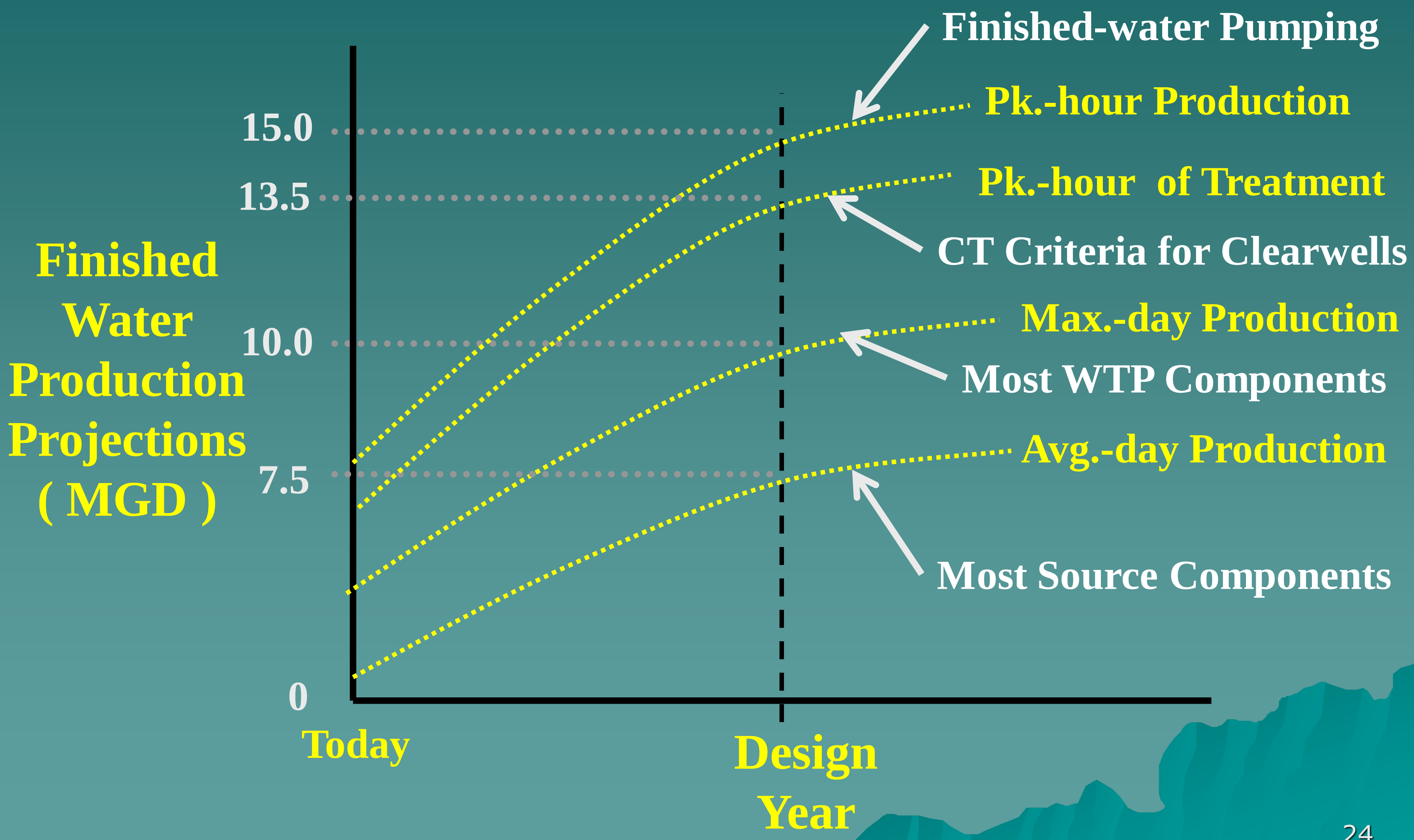
“Production” . . . (cont)

- “Other items” that cause a difference between WTP Production and Customer Demands are:
  - Accounted-for and Unaccounted-for Water losses
  - Inaccurate meters
  - Etc.

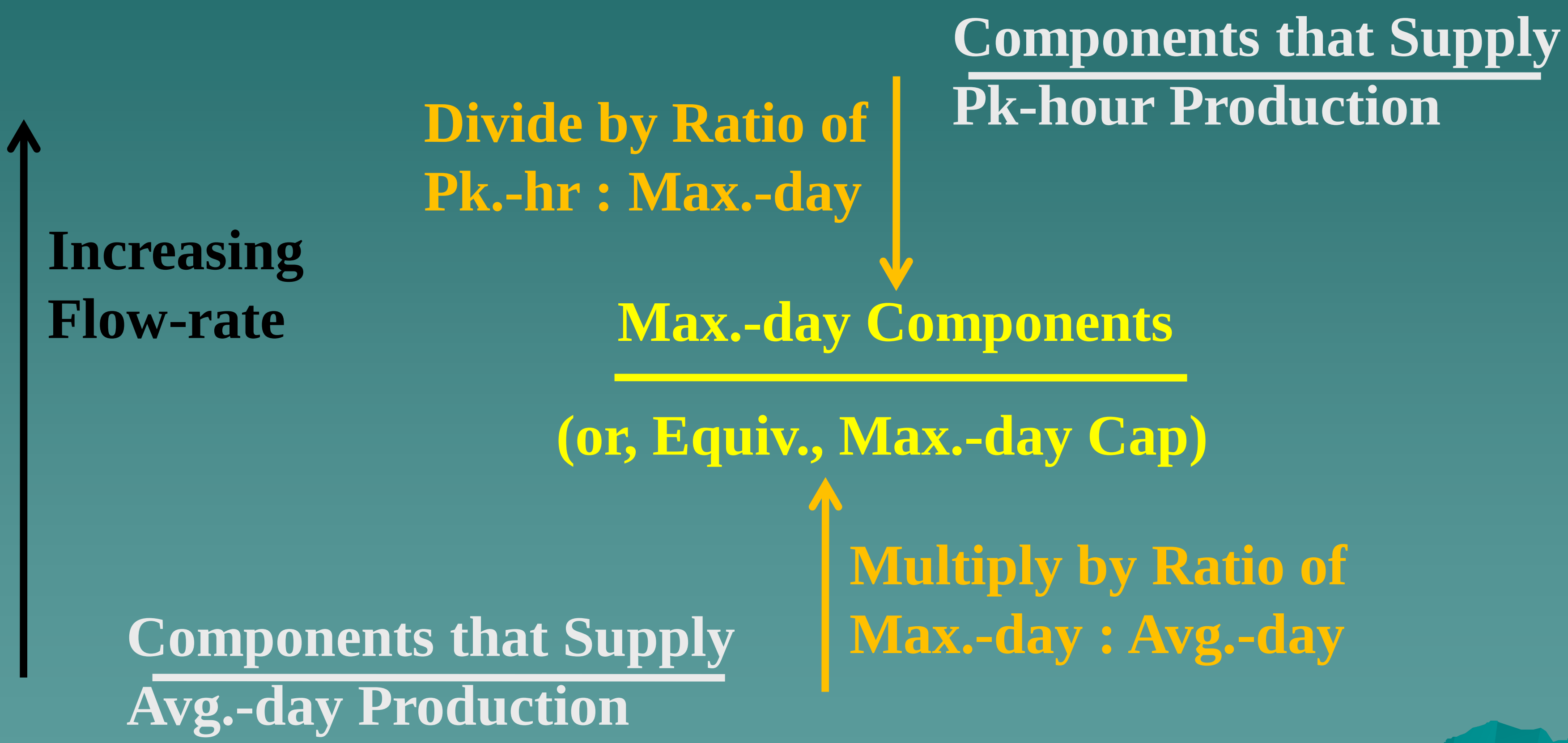
WTP Production Projections for a Growing Water System



The Size of Source and WTP Components are Related Through Water Production Projections

- Ideally the Relative Size of Source and WTP Components are based on Meeting the Respective Water Production Projections in the Design Year
- However, it is not uncommon that a component is not able to supply its respective Design-year production, and is the Limiting Component sooner

A Common Denominator Allows Comparison of Components



Components that Supply
Pk-hour Production

Divide by Ratio of
Pk.-hr : Max.-day

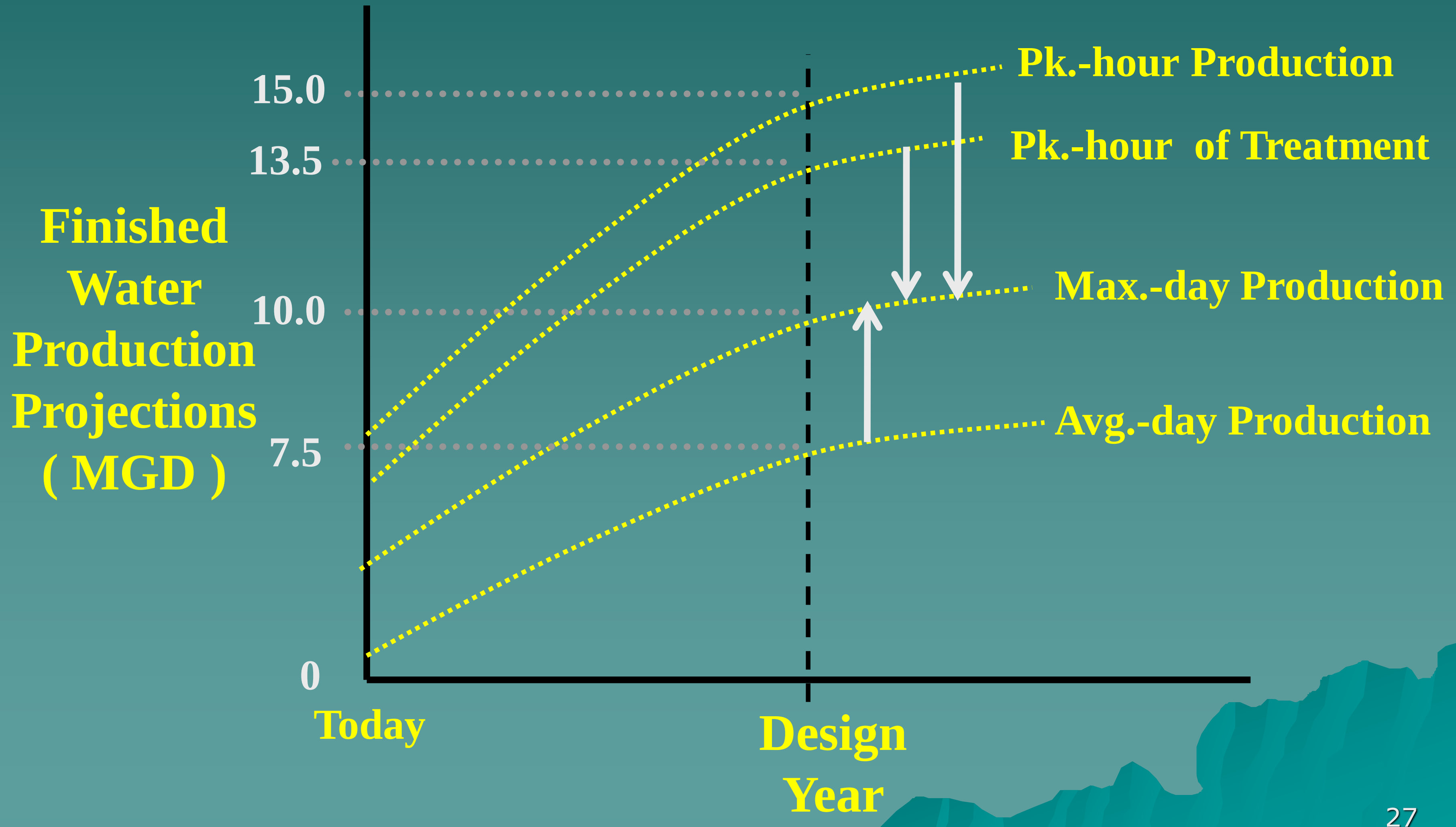
Max.-day Components
(or, Equiv., Max.-day Cap)

Multiply by Ratio of
Max.-day : Avg.-day

Components that Supply
Avg.-day Production

Increasing
Flow-rate

In Essence all of the Productions are Normalized around Max.-day



For Components based on Supplying Avg.-day WTP Production . . .

. . . The Component Capacity is converted to an “Equivalent Max.-day Capacity” by:

‘Multiplying’ the Component Capacity by the ratio of Max.-day to Avg.-day production:

E.g., a well field’s component capacity is 5.0 MGD, and the water system’s ratio of Max.-day to Avg.-day production is 1.25:

$$\frac{5.0\text{ MGD }\cancel{\text{Avg.-day}}}{1} \times \frac{1.25\text{ Max.-day}}{\cancel{\text{Avg.-day}}} = \mathbf{6.25\text{ MGD Equiv. Max.-day}}$$

The Approved Capacity of a "Water-supply Source" . . .

. . . Must be large enough that source water can be delivered to the WTP:

1. continuously, at a flow rate equivalent to the Design-year, Avg.-day water production,

   and

2. on at least a one-day basis, at a flow rate equivalent to the Design-year, Max.-day water production.

For Components based on Supplying Pk.-hr Water Production . . .

. . . The Component Capacity is converted to an “Equivalent Max.-day Capacity” by:

‘Dividing’ the Component Capacity by the ratio of Pk.-hr to Max.-day production:

E.g., a finished-water pump station’s component capacity is 10.0 MGD, and the water system’s ratio of Pk.-hr to Max.-day production is 1.4:

$$\frac{10.0\text{ MGD }\cancel{\text{Pk.- hr}}}{1} \text{ X } \frac{\text{Max.-day}}{1.4\text{ }\cancel{\text{Pk.-hr}}} = \textbf{7.1 Equiv. Max.-day}$$

The Approved Capacity of a “WTP” . . .

. . . Must be large enough that finished water can be:

1. on at least a one-day basis; processed at a flow rate equivalent to the Design-year, Max.-day production,

   and

2. on at least a one-hour basis:

   a) disinfected at a flow rate equivalent to the Design-year, Pk.-hr of treatment rate, **and**

   b) delivered to the distribution system at a flow rate equivalent to the Design-year, Pk.-hr production.

The Approved Capacity of a "Source/WTP System" . . .

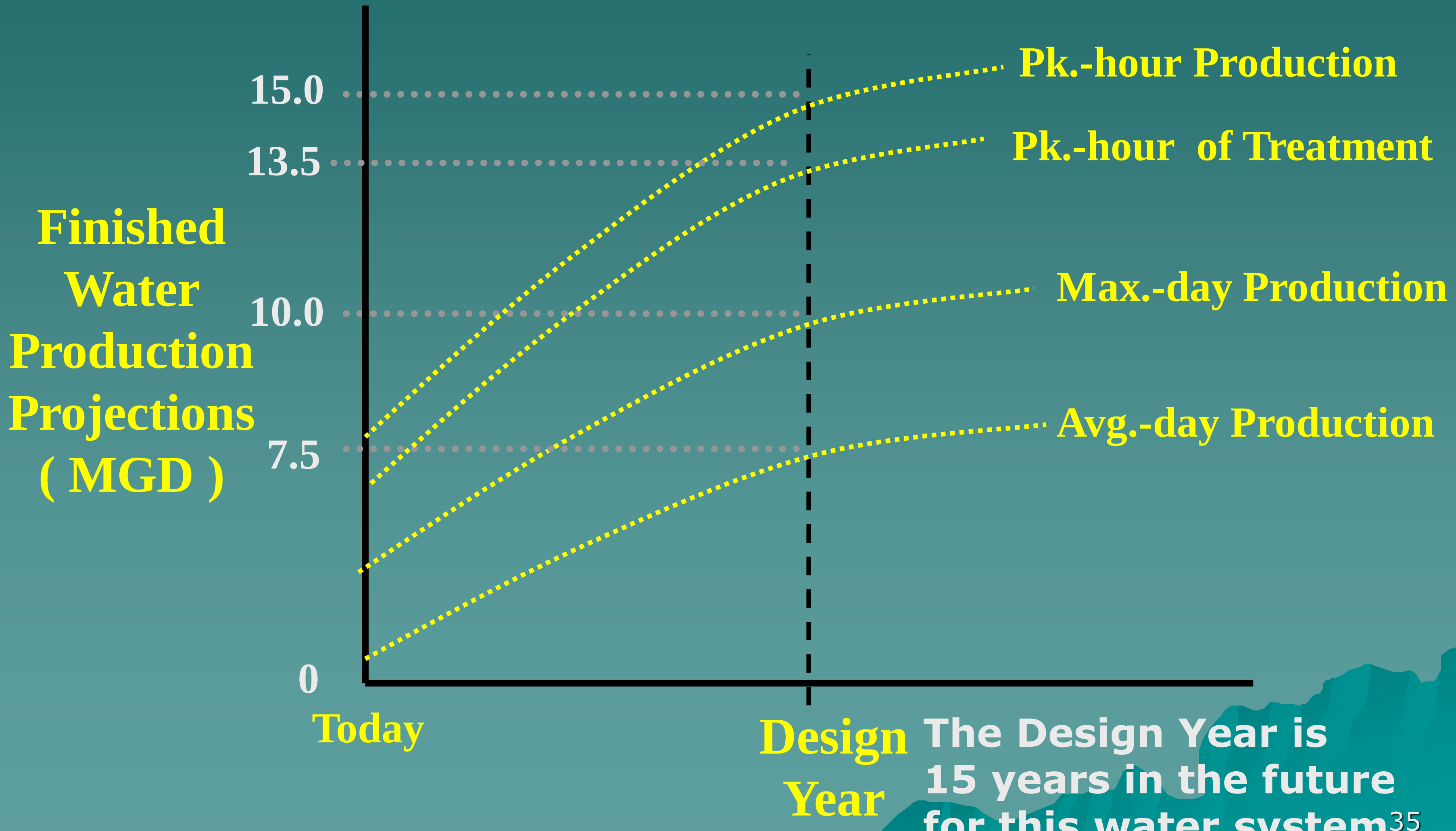
. . . Must be large enough that finished water can be delivered to the distribution system at a flow rate equivalent to the Design-year, Pk.-hr production

New Approach for Determining the Approved Capacity of a Source/WTP System

EXAMPLE

Determining the Approved Capacity of a Source/WTP System

WTP Production Projections Show this is a Growing Water System



The Design Year is 15 years in the future for this water system

Determining Approved Capacity of a Source/WTP System (cont)

This PWS wants to expand its 7.5-MGD water system to an approved capacity of 10.0 MGD (i.e., to be able to meet the projected, Max.-day production in the design year)

The ratio of Projected, Pk.-hour : Max.-day production is:

$$\frac{15.0 \text{ MGD}}{10.0 \text{ MGD}} = 1.50$$

The ratio of Projected, Pk.-hour treatment rate : Max.-day production is:

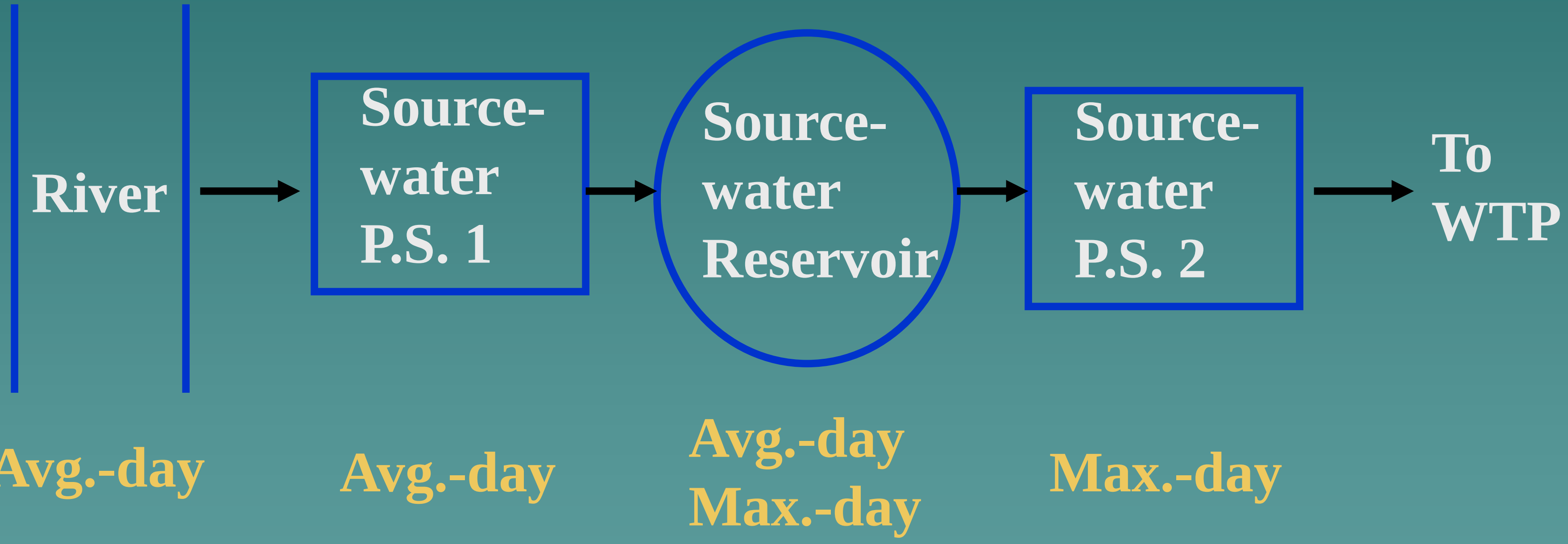
$$\frac{13.5 \text{ MGD}}{10.0 \text{ MGD}} = 1.35$$

The ratio of Projected, Max.-day : Avg.-day production is:

$$\frac{10.0 \text{ MGD}}{7.5 \text{ MGD}} = 1.33$$

Determining Approved Capacity of a Source/WTP System (cont)

Water-supply Source



River

Source-water P.S. 1

Source-water Reservoir

Source-water P.S. 2

To WTP

Avg.-day

Avg.-day

Avg.-day
Max.-day

Max.-day

Flow-rate Basis for Component Design Criteria

A Basis-of-Design (B-o-D) Table is required with all Plan Submittals

The Basis-of-Design Table Contains Information in Eight (8) Columns

1) Component of Water-supply source and WTP
2) Number of units, and Characteristics of units
3) Design standards (Design professionals’ suggestions)
4) Component Design criteria
5) Whether the component design criteria is Required (“Shalls/Musts” of TSS) or Recommended (“Shoulds”)
6) Component capacity
7) Finished-water flow rate (production) on which the component capacity is based (Avg.-day, etc. – and, the Ratio used to calculate Equiv., Max.-day capacity)
8) Equiv., Max.-day capacity for each Component, and Approved Capacity of the Water-supply source and the WTP (based on the Limiting component, respectively)

The Basis-of-Design (B-o-D) Table for Water-supply Source Components

1 Component	2 # of units	3 Design Standard	4 Design Criteria	5 Req'd / Rec	6 Component Capacity	7 Flow Basis of Comp. Cap. / Ratio	8 Equiv. Max.-day Capacity
River	One		Stable Yield based on an Engrg. Submission (1)	Req'd	7.5 MGD	Avg. day 1.33	10.0 MGD
Source-water P.S. 1	Four Pumps		Avg. day w/o largest	Req'd	9.0 MGD	Avg. day 1.33	12.0 MGD
		Max. day w/ all in-service		Rec	12.5 MGD	Max. day 1.0	(2)

(1) Engineering submission based on "USGS, Water-Resources Investigations Report 01-4256"

(2) No Equiv. Max-day Capacity based on Design standards or Recommended Design criteria. Only Required Design criteria determines approved capacity.

1 Component	2 # of units	3 Design Standard	4 Design Criteria	5 Req'd / Rec	6 Comp. Capacity	7 Flow Basis of Comp. Cap. / Ratio	8 Equiv. Max.-day Capacity
Source-water Res.	**One**		**Based on an Engrg. Submission (3)**	**Req'd**	**8.5 MGD**	**Avg. day** **1.33**	**11.3 MGD**
		Storage to Assist w/ Max. day		**Rec**	**12.0 MGD**	**Max. day** **1.0**	
Source-water P.S. 2	**Five Pumps**		**Max. day w/o largest**	**Req'd**	**12.5 MGD**	**Max. day** **1.0**	**12.5 MGD**
		Pk. hour Trtmnt w/ all in-service		**Rec**	**16.5 MGD**	**Pk. hour Trtmnt** **1.35**	

(3) An Engineering submission must justify the River, Source-water P.S. 1 & Source-water Reservoir working closely together as a Single Component.

Key Conclusions from the B-o-D Table for the Water-supply Source

1. The Approved capacity of the Water-supply source is 11.3 MGD (i.e., the 8.5 MGD Avg.-day Combined Component capacity for the River, Pump Sta. and Reservoir makes this combination the Limiting component of the Water-supply Source)

2. The water system will have to draw from a new River or construct an additional off-line storage reservoir(s) if another expansion is ever needed to meet an Avg.-day water production > 8.5 MGD

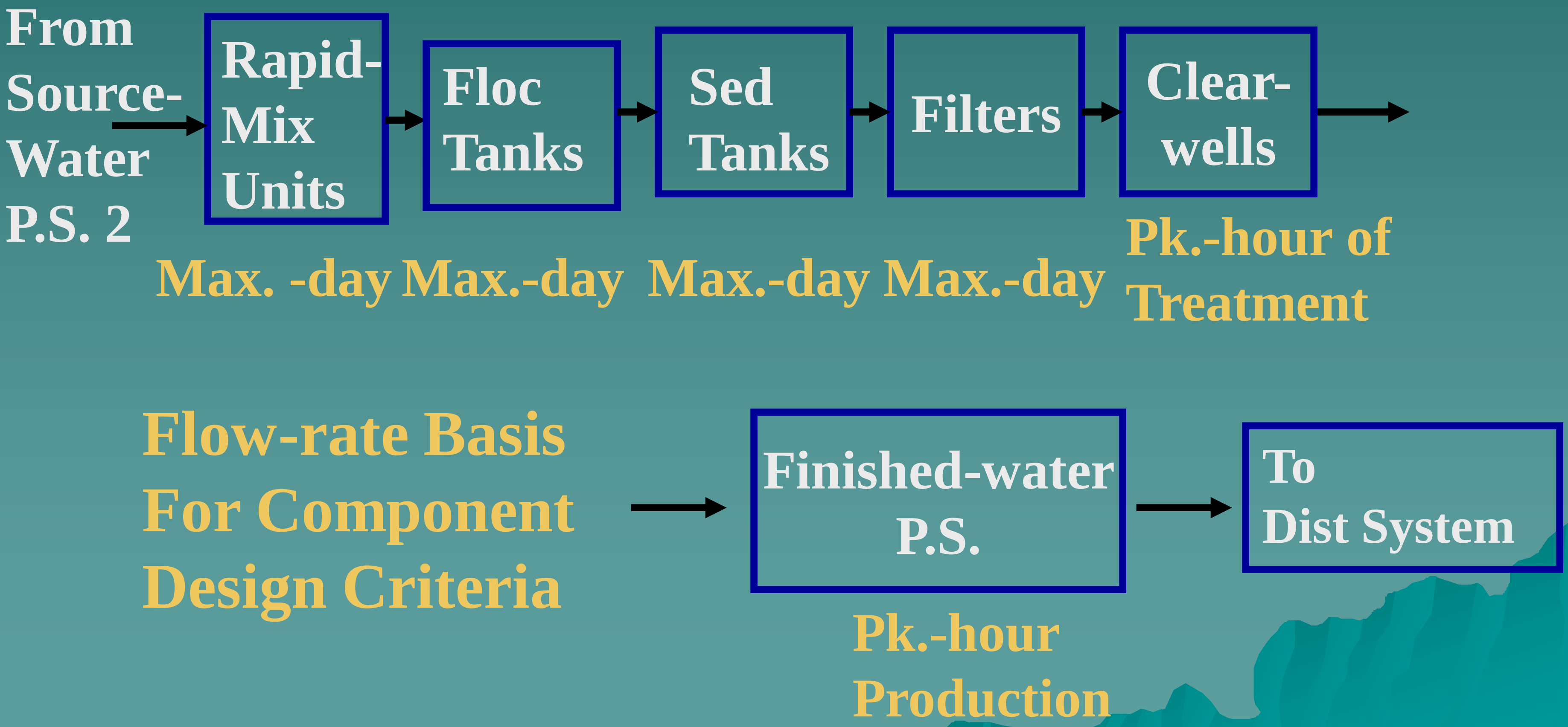
3. Source-water P.S. 1, by itself, must deliver only Avg.-day water production since it pumps into the Source-water Reservoir (for which the reservoir storage provides a buffering capacity)

4. An Engineering Submission must justify the combined capacity of the River, P.S. 1 & the Reservoir if these components are to be combined as a single component

5. Source-water P.S. 2 must deliver Max.-day water production since it pumps directly to the WTP

Determining Approved Capacity of a Source/WTP System (cont)

Water Treatment Plant (WTP)



From Source-Water P.S. 2

Rapid-Mix Units

Floc Tanks

Sed Tanks

Filters

Clear-wells

Max. -day Max.-day Max.-day Max.-day

Pk.-hour of Treatment

Flow-rate Basis For Component Design Criteria

Finished-water P.S.

To Dist System

Pk.-hour Production

The Basis-of-Design (B-o-D) Table for WTP Components

1 Component	2 # of units	3 Design Standard	4 Design Criteria	5 Reg'd / Rqc	6 Component Capacity	7 Flow Basis of Comp Cap. / Ratio	8 Equiv. Max.-day Capacity
Rapid mixers	Two		Det Time < 30 sec	Req'd	15.0 MGD	Max. day 1.0	**15.0 MGD**
		G Value of +/- 1,000		Rec	15.0 MGD	Max. day 1.0	
Floc basins	Four		Det Time > 30 min	Rec	12.0 MGD	Max. day 1.0	
		Gt Value of 25 - 100		Rec	12.5 MGD	Max. day 1.0	
Sed basins	Four		Det Time > 4 hrs	Req'd	11.5 MGD	Max. day 1.0	**11.5 MGD**
		Flow-thru Vel < 0.5 fpm		Rec	11.0 MGD	Max. day 1.0	

1 Component	2 # of units	3 Design Standard	4 Design Criteria	5 Req'd / Rec	6 Component Capacity	7 Flow Basis of Comp. Cap. / Ratio	8 Equiv. Max.-day Capacity
Filters	Five		Max. day w/o largest	Req'd	12.5 MGD	Max. day 1.0	**12.5 MGD**
		Pk. hour Trtmnt w/ all in-service		Rec	15.5 MGD	Pk. hour of Trtmnt 1.35	
Clear-wells	Two		CT for 0.5-log Giardia	Req'd	12.5 MGD	Pk. hour of Trtmnt 1.35	**9.3 MGD**
		Storage for Pk hr Product.		Rec	16.0 MGD	Pk. hour Product. 1.50	
Finished-water P.S.	Five		Pk. hour w/o largest	Req'd	18.0 MGD	Pk. hour Product. 1.50	**12.0 MGD**
		Fire flow w/ all in-service		Rec	??	Fire flow	

Key Conclusions from the B-o-D Table for the WTP

The Approved capacity of the WTP is
9.3 MGD

(The 12.5 MGD Pk.-hour of treatment Component capacity for CT makes the Clearwells the Limiting component of the Source/WTP System)

Approved Capacity of the Source/WTP System is 9.3 MGD

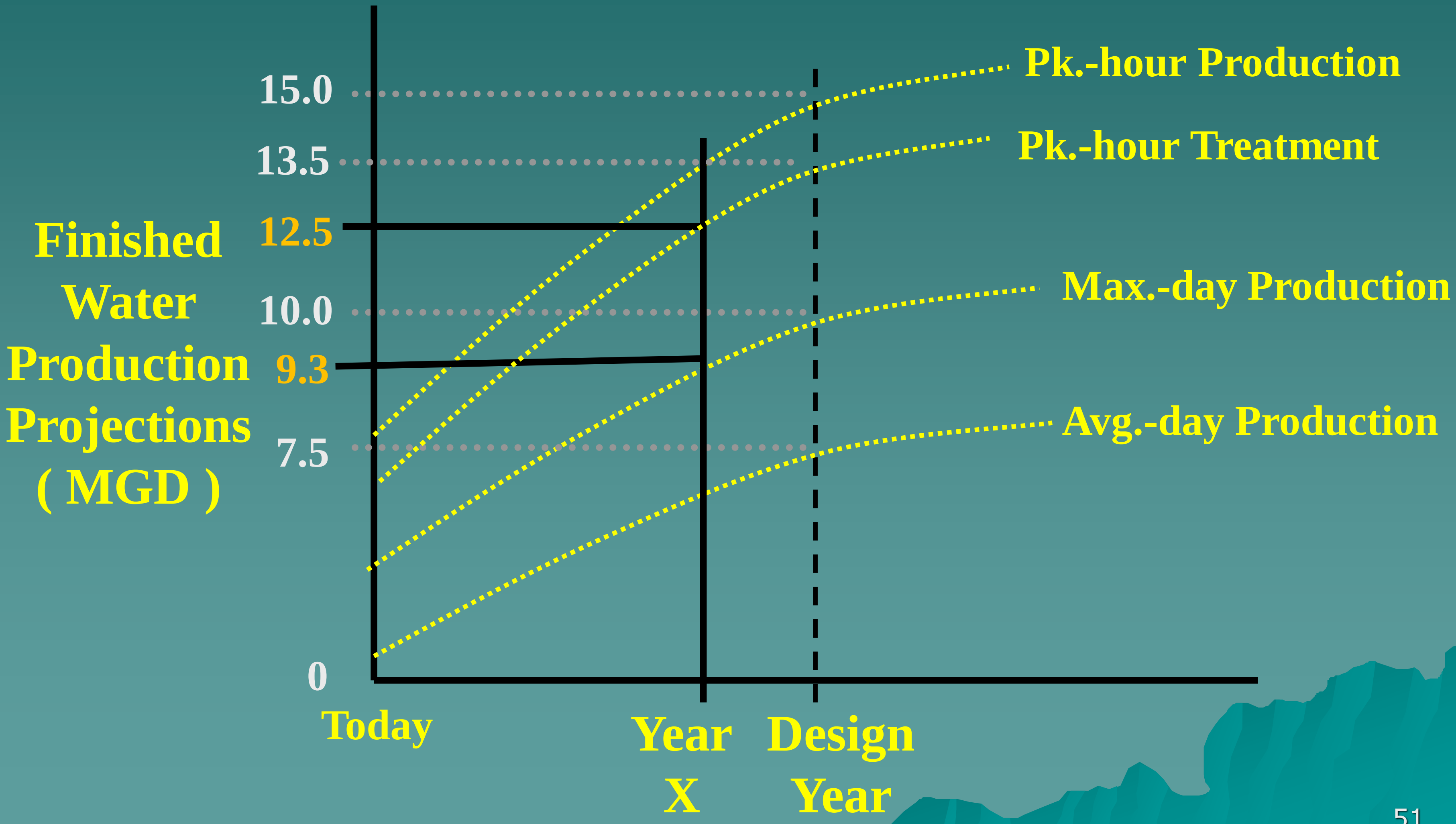
- The Approved capacity of the Water-supply Source is 11.3 MGD
- The Approved capacity of the WTP is 9.3 MGD
- The Approved capacity of the Source/WTP System is 9.3 MGD
  (Lesser of the two approved capacities)

Key Conclusions from the B-o-D Table for the WTP (cont)

Essentially, in Year X (see Figure on next slide) when the Winter, Max.-day production reaches 9.3 MGD (i.e., an associated Pk.-hour of treatment rate of 12.5 MGD has been reached):

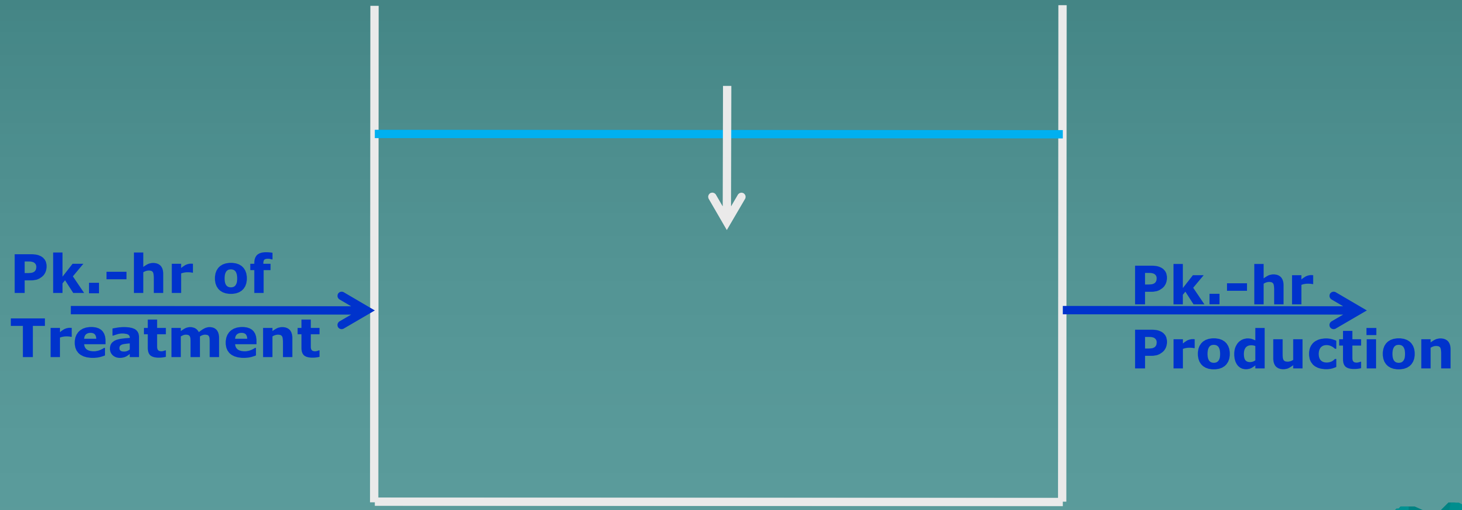
The WTP will be first challenged in Year X and beyond to meet the required daily CT value in the Winter at a water temperature of 0.5 C

The Clearwell CT Capacity Shortage Occurs in Year X



YES – a Clearwell can be the Limiting Component

First thing a water system can consider to possibly increase Component capacity of the Clearwell is to use Pk.-hr of Treatment instead of Pk.-hour Production (i.e., Production generally > Treatment during Pk.-hr conditions, and Water level in Clearwell is typically dropping)



CT = residual disinfectant **C**oncentration x effective contact **T**ime
T is based on pk.-hr of treatment and corresponding clearwell level

To Increase the Approved Capacity, the Water System could . . .

- Increase the “C” of CT by increasing the free chlorine residual (i.e., DBPs don’t form as readily in the winter),
- Increase the “T” of CT by increasing the effective volume factor, EVF, of the Clearwells (e.g., install baffles),
- Increase the “T” of CT by maintaining a higher water level in the Clearwells (e.g., install VFDs on finished-water pumps),

To Increase the Approved Capacity, the Water System could also . . .

- Decrease the “Ratio” of Pk.-hour of treatment to Max.-day water production (e.g., install VFDs on both source-water and finished-water pumps),
- Decrease the “Ratio” of Pk.-hour water production to Max.-day water production (e.g., construct additional distribution-system storage),
- Request a “seasonal CT” approved capacity for the Clearwells (particularly if the Summer, Max.-day water production is significantly larger than the Winter, Max.-day water production)

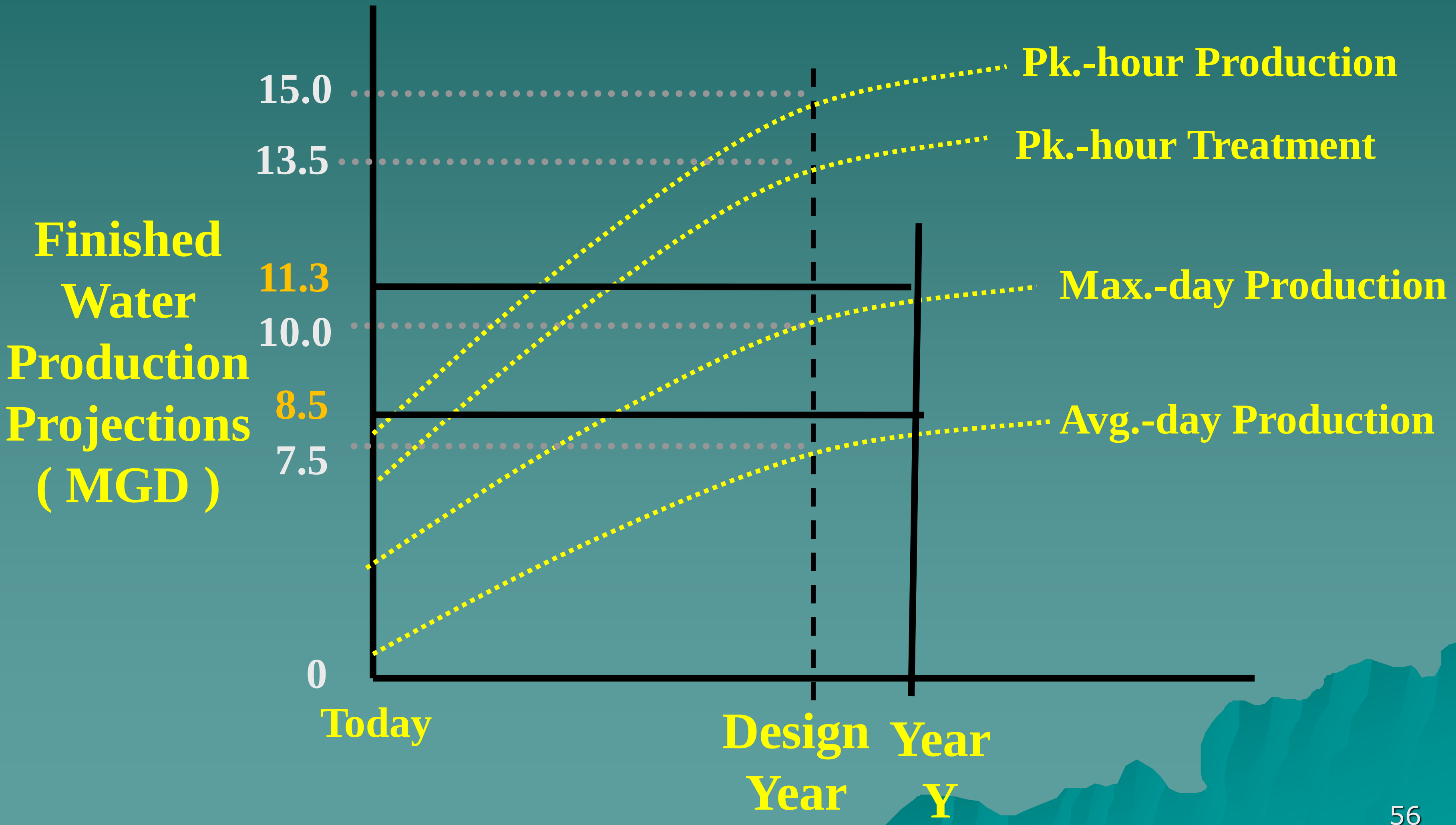
Additional Baffles were Installed to Increase the EVF from 0.4 to 0.6

- The New Equiv. Max.-day Capacity for the clearwell is now:

$$\frac{9.3 \text{ MGD}}{1} \text{ X } \frac{0.6}{0.4} = 14.0 \text{ MGD}$$

- Therefore, the Approved Capacity of the WTP is now 11.5 MGD (i.e., the Sed basins are now the Limiting component)
- The Approved Capacity of the Source/WTP System is now 11.3 MGD (i.e., the River, P.S. 1 and Reservoir combination is now the Limiting Component)

The Source-water Capacity Shortage Occurs in Year Y



What Constitutes a Violation of Plan Approval

For all Components Except Clearwells and Most Pumps *

- If any component is operated:

1) for a one-day period – or,

2) for the period the component is in operation that day;

at an average rate in excess of the source/WTP system's approved capacity . . .

. . . This will result in a violation of plan approval.

* Well pumps are the only pumping units for which operation "can" result in a violation of plan approval.

And, the operation of well pumps "does not" result in a violation of plan approval if these pumps are conveying water to a source-water storage reservoir (i.e., are not pumping directly to the WTP).

“Pumps” can limit the approved capacity of the Water-supply source, or WTP . . .

. . . But, operating Pumps (other than Well pumps) for a one-day period at an average rate in excess of the Source/WTP system’s approved capacity does not result in a violation of plan approval.

- However, operating Pumps for a one-day period at an average rate in excess of the Source/WTP system’s approved capacity “could” result in a violation of plan approval by the component upstream or downstream of the pumps.

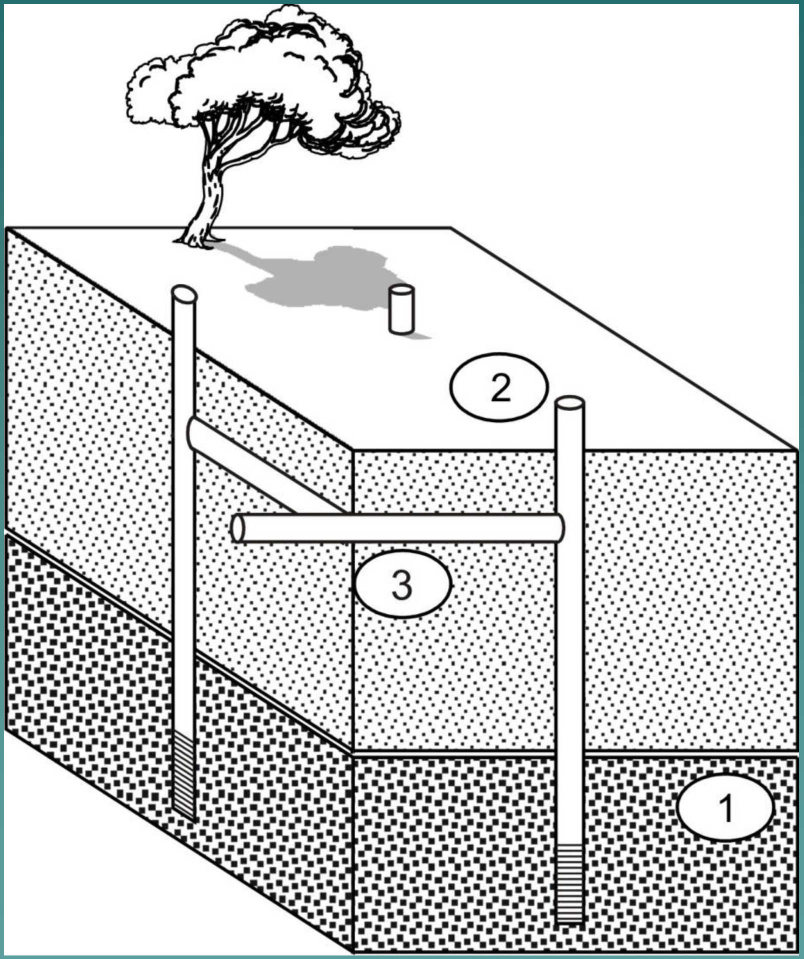
“Clearwells” can limit the approved capacity of the WTP . . .

. . . But, operating Clearwells for a one-day period at an average rate in excess of the Source/WTP system’s approved capacity does not result in a violation of plan approval.

- However, operating Clearwells for a one-day period at an average rate in excess of the Source/WTP system’s approved capacity “could” result in a violation of the CT criteria defined in OAC 3745-81-74.

Additional Examples

Determining the Approved Capacity of a Groundwater Source



1. Aquifer
2. Well, including well pump
3. Pipeline to WTP

Determining the Approved Capacity of a Groundwater Source (cont)

- Component Capacity of the well field = 20 MGD

  (i.e., based on supplying the Design-year, Max.-day production - determined by the largest pump in the well field being out-of-service)

- The historic ratio of Max.-day to Avg.-day, finished-water production for this system = 1.5.

Determining the Approved Capacity of a Groundwater Source (cont)

- The Component Capacity of the wells is based on supplying the Max.-day production (no source-water storage between well field and WTP, so well pumps must deliver source water directly to the WTP)

Therefore, the Equiv. Max.-day Cap. of the well field is:

$$\frac{20\text{ MGD Avg.-day}}{1} \text{ X } \frac{1.0\text{ Max.-day}}{\text{Max.-day}} = \begin{array}{c}20\text{ MGD Equiv.}\\ \text{Max.-day}\end{array}$$

Determining the Design-year, Peak-hour of Treatment for Clearwells

Determining the Design-year, Pk.-hr of Treatment for Clearwells (cont)

An existing, 3.0-MGD Surface WTP is being expanded to an Approved Capacity of 4.5 MGD (i.e., to supply customers with the projected Design-year, Max.-day Production).

Current production rates for the existing, 3.0-MGD surface WTP are:

- Avg.-day, Production = 1.5 MGD
- Max.-day , Production = 2.5 MGD
- Pk.-hour, Treatment = 4.0 MGD *
- Pk.-hour, Production = 5.0 MGD

* The available storage volume in the Clearwells has made it such that this existing surface WTP has only had to process water at 4.0 MGD during the Pk.-hour of treatment.

Determining the Design-year, Pk.-hr of Treatment for Clearwells (cont)

At what Pk.-hour of treatment rate must the Clearwells be designed to meet the design-year, daily 0.5-log inactivation of *Giardia* criterion during the worst-case conditions (i.e., winter, at a water temperature of 0.5 C) after filtration ?

The current ratio of Pk.-hour of treatment rate to Max.-day production at this surface WTP is:

$$\frac{4.0 \text{ MGD}}{2.5 \text{ MGD}} = 1.6$$

Determining the Design-year, Pk.-hr of Treatment for Clearwells (cont)

It is assumed for this example that this ratio will still be the same in the design year. Therefore, the Pk.-hour of treatment rate at which the Clearwells for the expanded WTP must be designed is:

$$\frac{\text{4.5 MGD (Max.-day)}}{} \quad \text{X} \quad \frac{\text{1.6 (Pk.-hour)}}{\text{(Max.-day)}} = \text{7.2 MGD Pk.-hr}$$

- So, this expanded surface WTP will have an Approved Capacity of 4.5 MGD only if the Clearwells have a Component Capacity of 7.2 MGD or greater

Determining the Design-year, Pk.-hr of Treatment for Clearwells (cont)

- “Approved capacity” is the Max.-day water production the Clearwells would be able to help support in the design year

- Another way of stating this definition is - In the design year when the Max.-day production has reached 4.5 MGD at this expanded WTP, the associated Pk.-hour of treatment rate would become 7.2 MGD (based on the Pk.-hour treatment to Max.-day production ratio of 1.6).

Determining the Equiv. Max.-day Capacity of a Finished-water Pump Station

A Water System's Projected Production is:

- Pk.-hour production = 14.0 MGD
- Max.-day production = 10.0 MGD (i.e., the ratio of Pk.-hour to Max.-day production = 1.4)
- Avg.-day production = 7.5 MGD
- Component Capacity of the Finished-water P.S. is 17.5 MGD (based on Pk.-hour production), with the largest unit out-of-service

Therefore, the Equiv. Max.-day Capacity of the Finished-water P.S. is:

$$\frac{\textbf{17.5 MGD Pk.-hour}}{} \times \frac{\textbf{Max.-day}}{\textbf{1.4 Pk.-hour}} = \textbf{12.5 MGD Equiv. Max.-day}$$

Questions?