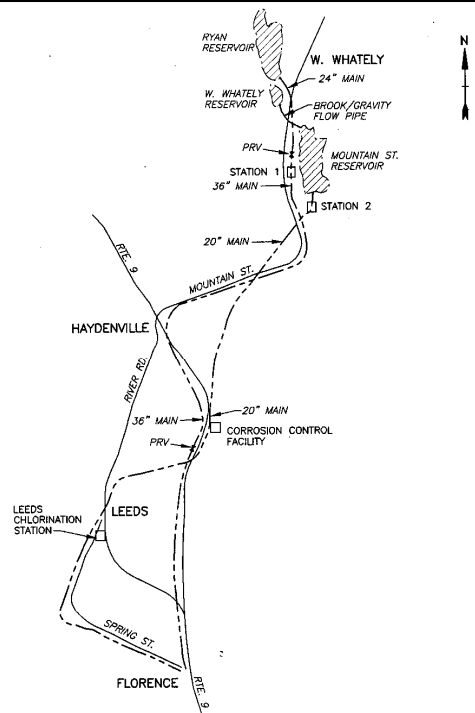


# Northampton Water Treatment Facility

## Raw Water

- ▶ Reservoirs &
- ▶ Transmission Mains
  - Not to scale



# Raw Water

- ▶ Reservoirs &
- ▶ Transmission Mains



# Mt. Street Reservoir



## 139 years of public water, 75 years of disinfection, 15 months of filtration

- ▶ 1870 Nov: vote by Northampton citizens approving purchase of water rights from the Northampton Aqueduct Company
- ▶ 1934: MA DPH determines that Northampton must chlorinate their water supply; the city complies on November 9<sup>th</sup>.
  - 1939 (Oct) two new Wallace & Tiernan chlorinators were placed in service (PWA project)
- ▶ 2008 Jan 18: Plant goes on-line

## Road to Filtration

- ▶ November: The same engineer responsible for the new 12 MDG Cambridge filtration plant was retained by Northampton to plan for design and construction of a filtration plant for the City. He and his assistant have “prepared figures and will submit plans to the board”
- ▶ “The work which is soon to be undertaken” ... “has been in contemplation for a long time and has been brought to a head by the board of public works”
  - Gazette: November 22, 1921
  - The engineer was George A. Johnson, co-designer of the first modern filtration plant (Little Falls, NJ); and the first water chlorination system (Boonton, NJ)

## Chapter 2

- ▶ On May 4<sup>th</sup>, the Northampton Board voted to ask City Council to issue bonds for construction of a 4–6 MGD filtration plant.
  - Quotes from the May 5<sup>th</sup> Gazette: “the primary need of the purification plant is the condition of the ... supply... Some tributaries ... run through swamp areas and these tend to produce a high color in the water, besides a large amount .... of algae, which causes a very objectionable odor and taste in the water”
  - The estimated cost is approximately \$175,000
    - The year: 1932

## Chapter 3

- ▶ 1937 January: construction of a filtration plant was discussed by the Water Board, but not formally proposed. The mayor didn't want a bond issue that year. The chair thought that an opportunity was allowed to slip away, because of federal money that might be available (PWA)

## The Road to Filtration: Chapt 4

- ▶ 1987–89 ⇒ Anderson–Nichols Study
  - Recommended that construction of a plant be delayed until DEP has developed filtration avoidance policy
  - \$4.8 M estimated cost
- ▶ 1994: M&E preliminary design
- ▶ 1995, Ryan transmission line was completed, as well as the two new chlorination facilities
- ▶ 1998, August: Northampton receives filtration waiver
- ▶ 2001: DEP consent order – move toward filtration
  - Value engineering study: Tighe & Bond
- ▶ 2002: contract with M&E for final design
- ▶ 2008, January: plant goes on line

### ▶ Flow

- Max: 6.5 MGD
- Avg: 4.2 MGD
- Min: 3.0 MGD

### ▶ Clarifiers

- 3 @ 192 ft<sup>2</sup> each
- Loading
  - Avg: 5.1 gpm/ft<sup>2</sup>
    - Avg flow, 3 on line
  - Max: 11.8 gpm/ft<sup>2</sup>
    - Max flow, 2 on line
- Backwash: Air/water
- Washwater production
  - 233,000 gal (Advent)
  - 415,000 gal (Trident)

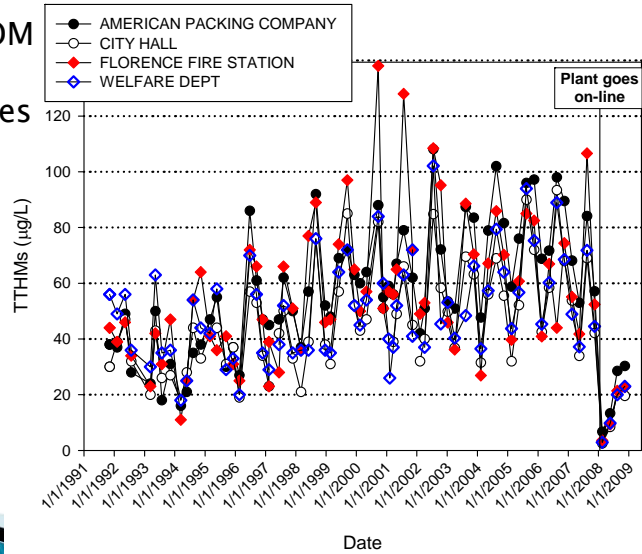
## 1995 Design

### ▶ Filters

- 4 @ 300 ft<sup>2</sup> each
- Loading
  - Avg: 2.4 gpm/ft<sup>2</sup>
    - 15.4 EBCT
    - Avg flow, 4 on line
  - Max: 5.0 gpm/ft<sup>2</sup>
    - Max flow, 3 on line
- Media:
  - 8x16 GAC
  - 60 in depth
- Backwash: Air/water
- Washwater & Filter to waste: 443,000 gal/day

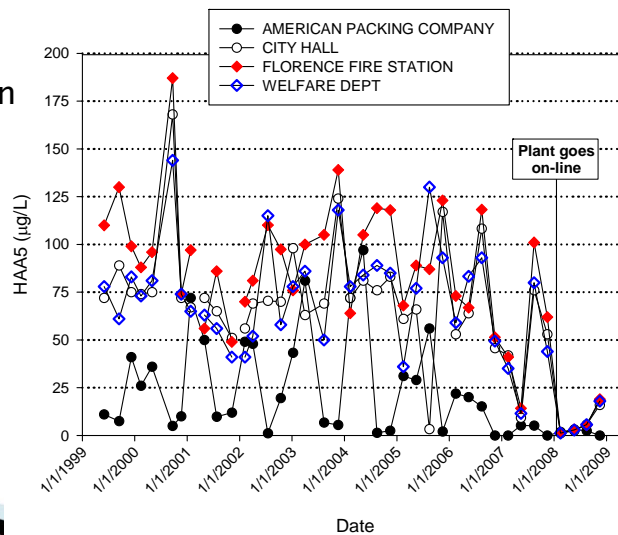
## TTHMs in distribution system

- ▶ Terrestrial NOM and long residence times = high THMs



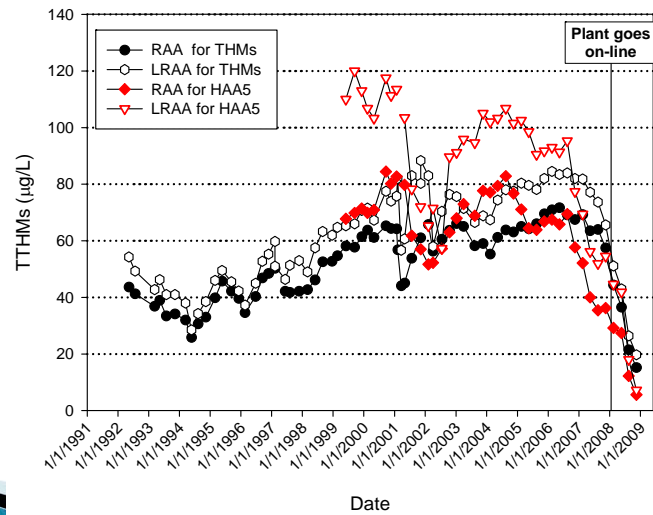
## Haloacetic Acids

- ▶ Ditto
- ▶ Some biodegradation



## Regulatory Compliance

- ▶ Looking much better !

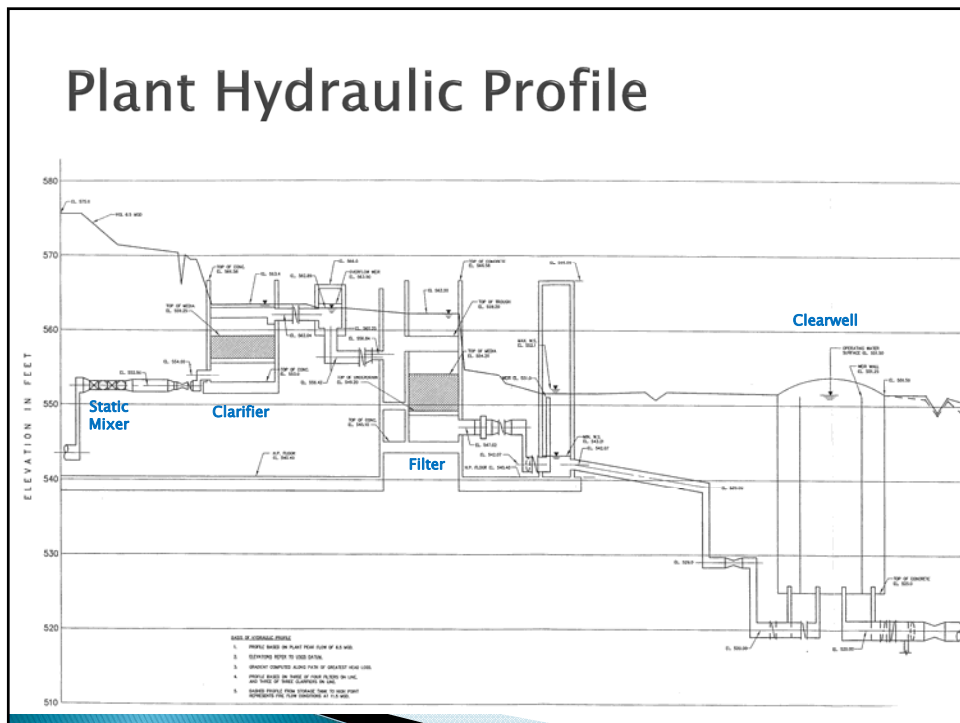
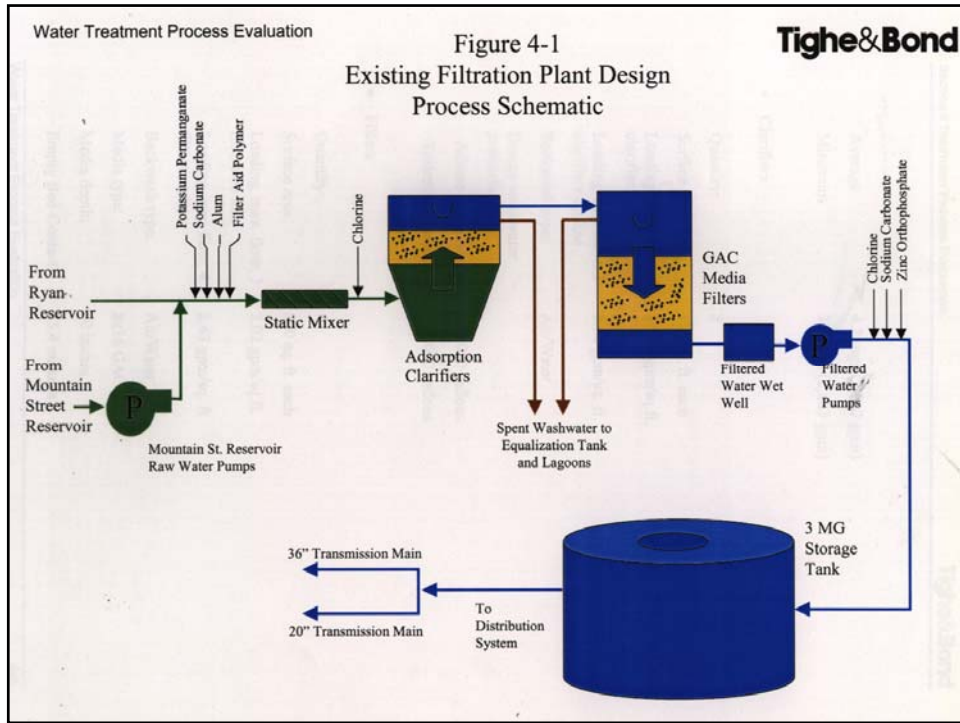


## Overview

- ▶ Plant Capacity
  - Average: 4.2 MGD
  - Maximum: 6.5 MGD
- ▶ Sources
  - Ryan Reservoir: primary supply
  - Mountain Street Reservoir: supplemental supply
- ▶ Process
  - Chemical Feed & static mixing
  - Contact Clarifier
  - GAC filter
  - Clearwell

Space for future addition of:

- Ozonation
- UV



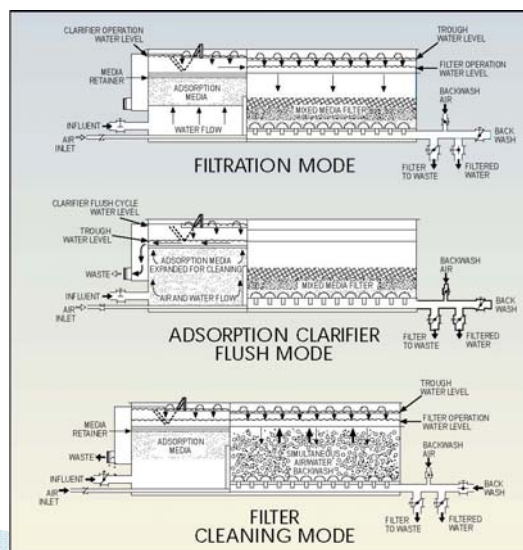


## Chemical Addition

- ▶ Prior to Plant (Manholes 1 & 2)
  - Potassium Permanganate: rarely used
- ▶ Just upstream of static mixer
  - Sodium Carbonate: rarely applied at this point
  - **Alum**: 8–9 mg/L typical dose
  - **Polymer**: 0.3 mg/L typical dose
  - Hypochlorite: rarely applied at this point
- ▶ Upstream of Clearwell
  - **Hypochlorite**: 1.5–1.7 typical dose
- ▶ Downstream of Clearwell
  - Hypochlorite: rarely applied at this point
  - **Sodium Carbonate**: 9–12 mg/L typical dose

## Upflow “Contact-Clarifier”

- ▶ Neutrally-buoyant media held in place by upward flow against a screen
- ▶ Floc does not need to be large enough to settle
  - Less coagulant
  - Less flocculation time
- ▶ Small clarifier footprint
  - 5–15 gpm/ft<sup>2</sup> vs 0.5–1.0 for conventional gravity settling



## Contact Clarifiers I

- ▶ 3 units; 2 normally in service
- ▶ Dimensions: 16 ft x 12 ft x 11 ft depth
  - 192 ft<sup>2</sup> surface area
  - 2 collection troughs per clarifier
    - 14ft length, adjustable V-notch weirs
- ▶ Media
  - High density polyethylene
  - 48 in media depth
    - 768 ft<sup>3</sup> media volume
  - Retainer set at 6'3" from floor

## Contact Clarifiers II

- ▶ Loading with 2 units in service
  - 12 gpm/ft<sup>2</sup> @ max flow
  - 7.6 gpm/ft<sup>2</sup> @ avg flow
- ▶ Backwashing
  - 4 hr minimum between flushes
  - 5 ft<sup>3</sup>/ft<sup>2</sup>/min air scour (960 ft<sup>3</sup>/min)
  - 6–12 gpm/ft<sup>2</sup> washwater rate (1,150–2,300 gpm)

## Contact Clarifier

- ▶ Early stages



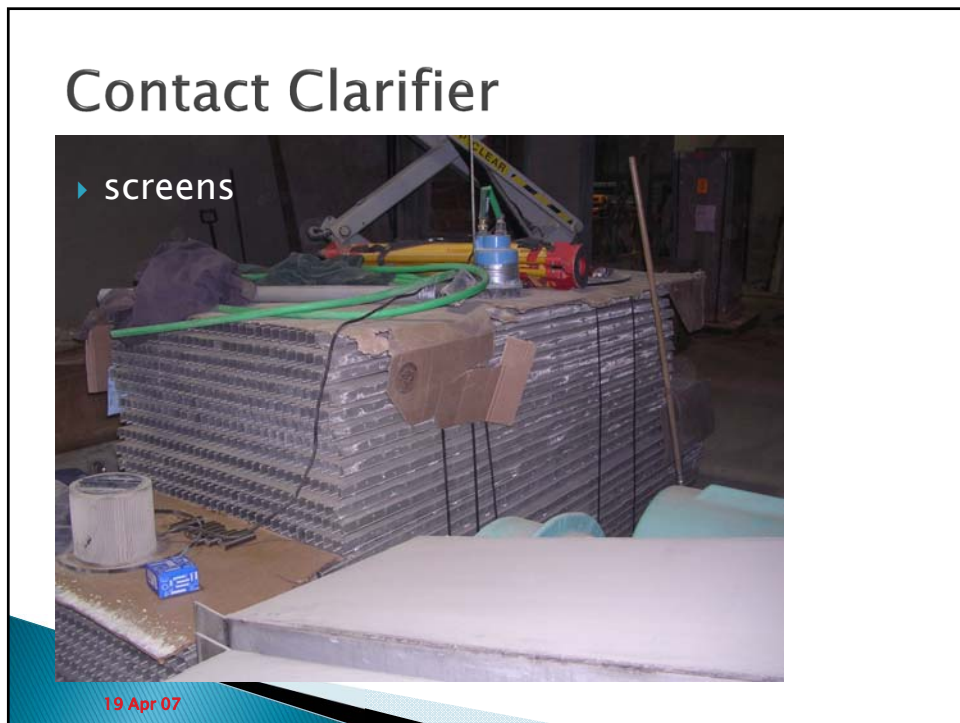
19 Apr 07

## Clarifier

- ▶ Showing 12" influent water pipe
- ▶ 8" air distribution header
  - ▶ With 15 one-inch laterals







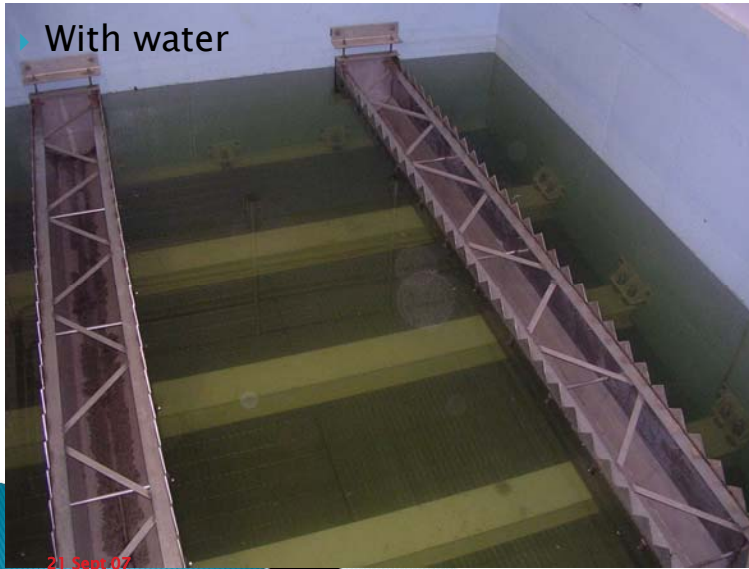
# Clarifier

- Installation of media retaining screens



## Contact Clarifier

With water

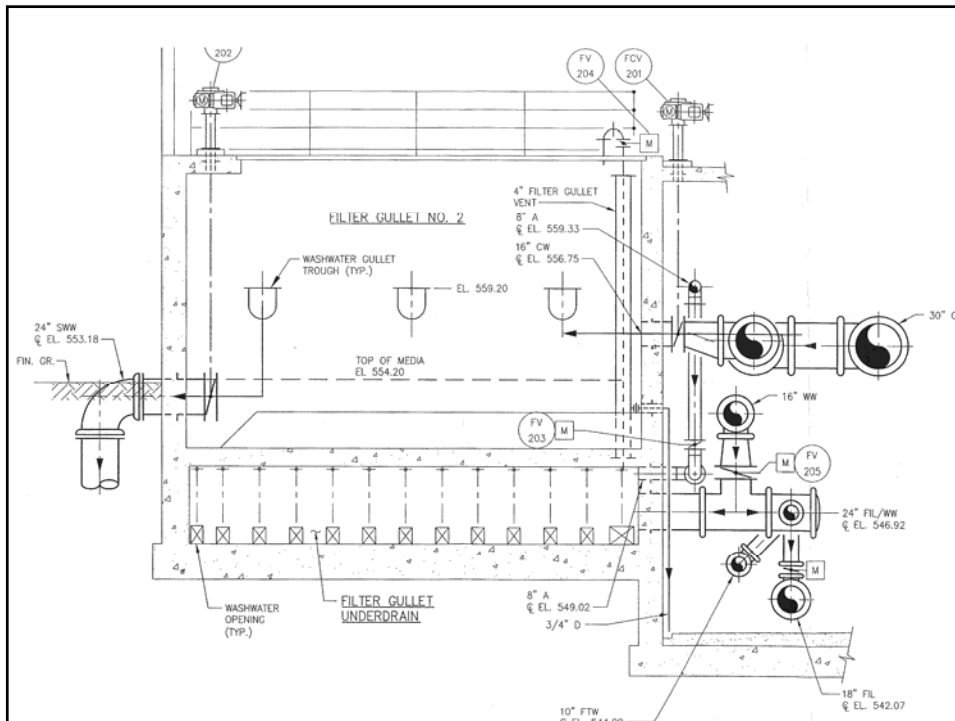
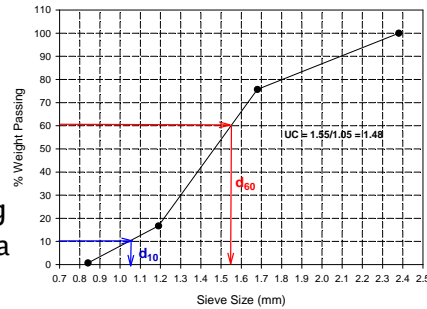


## Contact Clarifier



# Filters

- ▶ Four, high rate, deep bed GAC filters
  - 300 ft<sup>2</sup> each (25ft x 12 ft)
  - 5 ft media depth with 8 ft water
- ▶ Loading (3 in service)
  - 5.0 gpm/ft<sup>2</sup> @ max flow
  - 3.2 gpm/ft<sup>2</sup> @ avg flow
- ▶ Media Characteristics
  - Filtrasorb 820
  - ES = 1.0–1.2 mm
  - UC ≤ 1.4
  - Iodine number = 990 mg/g
  - ~1000m<sup>2</sup>/g BET surface area





## Filters

- ▶ Operation
  - Constant flow, rising head
- ▶ Underdrain
  - Siemens Nozzle system
    - Model 624 MCA nozzles
    - Spaced 8"
- ▶ Backwash
  - Water: 4–22 gpm/ft<sup>2</sup> (1,200–6,600 gpm)
  - Air: 4 ft<sup>3</sup>/ft<sup>2</sup>/min (1,200 ft<sup>3</sup>/m)
- ▶ Backwash criteria – whichever comes first
  - Nearing 0.3 NTU in filtered water
  - Nearing 8 ft headloss
  - 72 hrs of operation

## Filters

- ▶ Start
  - Leak testing



## Filters

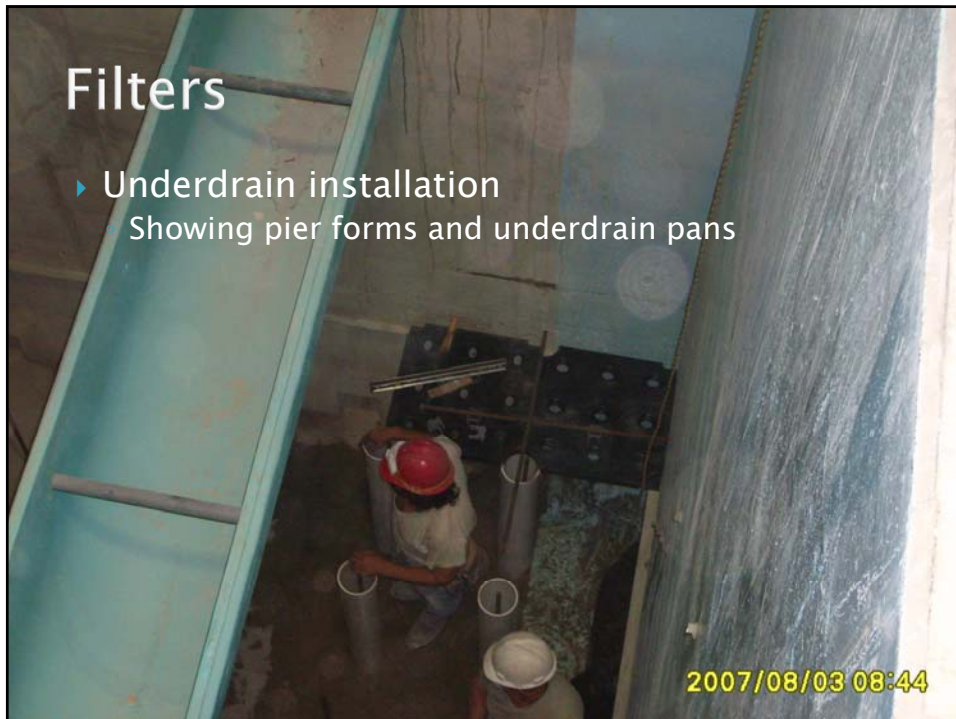
- ▶ Filter troughs



19 Apr 07

## Filters

- ▶ Underdrain installation  
Showing pier forms and underdrain pans

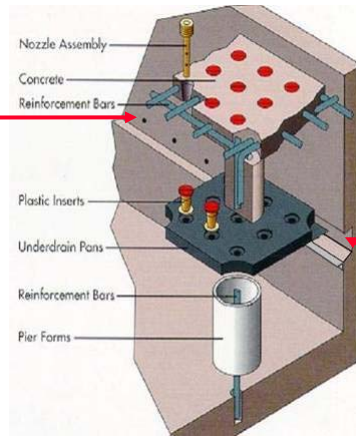


2007/08/03 08:44

## MULTICRETE II Underdrain Installation Options

- ▶ Standard ACI 318 loadings
  - 1,600 psf ↓, 1,400 psf ↑

**Doweled Rebar Design**



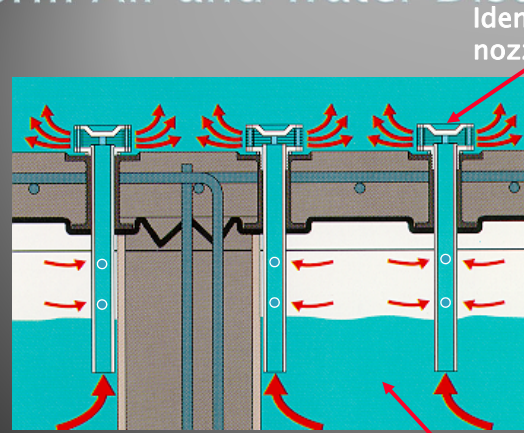
**Keyway Design**

## Filters

- ▶ Underdrain pan
- ▶ Nozzle & Insert



# Open Plenum Design Provides Uniform Air and Water Distribution



Identical headloss nozzles

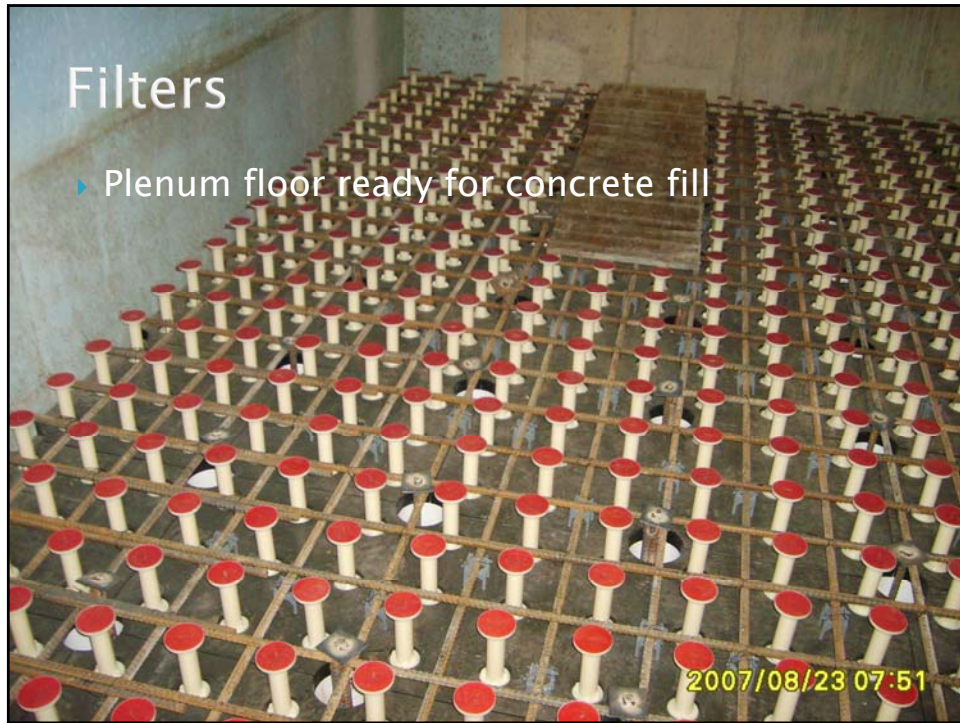
Low headloss open plenum

## Filters

- ▶ Under the watchful eye



21 Sept 07



## Filters

- ▶ Installing filter nozzles



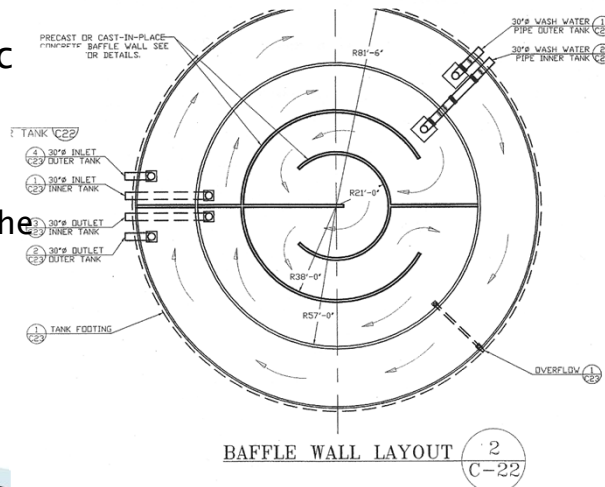
## Filters

- ▶ Educting media



## Northampton's Ground Storage

- ▶ 4.0 MG
- ▶ Two Concentric cells
  - Can be isolated to service one while keeping the other in service
- ▶ NaOCl added just prior to entry



## Clearwell or Ground Storage

- ▶ Multi-purpose
  - Chlorine contact tank for achieving "Ct"
    - Giardia controls
      - 3 log Giardia is more restrictive than 4 log virus when using chlorine
      - 2.5 log credit given for Giardia (clarification + filtration), leaving 0.5 log for Ct
      - Northampton has decided to see 1.0 log for Ct
    - Buffering system flows
    - Fire Flow
    - Backwash Storage

## Evaluation of Clearwell (cont.)

- ▶ Ct requirements
  - Design is for maintenance of Ct even when one of the two concentric tanks is taken out of service
  - “t” is normally evaluated for peak hourly flow
- ▶ Outer cell is considered less efficient based on length to width ratio
  - 22:1 for outer cell
  - 38:1 for inner cell
- ▶ Design conditions
  - Q = 6.5 MGD max plant flow
  - C = 0.5 mg/L
  - Temp = 0.5°C
  - pH = 7.5
  - 1.0 log inactivation
  - Ct = 79 mg/L – min
  - $t_{10} \geq 157 \text{ min}$

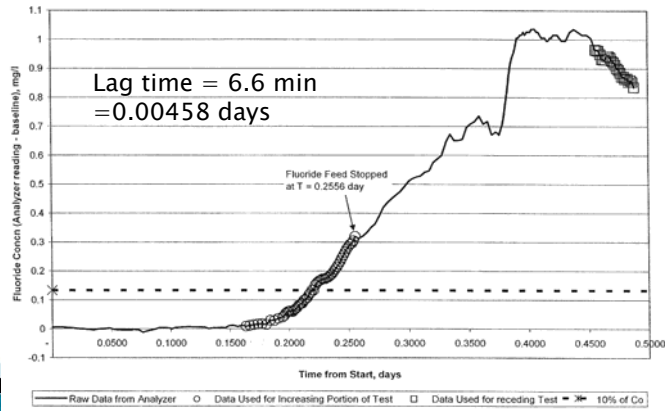
## Tracer Test I

- ▶ Tracer Test Conditions
    - Depth = 26.5 ft
    - Volume = 2,073,200 gal
    - Q = 3000 gpm = 4.32 MGD
    - Fluoride concentration
      - Background = 0.034 mg/L
      - Target = 1.33 mg/L
    - Temperature = 10.1 C
    - pH = 8.14
- }  $t_R = 11.52 \text{ hr}$



# Step dose method

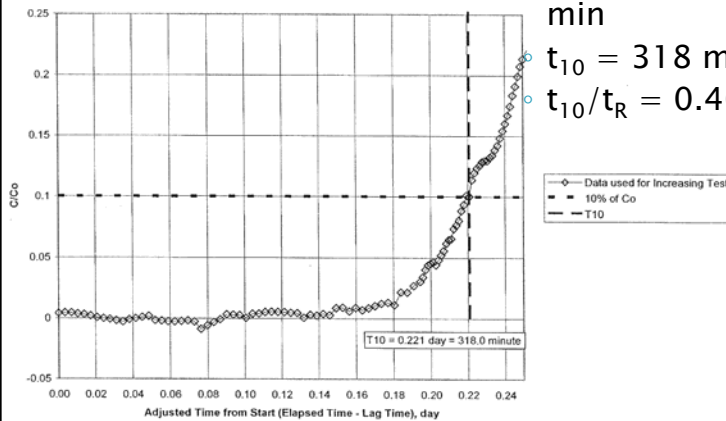
▶ December 13, 2007



# Outer cell data

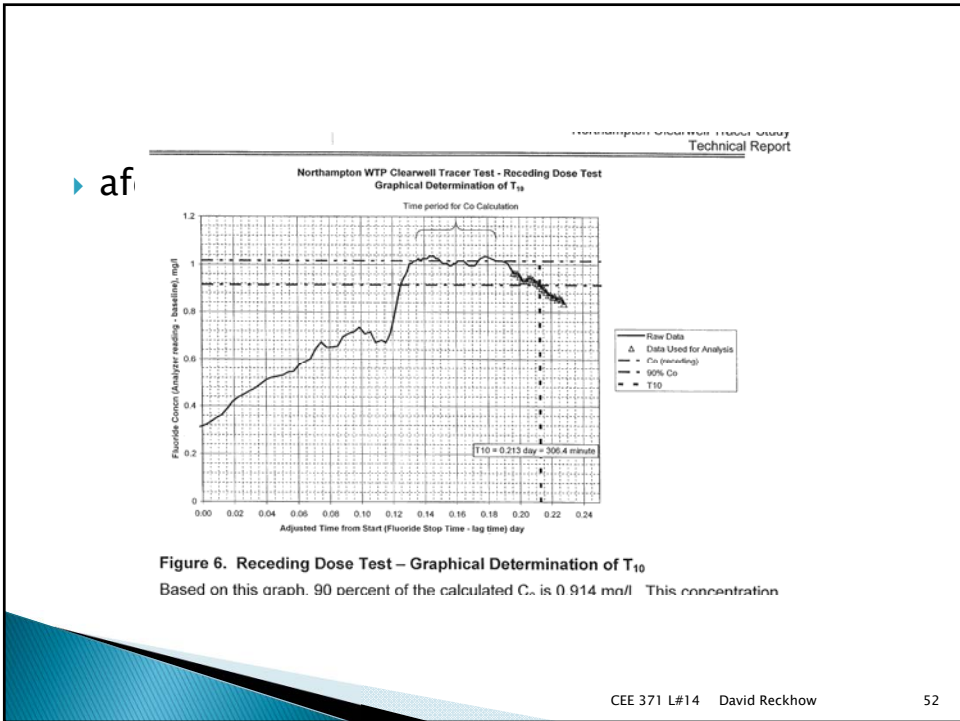
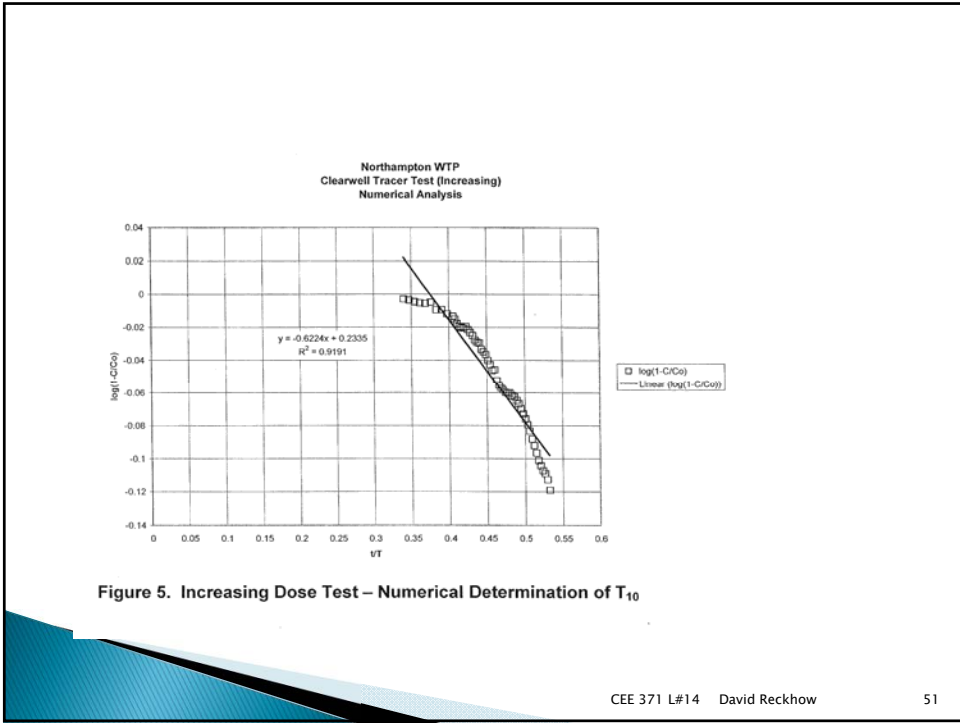
▶ Step dose test

- $t_R = 11.52 \text{ hr} = 691.1 \text{ min}$
- $t_{10} = 318 \text{ min}$
- $t_{10}/t_R = 0.46$



Reckhow

50



af

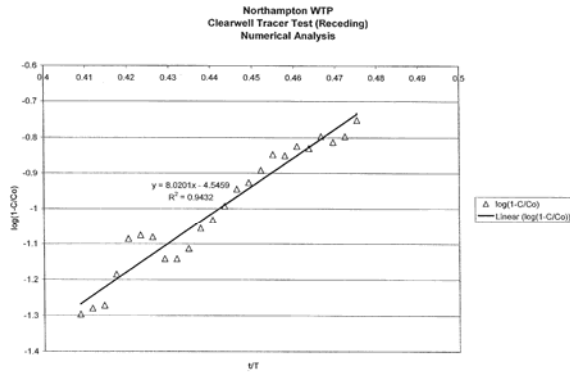


Figure 7. Receding Dose Test – Numerical Determination of T<sub>10</sub>

# CT for Giardia & Free Chlorine

Table C-1. CT Values for Inactivation of *Giardia* Cysts by Free Chlorine at 0.5°C or Lower

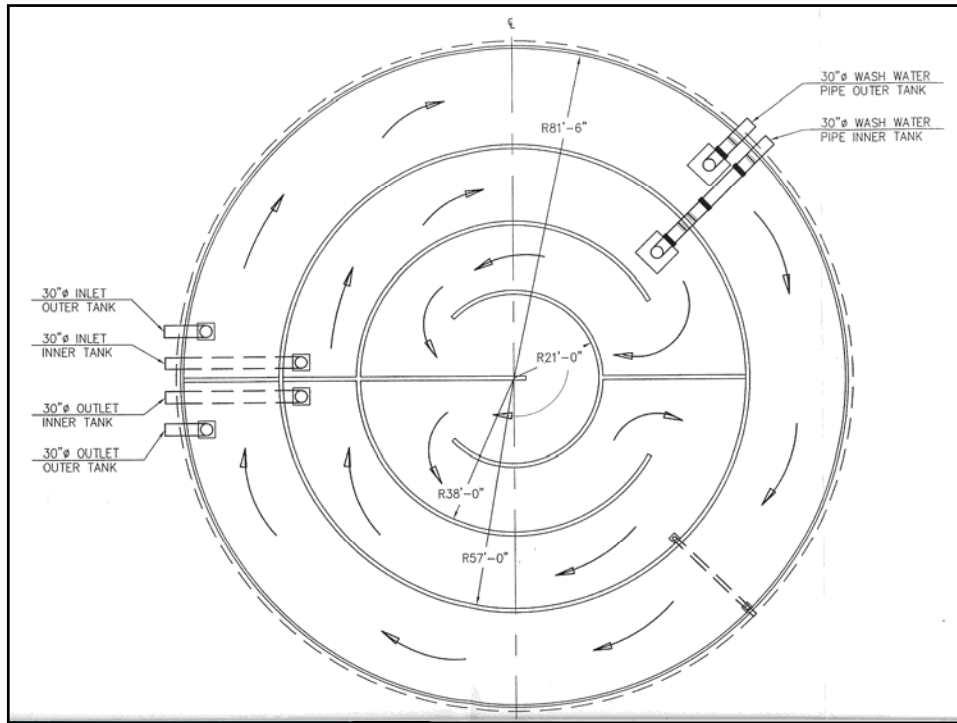
CHLORINE CONCENTRATION (mg/L)	pH=6					pH=6.5					pH=7.0					pH=7.5								
	Log Inactivation					Log Inactivation					Log Inactivation					Log Inactivation								
<=0.4	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.6	23	46	69	91	114	137	27	54	82	109	136	163	33	65	98	130	163	195	40	80	119	158	196	237
0.8	24	47	71	94	118	141	28	56	84	112	140	169	33	67	100	133	167	200	41	82	123	164	205	246
1	25	49	74	99	123	148	29	59	88	117	147	176	35	70	105	140	175	210	42	84	127	169	211	253
1.2	25	51	76	101	127	152	30	60	90	120	150	180	36	72	108	143	179	215	43	86	130	173	216	259
1.4	26	52	78	103	129	155	31	61	92	123	153	184	37	74	111	147	184	221	44	88	133	177	222	266
1.6	26	52	79	105	131	157	32	63	95	126	155	189	38	75	113	151	188	226	46	91	137	182	228	273
1.8	27	54	81	108	135	162	32	64	97	129	161	193	39	77	116	154	193	231	47	93	140	186	233	279
2	28	55	83	110	138	165	33	66	99	131	164	197	39	79	118	157	197	236	48	95	143	191	238	286
2.2	28	56	85	113	141	169	34	67	101	134	169	201	40	81	121	161	202	242	50	99	149	198	248	297
2.4	29	57	86	115	143	172	34	68	103	137	171	205	41	82	124	165	206	247	50	99	149	199	248	298
2.6	29	58	88	117	146	175	35	70	105	139	174	209	42	84	126	168	210	252	51	101	152	203	253	304
2.8	30	59	89	119	148	178	36	71	107	142	178	213	43	86	129	171	214	257	52	103	155	207	258	310
3	30	60	91	121	151	181	36	72	109	145	181	217	44	87	131	174	218	261	53	105	158	211	263	316
CHLORINE CONCENTRATION (mg/L)	pH=8.0					pH=8.5					pH=9.0													
<=0.4	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0						
0.6	46	92	139	185	231	277	55	110	165	219	274	329	65	130	195	260	325	390						
0.8	48	95	143	191	238	286	57	114	171	228	285	342	68	136	204	271	339	407						
1	49	98	148	197	246	295	59	117	177	236	295	354	70	141	211	281	352	422						
1.2	51	101	152	203	253	304	61	122	183	243	304	365	73	146	219	291	364	437						
1.4	52	104	157	209	261	313	63	125	188	251	313	376	75	150	226	301	376	451						
1.6	54	107	161	214	268	321	65	129	194	258	323	387	77	155	232	309	387	464						
1.8	55	110	165	219	274	329	66	132	199	265	331	397	80	159	239	319	398	477						
2	56	113	169	225	282	338	68	136	204	271	339	407	82	163	245	326	408	489						
2.2	55	115	173	231	288	346	70	139	209	278	348	417	83	167	250	333	417	500						
2.4	59	118	177	235	294	353	71	142	213	284	355	426	85	170	256	341	426	511						
2.6	60	120	181	241	301	361	73	145	218	290	363	435	87	174	261	348	435	522						
2.8	61	123	184	245	307	369	74	148	222	296	370	444	89	178	267	355	444	533						
3	63	125	188	250	313	375	75	151	226	301	377	452	91	181	272	362	453	543						
	64	127	191	255	318	382	77	153	230	307	383	460	92	184	276	369	460	552						

Source: EPA, 1999, Guidance Manual for Disinfection Profiling and Benchmarking

Source: AWWA, 1991.

EPA Guidance Manual Disinfection Profiling and Benchmarking August 1999 C-2

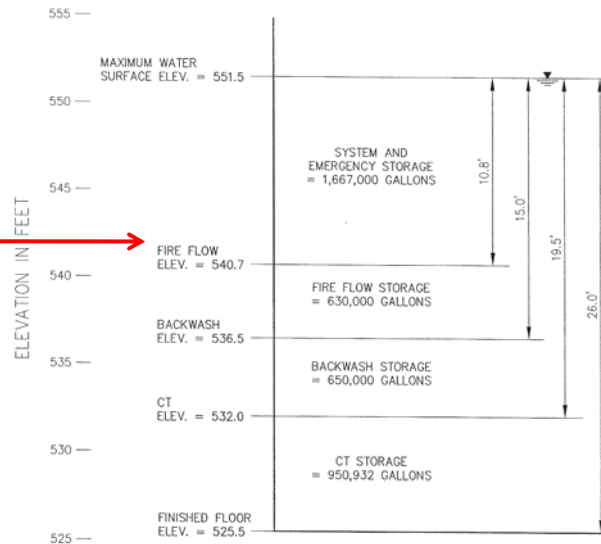
APPENDIX C. CT VALUES FOR INACTIVATIONS ACHIEVED BY VARIOUS DISINFECTANTS



## Storage profile

4 MILLION GALLON CLEARWELL  
AT MOUNTAIN STREET RESERVOIR  
WATER TREATMENT PLANT

- ▶ Also below 542 ft surface elevation, the washwater pumps can no longer draw suction

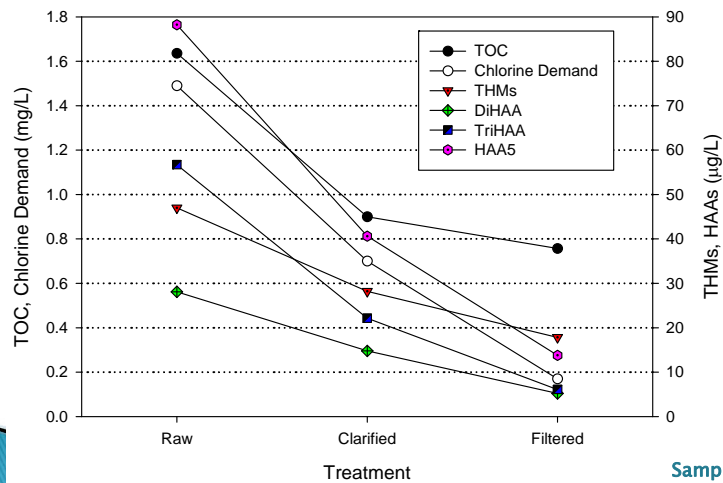


## Residuals & Lagoons

- ▶ Backwash
  - Typical filter run lengths: 65 hrs
  - Backwash volume: 72,000 gal
  - Filter to waste volume: 11,600 gal
- ▶ Equalization Tank
- ▶ Lagoons
  - 2 units
  - Area: 35,000 ft<sup>2</sup> (225 ft x 155 ft)
  - Depth: 10 ft maximum

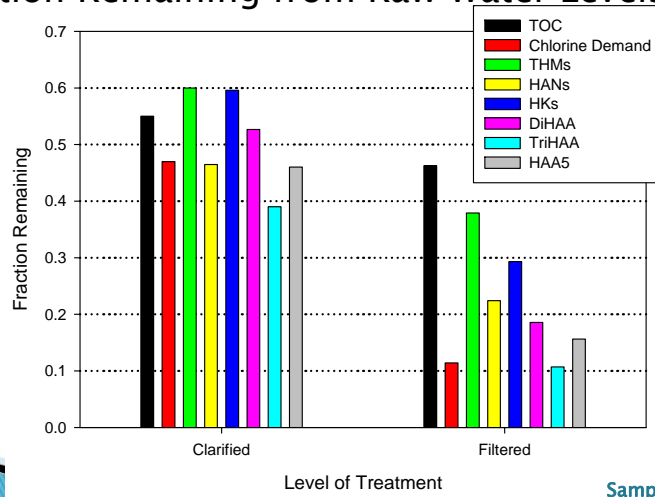
## Performance: NOM & Precursors

- ▶ Concentrations of TOC and DBP Precursors



## Performance: NOM & Precursors

### ► Fraction Remaining from Raw Water Levels



Samples Collected:  
April 15, 2009

End