Unique Riverbank Filtration System Provides 80 MGD at Louisville.

Henry Hunt
Ranney Collector Wells
A Layne Christensen Technology

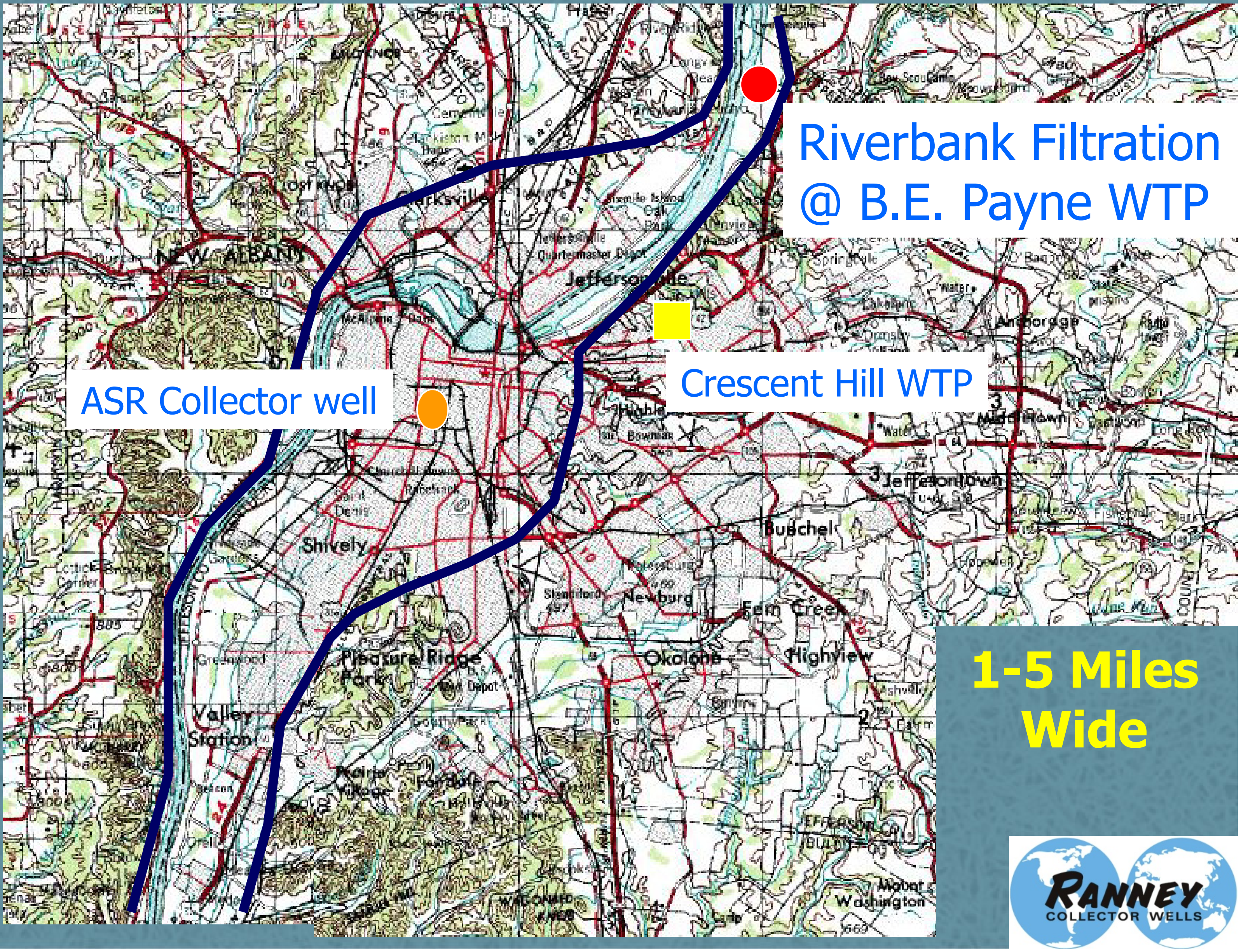
Riverbank Filtration (RBF)

- RBF has been developed since the early 1940's in the US and for over 100 years in Europe (induced infiltration)
- Biblical and primitive references
- LWC brought the term to forefront
- LWC has in effect become the Face for RBF here in the U.S.

Louisville Water Company

- Celebrated 150th Anniversary in 2010
- 7 Member Bi-partisan Board appointed by Mayor
- Officers elected annually by Board
- Over 800,000 Customers
- Two Water Treatment Facilities:
  - B.E. Payne WTP – 60 MGD
  - Crescent Hill WTP – 180 MGD
- Demand – 110 MGD – Winter
- Demand – 200 MGD peaks in Summer
- EPA-certified lab, >300 samples/day

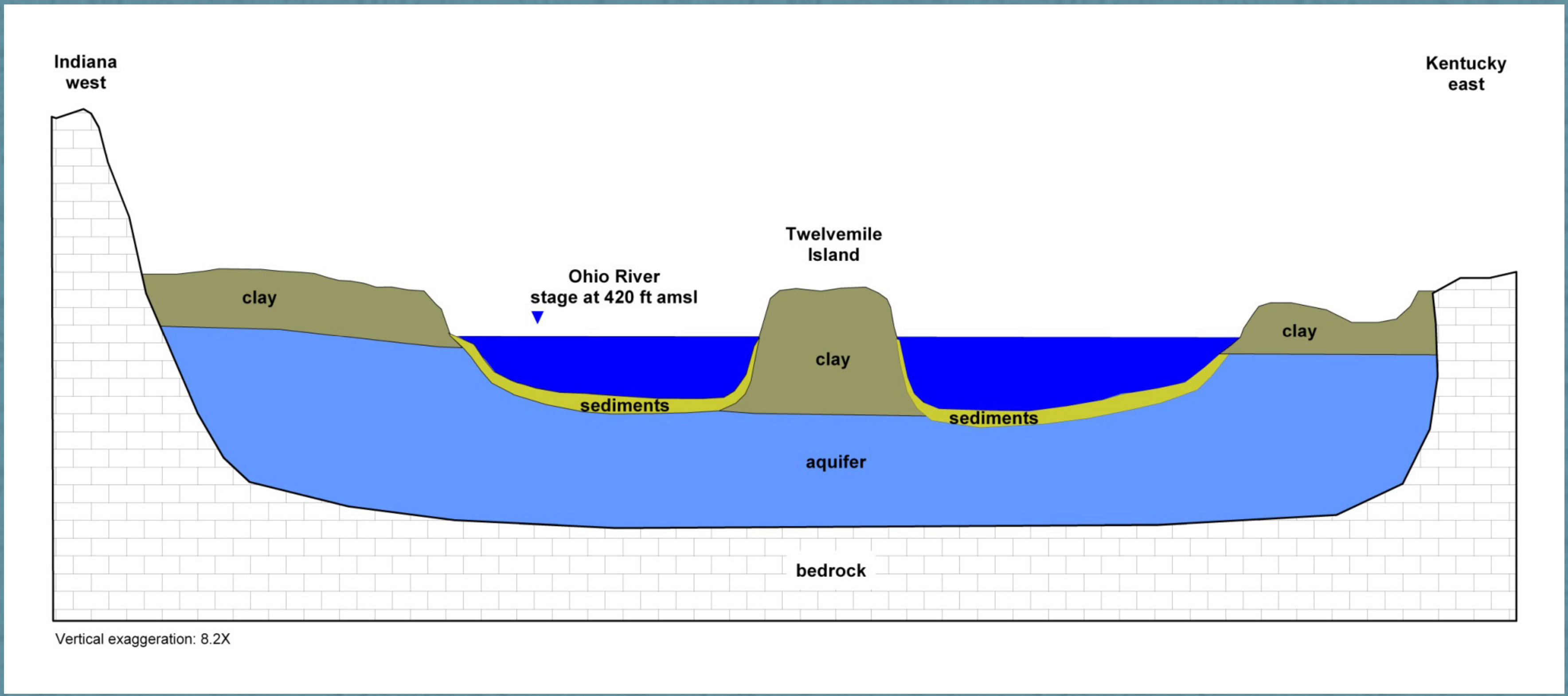
Louisville, KY – alluvial deposits



1-5 Miles Wide

Generalized Cross-section

River width (average) = ~ 2000 feet



LWC - RBF Experience

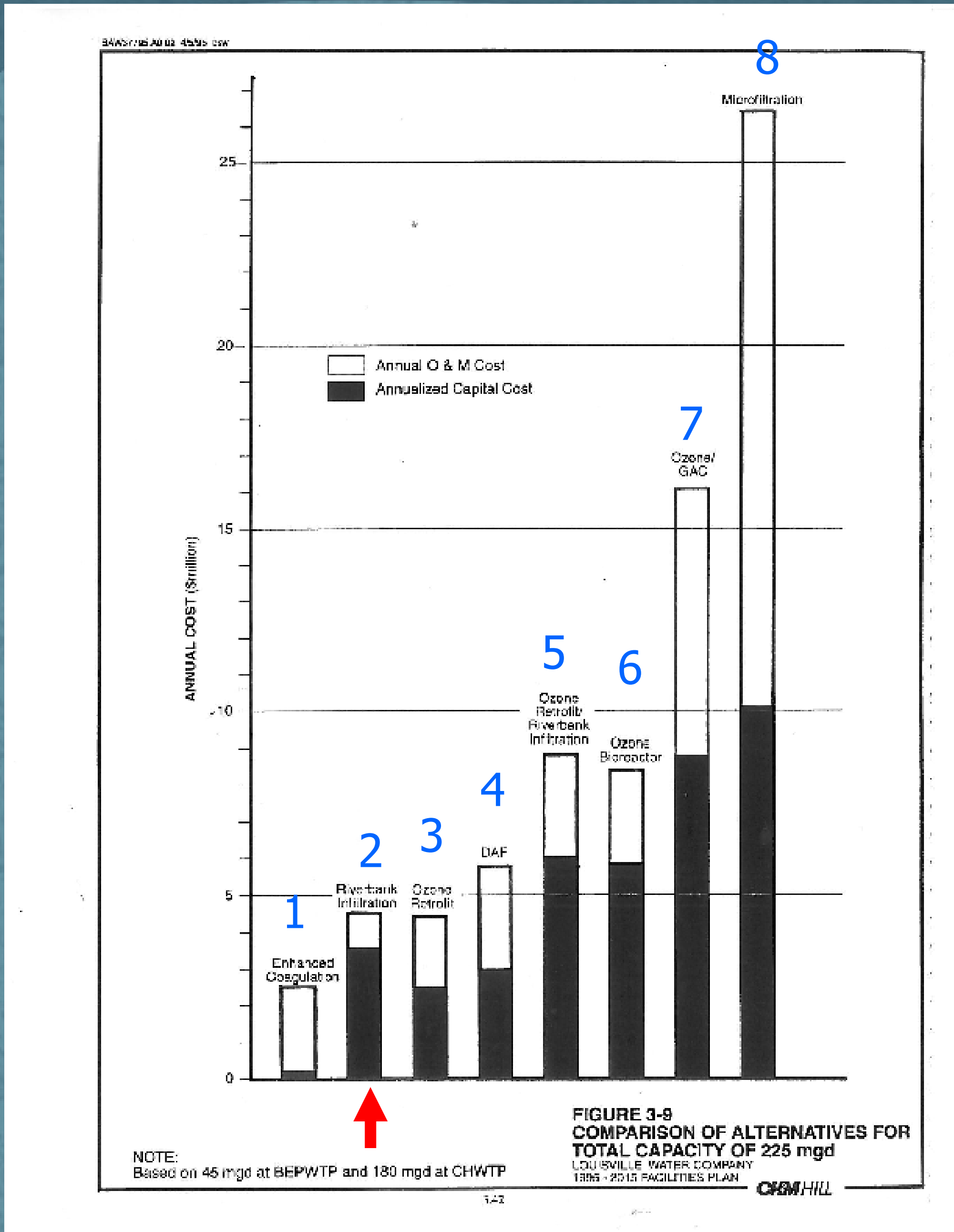
- 1860 – George Warren Fuller filtration experiments
- Began studying RBF in 1940’s with USGS
- USGS indicated 280 MGD available
- Milwaukee Cryptosporidium outbreak in 1993 re-focused interest in protection
- Facilities Plan in 1995 (1995 – 2015)
- Advantages: turbidity, NOM, Cryptosporidium, temperature control - line break reductions, etc.
- Phase I – 1997-1999 (Well #1 – demonstration)
- Phase II – 2006-2010 (Wells #2-5)

Comparison of non-economic factors

Table 3-25
Comparison of Alternatives for Noneconomic Criteria

Alternatives	Future Regulations			Additional Benefits					
	ESWTR (Crypto Removal)	D/DBPR (THM Precursor Removal) (percent)	Flexibility Future Regulations	Distribution Water Quality	Synthetic Organics Removal	Zebra Mussels	Reduction of Chemical Use	Temp. Main Breaks	Turbidity Reduction
No Action	2 log ±	20	o	o	o	o	o	o	o
Enhanced Coagulation	3 log	30	o	o	o	o	-	o	+
Dissolved Air Flotation	4 log	20 to 30	+	o	o	o	+	o	+
Ozone Retrofit	4 log	30	+	o		o	+	o	+
Riverbank Infiltration	4 log ±	30	+	+	+	+	++	+	++
Ozone/GAC	5 log	80	++	+++	+++	o	−	o	+
Ozone/GAC Bioreactor	5 log	60	+	++	+	o	+	o	+
Riverbank Infiltration/ Ozone Retrofit	6 log	50	+	+	+	+	++	+	++
Microfiltration	6 log	20	o	o	o	o	+	o	++
Nanofiltration	6 log	90	++	+++	+	o	o	o	+++

Facilities Plan, 1995, CH2M Hill



Comparison of Annual O&M Costs

1 - Enhanced Coagulation
2 – RBF
3 – Ozone retrofit
4 – DAF
5 – Ozone Retro/RBF
6 – Ozone Bioreactor
7 – Ozone/GAC
8 - Microfiltration

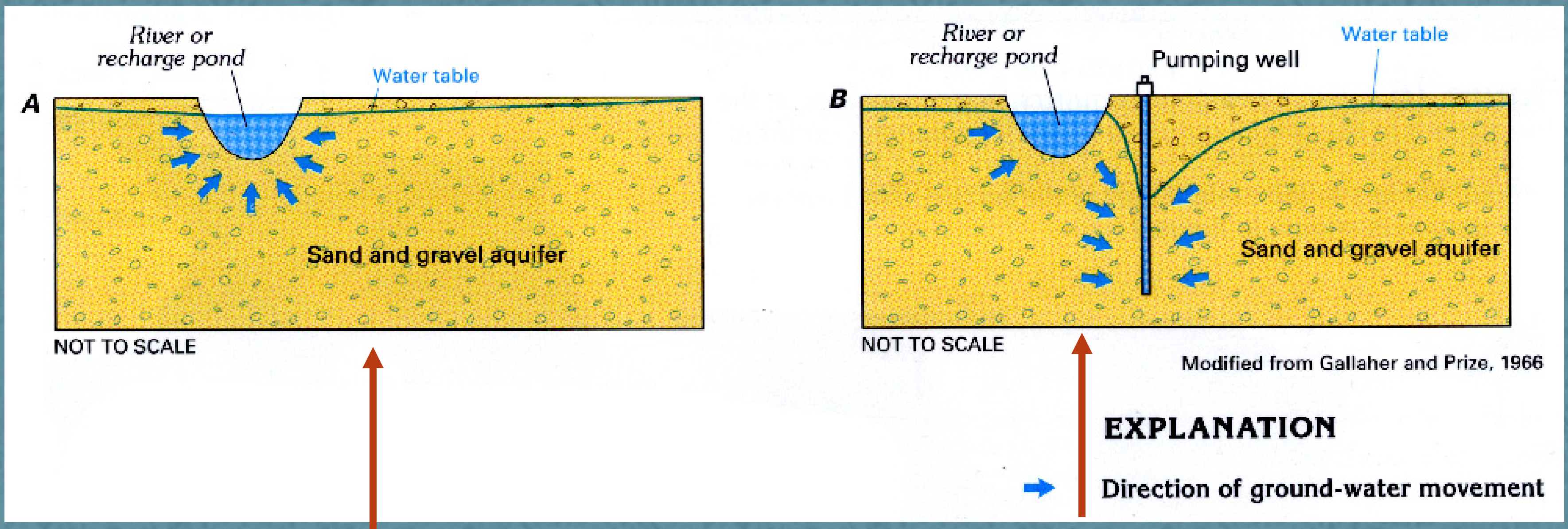
Facilities Plan, 1995, CH2M Hill

Riverbank Filtration (RBF)

Natural filtration process using alluvial deposits

- Selected following Facilities Plan
- Demonstration well and trial period (Well #1)
- Treat water through B.E. Payne WTP
- Evaluate O&M costs vs Surface Water
- Work w/local historical/conservation groups

Riverbank (Induced) Filtration



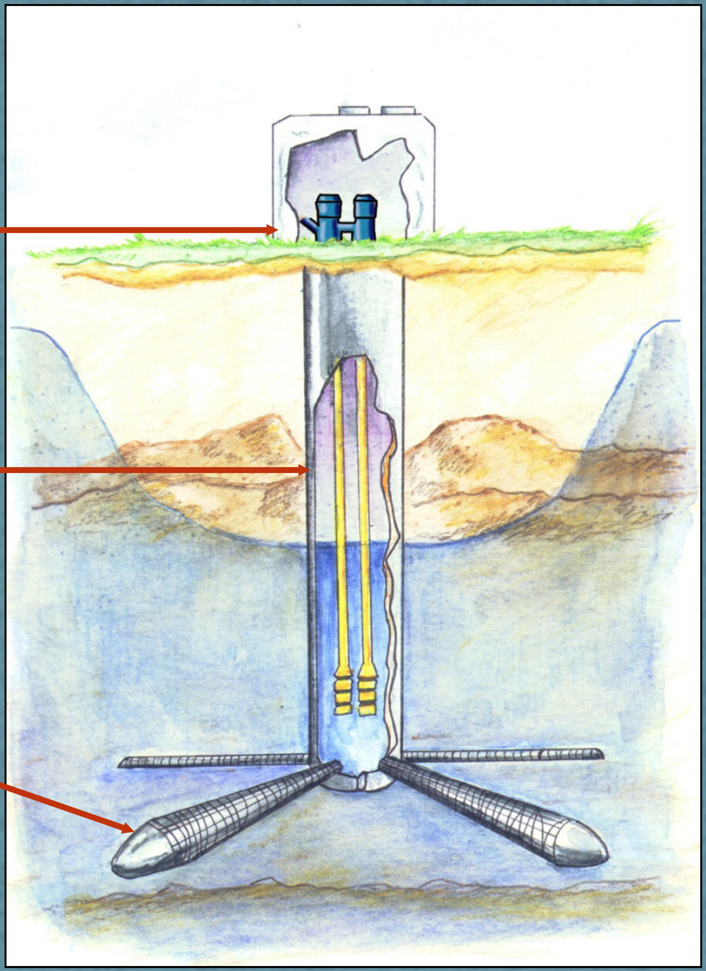
Groundwater recharges river **Gradient Reversed**

Benefits of RBF vs Surface Water

- Avoids intake of aquatic organisms
- More consistent water quality
- Reduced temperature extremes
- Easier to permit than intakes
- Fish protection
- Can allow automation of WTP
- Natural filtration of suspended particulates, turbidity, NOM, microbials, DBPs, EDs, PPCPs
- Dampening of shock loads and spill protection
- Reduced vulnerability to weather events
- Reduced effects of pesticides and agricultural runoff

Demonstration Radial Collector Well

- Pump Station
- Reinforced Concrete Caisson
- Lateral Well Screens



Building caisson sections

Port assemblies

Sinking the caisson

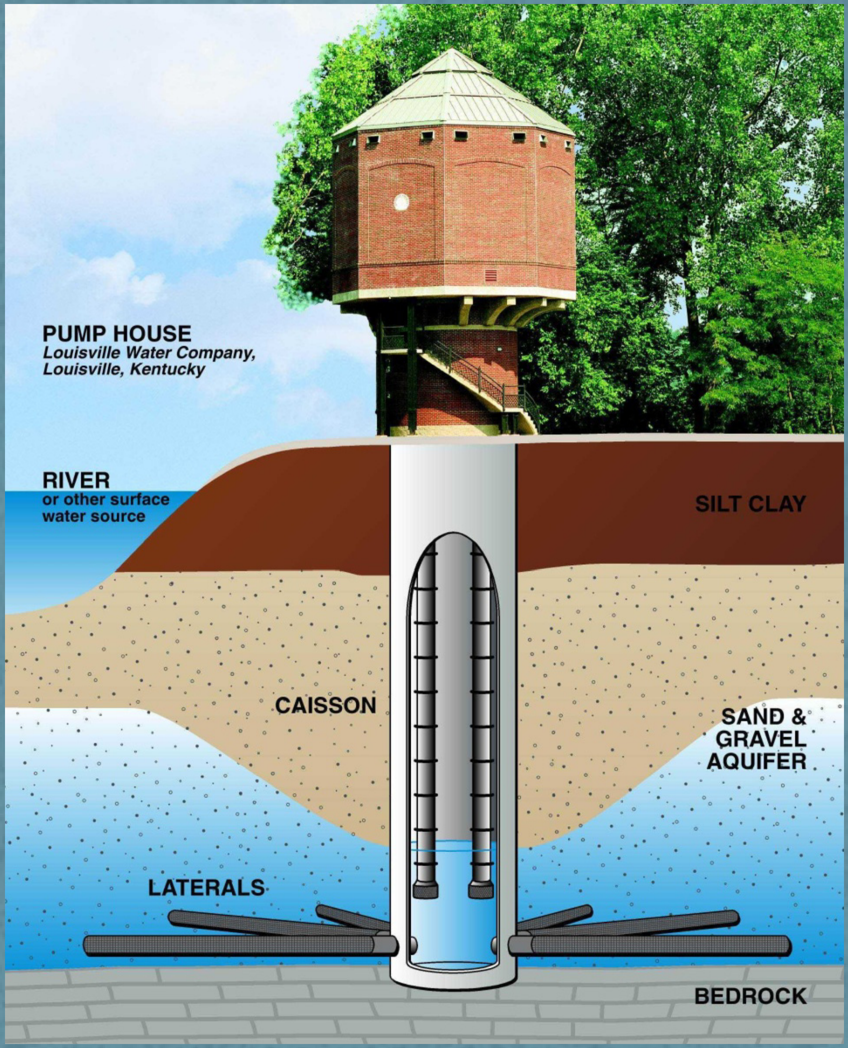
Forming & pouring sections

Sampling of riverbed interface

Lateral well screen projection

Well Screen Development

Phase I – demo well complete



100 feet deep

25 feet above grade

> 1560 LF 12′ screen in 8 laterals

Q = 15-20 MGD

Water Quality Comparison – Well #1

Parameters	River Water	Infiltrated Groundwater	Groundwater
pH	7.7 - 7.9	7.4 - 7.5	7.2 - 7.3
Total Hardness (mg/L)	90 - 205	205-250	530 - 582
TDS (mg/L)	184	234	606
TOC (mg/L)	2.1 - 4.9	0.3 - 0.6	0.4 - 0.7
Turbidity (NTU)	2 - 1,500	<0.08	NA
D.O. (mg/L)	>5.0	<0.1	NA
Iron (mg/L)	<1	2.5	15.8
Temperature (F)[1]	32 - 86	50 - 78	About 55

From Wang 2002, 2003, and CH2M Hill 1996

System configurations

- Soft-ground tunnel with laterals
- Hard rock tunnel with vertical wells (30+)
- Hard rock tunnel with collector wells (4)
- Collector wells with pumps and piping

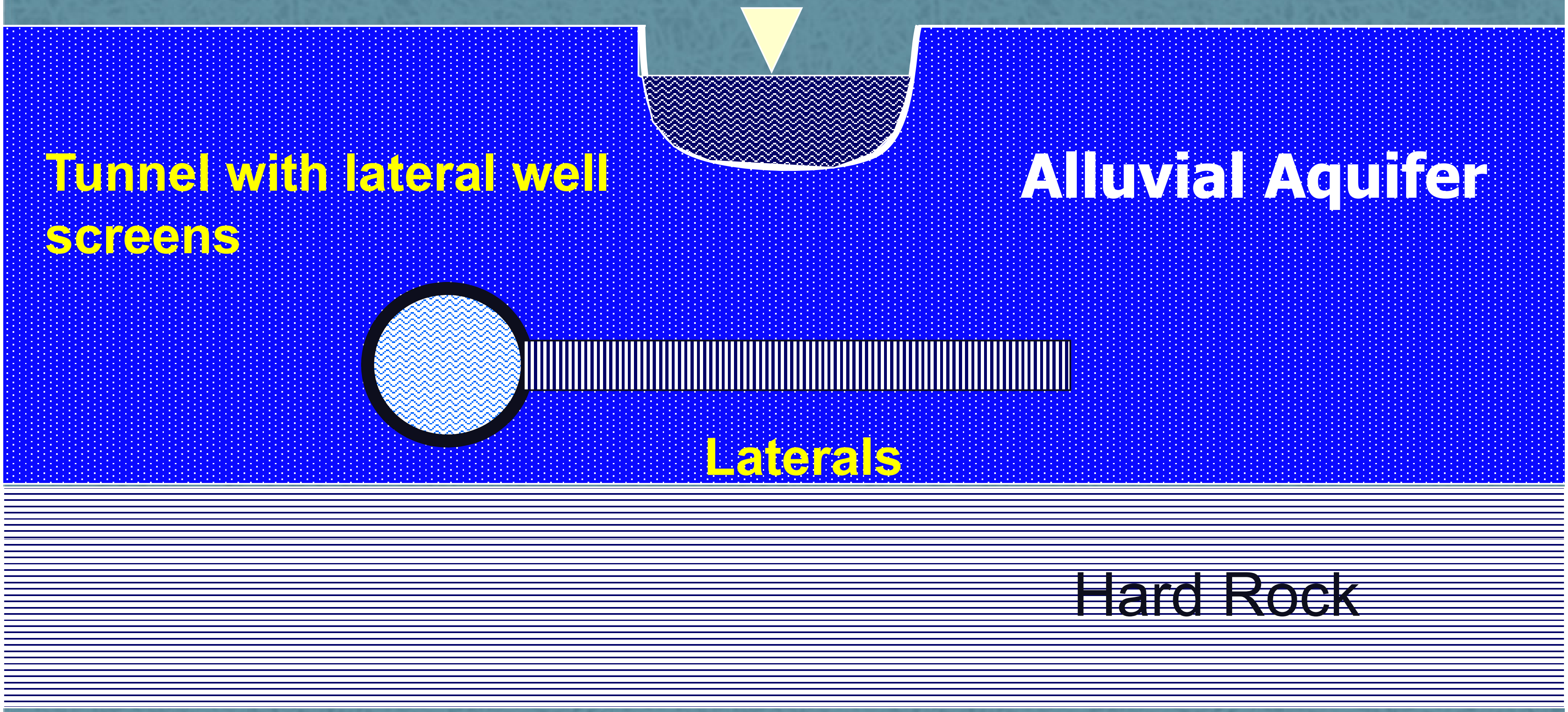
- Preferred gravity (tunnel) approach
- Vertical well arrangement - well over budget
- Collector wells with tunnel - within budget

  "- Limited Risk and more cost-effective"

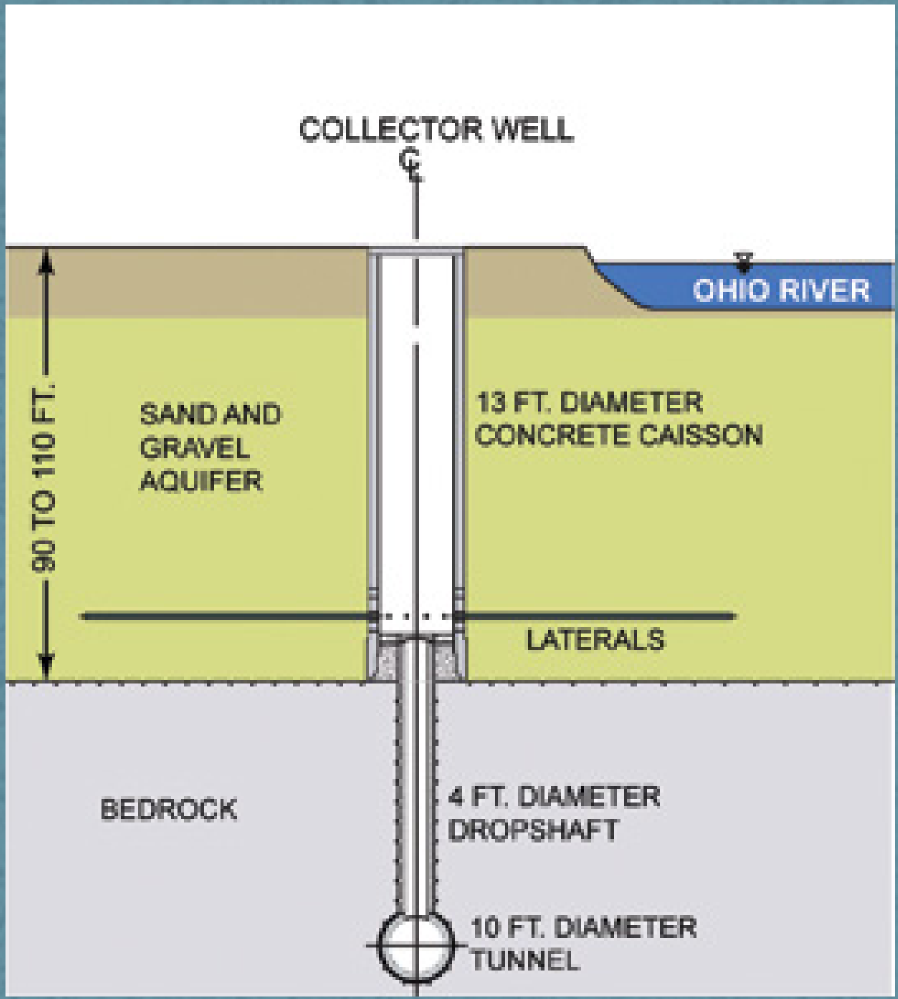
Tunnel Approach Advantages

- Gravity Flow – centralized pumping
- Aesthetics – low profile completions in residential and public-use areas
- Flood accessibility to Pump Station

Soft-ground tunnel approach



Hard-rock tunnel approach



Project Site

Pump Station

Collector Wells

Riverbank Filtration Tunnel and Pump Station
B.E. Payne Water Treatment Plant

Phase II – collector wells + tunnel

4 Collector Wells

Each shaft ~ 100 feet deep

13 – foot ID

8 – 12" laterals

Q ~ 15 MGD each

8-foot diameter drop shaft

Drop shaft reaching tunnel

Low-profile completion

Pump station shaft

Hydromill – slurry wall

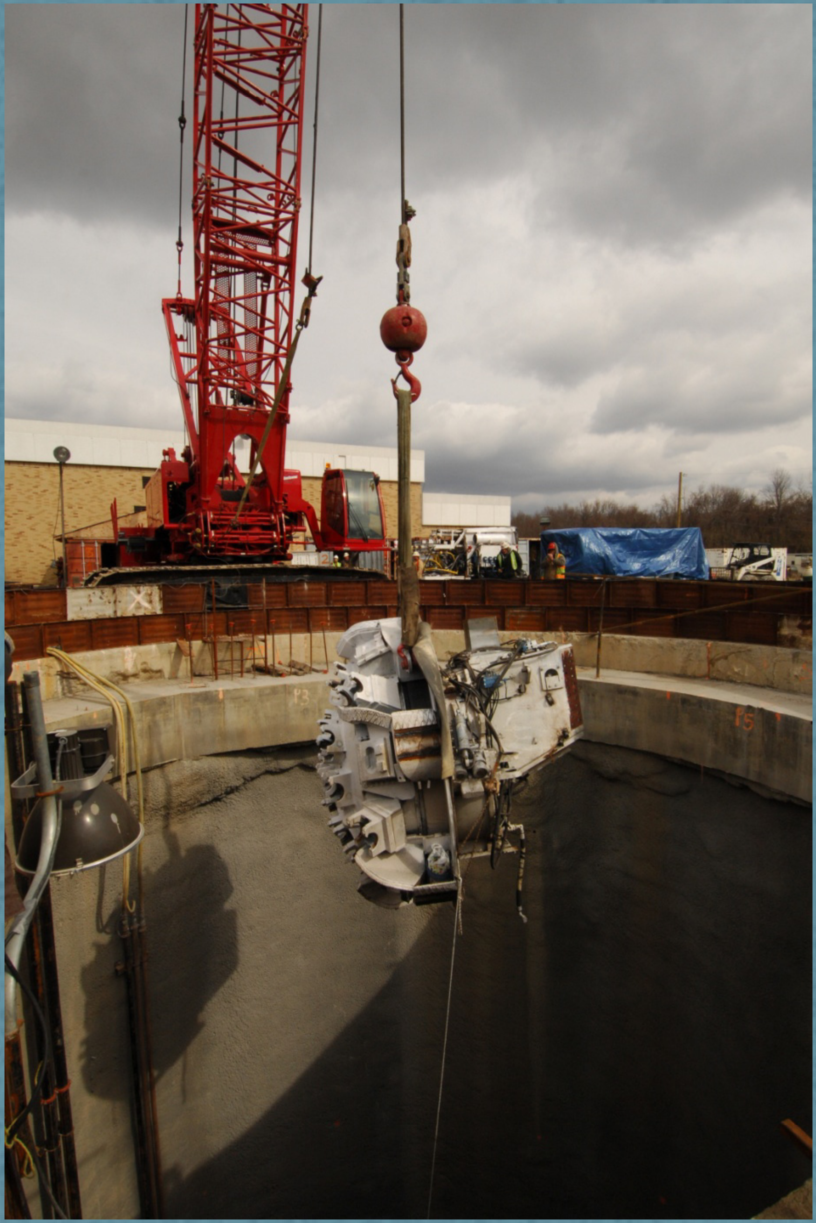
40 – foot diameter

100 feet of overburden

15 feet into rock

Traditional drill & blast to 200 feet with finished diameter of 25 feet

Shaft & tunnel construction



Tunnel Boring Machine (TBM)

Tunnel start within pump station shaft

Tunneling

Water tunnel

1.5 Miles long – 12 ft borehole
150 ft below grade
10 ft finished ID

Pump station – 65 MGD

2 – 20 MGD pumps, 1 – 15 MGD pump, 1 -10 MGD pump

Currently . . .

- Wells pumping into the treatment plant
- Finding the right treatment settings as the water quality stabilizes
- **Winner** - **Outstanding Projects and Leaders Awards (OPAL)** (ASCE) 2011 competing with the Dallas Cowboy's new stadium, Incheon Bridge (Korea), Taum Sauk Upper Reservoir Rebuild Project (MO), and the Washington Dulles new Airport Terminal.

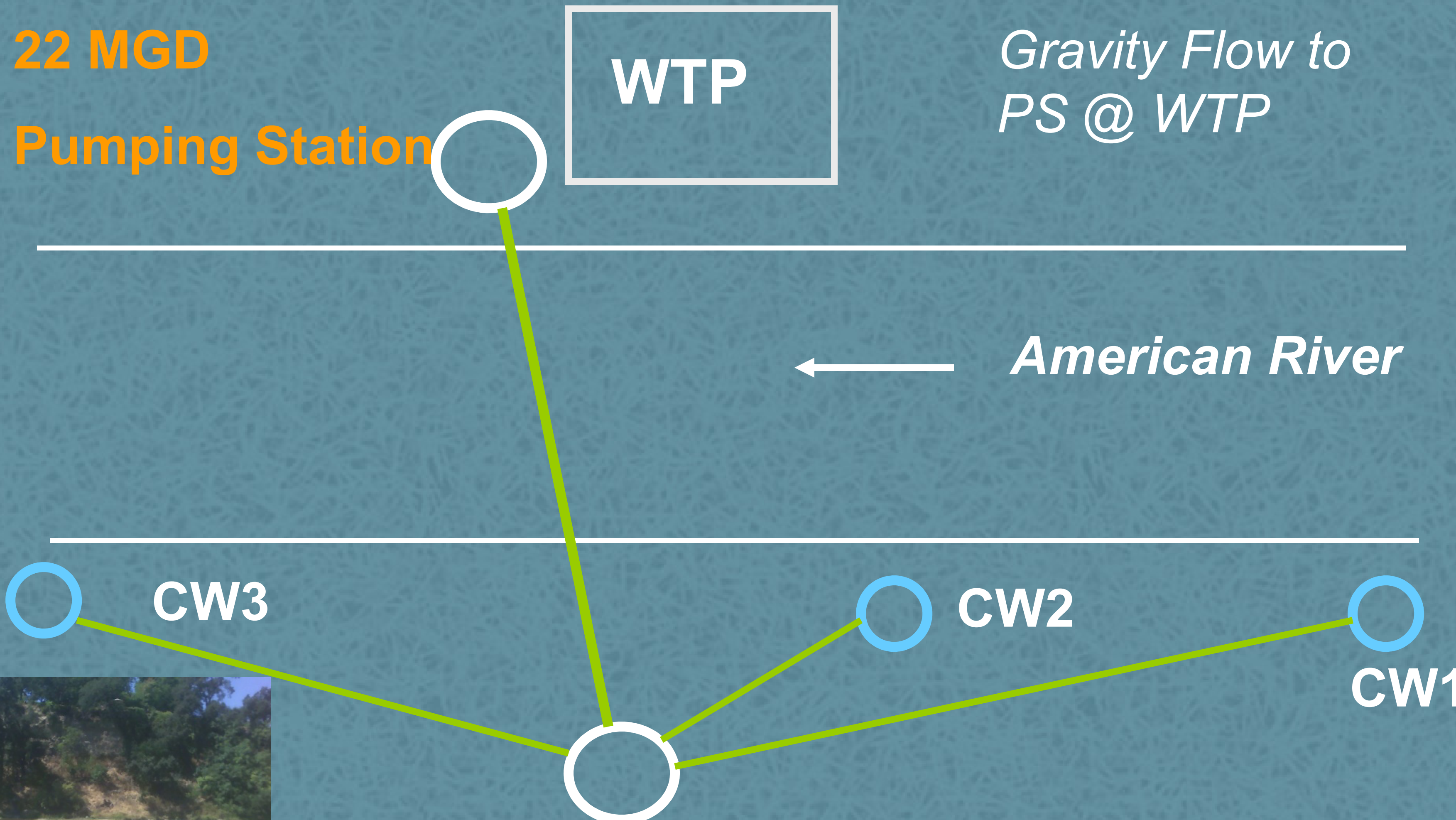
Start-up Findings (from the Owner)

- Minimizes Water Quality Challenges:
  - Taste & Odor
  - Spills
  - Pesticides
  - Contaminants of emerging concerns
  - Microbials
  - Distribution Water Quality – Unexpected !
    - NO nitrification events in any tanks
    - Removals of 90% AOC (assimilable carbon)
    - Removals of 70% NDMA Formation

Project Team

- Owner - Louisville Water Company
- Design - JJG (Jacobs Engineering)
- Tunnel/GC – Mole Constructors
- Shaft – Bencor (Layne Christensen)
- Collector Wells – Ranney Collector Wells (Heavy Civil Division –Layne Christensen)
- Pump Station – Reynolds, Inc. (Heavy Civil Division - Layne Christensen)

Carmichael Water District, CA



Tunnel System – St. Louis

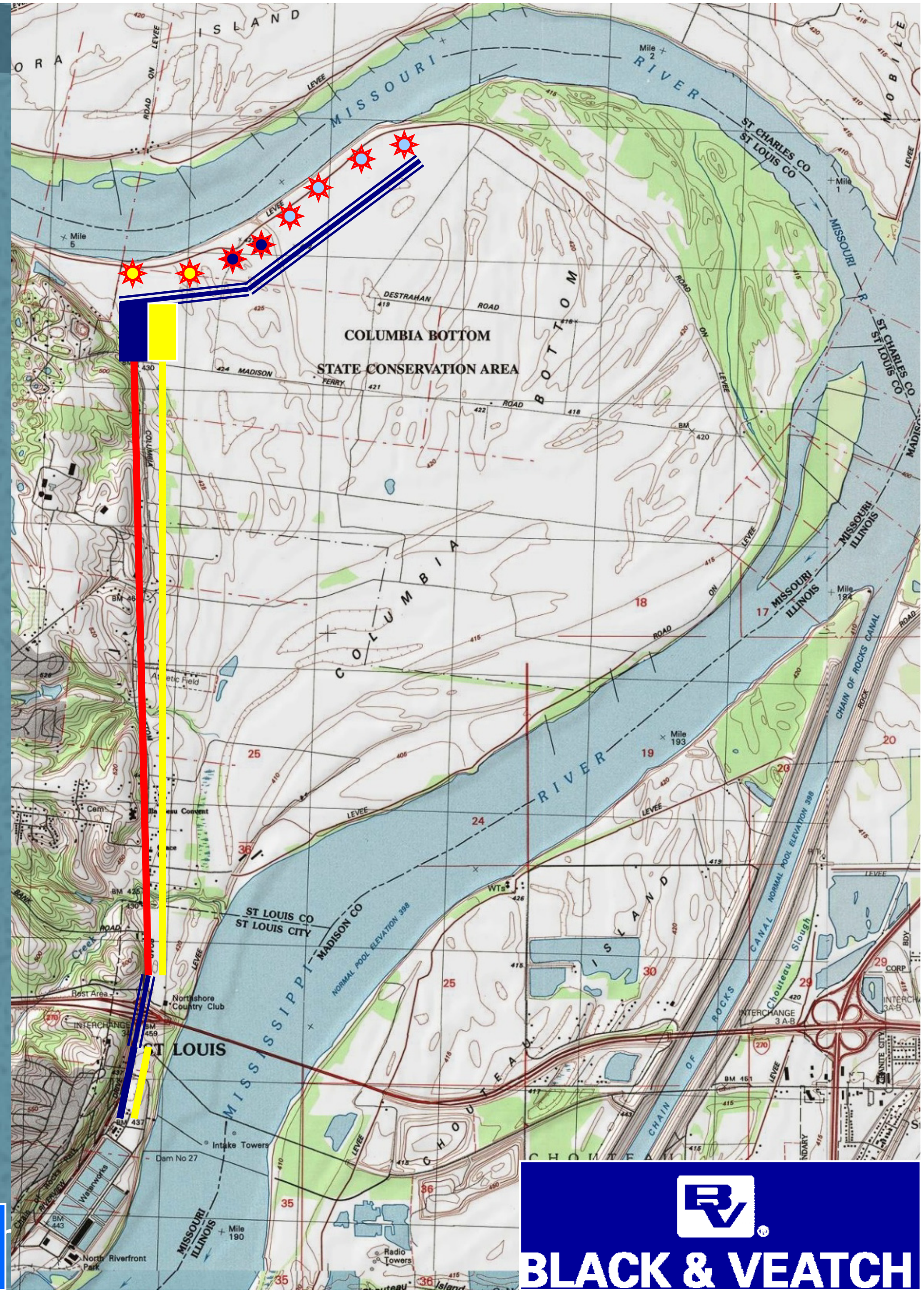
Layout Number 3 rev1

Collector Wells along Missouri River

Tunnel to Central Pump Station

Force Main Pump Station – C.O.R
60 mgd initial
65 mgd second phase
35 mgd final phase (15 mgd left)

- Phase 1 Collector Well
- Phase 2 Collector Well
- Phase 3 Collector Well
- Phase 1 Force Main
- Phase 2 Force Main
- Phase 3 Force Main
- Phase 1 Tunnel
- Phase 1 Pump Station
- Phase 3 Expand Pump Station



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Thank You ~ Questions ?

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