PURSUING DEVELOPMENT OF A PUBLIC COMMUNITY WATER SUPPLY UNDER LIMITED ACCESS AND AQUIFER CONDITIONS

Presented At:

PA-AWWA 66th Annual Conference

May 6-8, 2014

Sands Casino Resort in Bethlehem, PA.

By: Frank Getchell, PG and Karen Benson

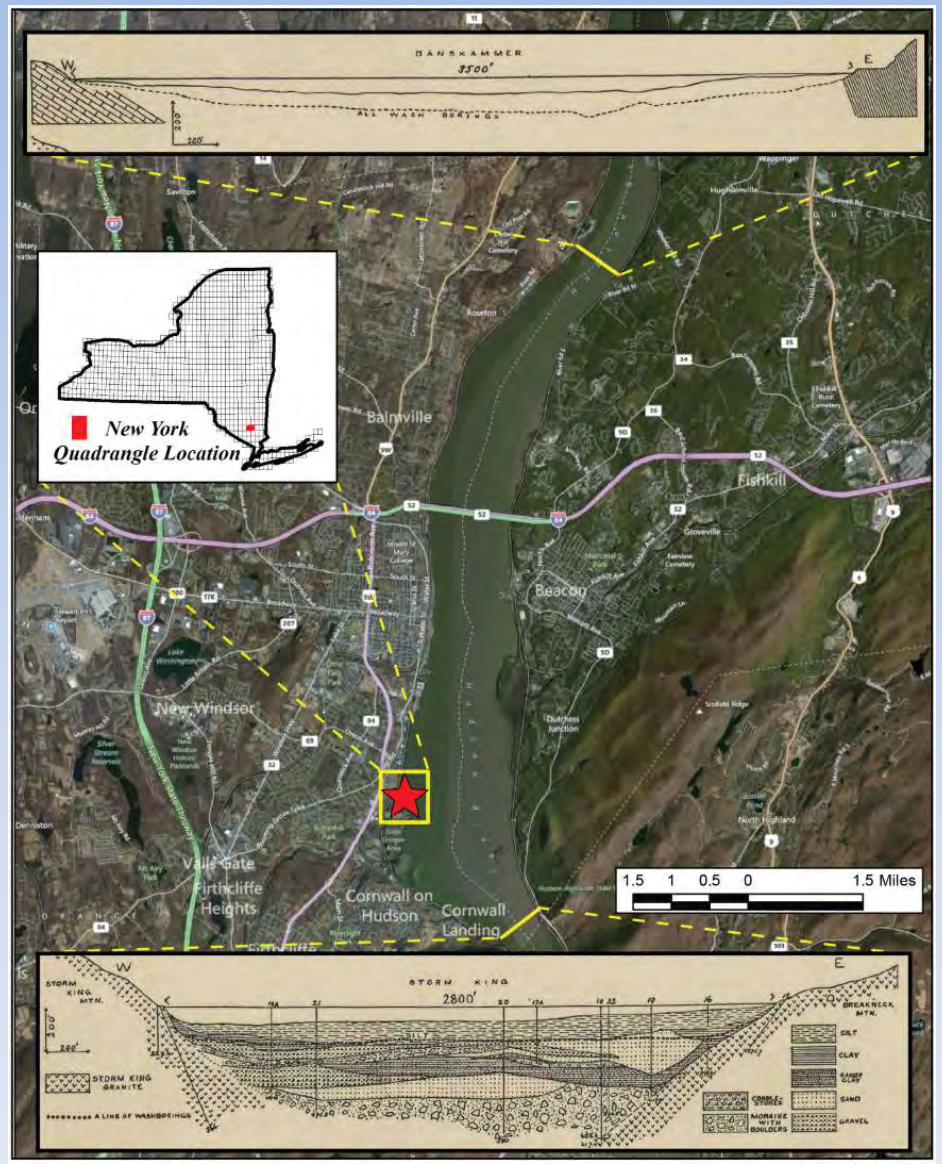
Leggette, Brashears & Graham, Inc.

Lower Hudson River Valley Case Study

- Develop a minimum 2 million gallons per day (MGD) supplemental Public Community Water Supply by 2015/2016 for a partial NYC-water interconnect-dependent Town
- Yield potential and groundwater resources accessibility within Town limit the availability for developing the necessary supply
- Several sites already evaluated only exhibited typical yield gain potential of about 0.3 to 0.5 MGD

Possible Solution

- Previous studies of the Hudson River channel deposits previously completed in connection with the New York City water supply, indicated the presence of a laterally and vertically (but possibly thin) extensive glacial deposits aquifer system.
- Town park exists along the shoreline of this stretch of the Hudson River.



What Was Originally Known About The Groundwater Resource

- The aquifer underlying the tidal Hudson River is overlain by a thick sequence of river-bottom sediment and glacial clay and silt, which is believed to protect it from surface-water quality impacts (e.g., brackish water)
- Preliminary testing and analyses by others for NYC indicated that the overall aquifer capacity potential is on the order of about 250 to 300 MGD.

Exploration/Data Collection

- Phase One
  - Exploration program at top of glaciodeltaic terrace
  - Vertical test well at shoreline
  - Hudson River barge borings
  - Conceptual hydrogeologic model favors angle well development near shoreline
- Phase Two
  - Sonic rig setup and sampling at shoreline
  - Angle Boring #1 - to explore near shore aquifer and deltaic deposits
  - Angle Boring #2 - to explore anticipated maximum aquifer thickness perpendicular to shore
  - Angle Boring #3 - to further explore possible deltaic deposits near shore
  - Real-time yield and quality testing
- Phase Three
  - Large Diameter Angled Test Well

Initial Exploration – Phase One

Exploration at Top of Glaciodeltaic Terrace

Initial Exploration Phase

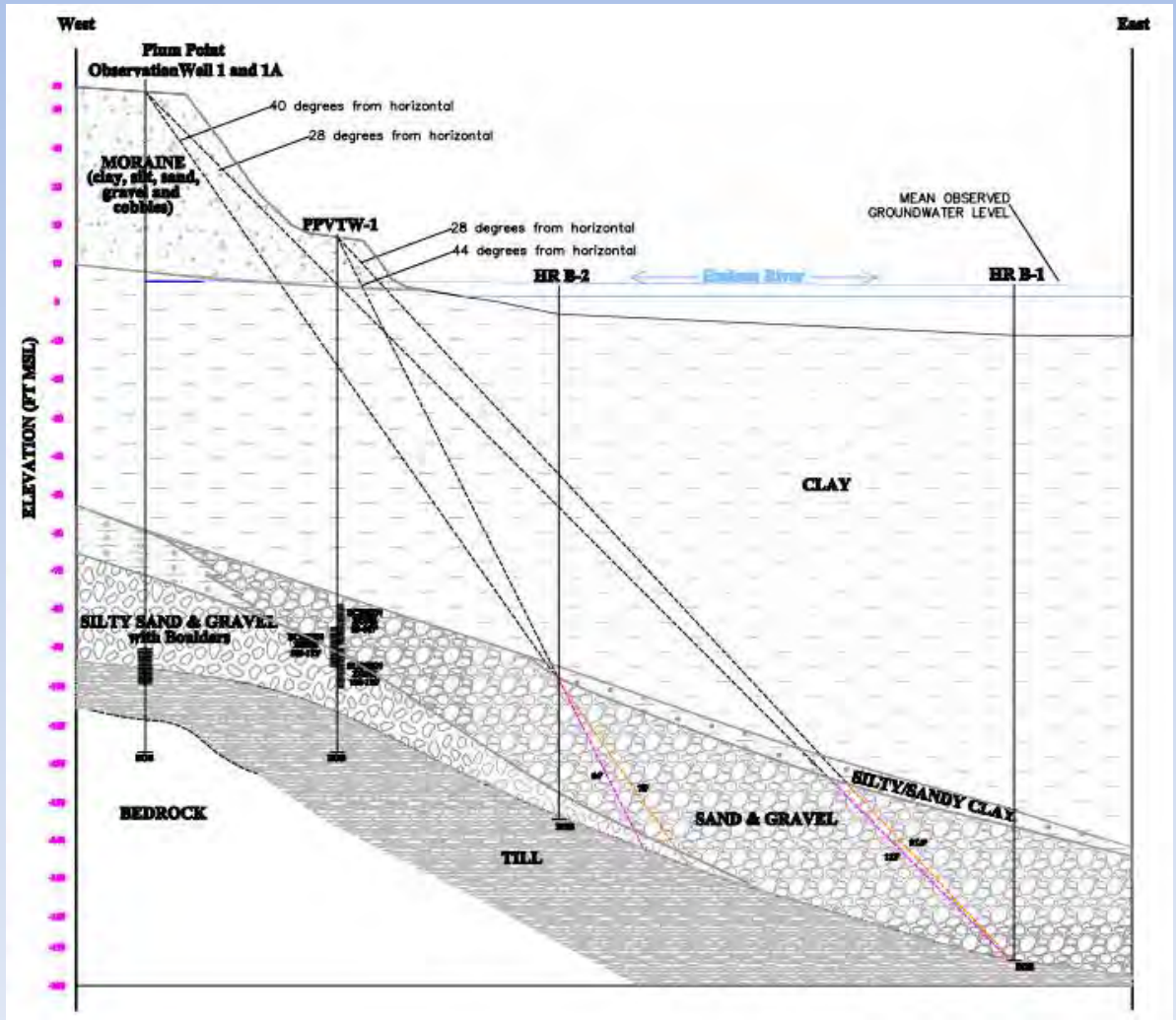
Vertical Test Well at Shoreline

Initial Exploration Phase

Hudson River Barge Borings

Conceptual Hydrogeologic Model

Atypical Aquifer Configuration Does Not Favors Vertical Well Development From Near Shoreline

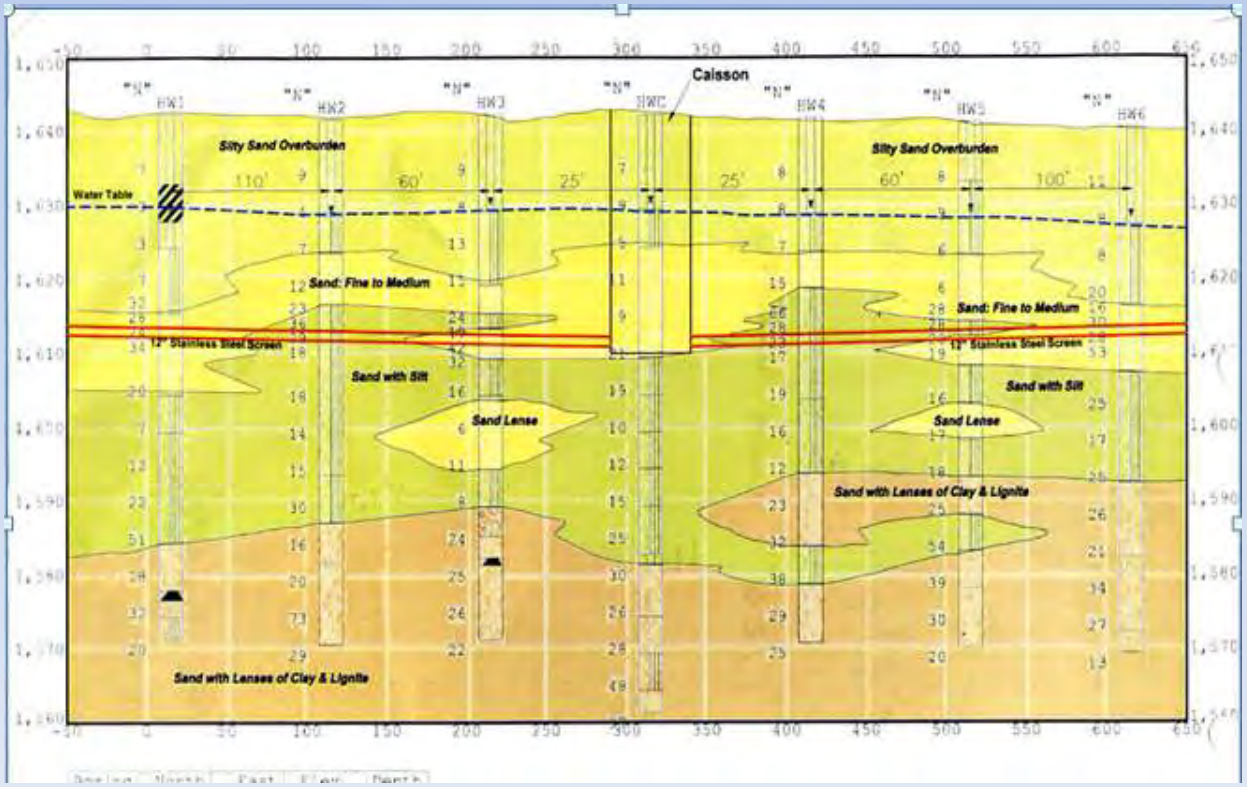


Possible Alternative Supply Well Options for “Atypcial” Aquifer

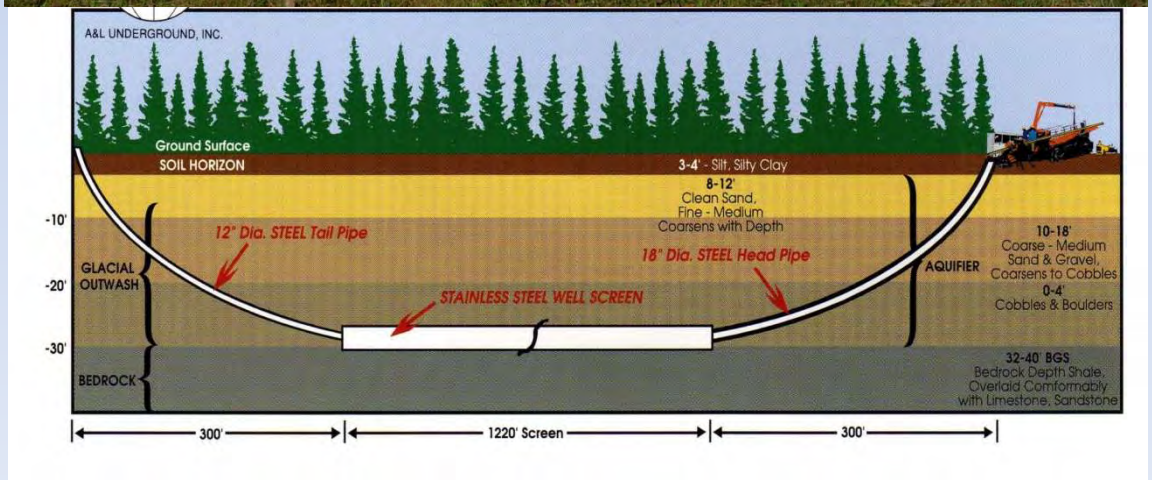
- Development of groundwater supplies from hydrogeologically atypical aquifers often require the use of innovative well designs and management techniques.
- Types:
  - Horizontal Wells/Infiltration Galleries (generally depth limited)
  - Collector Wells (laterals are oriented horizontally)
  - Angle Wells

Some Examples of Atypical Groundwater Resources

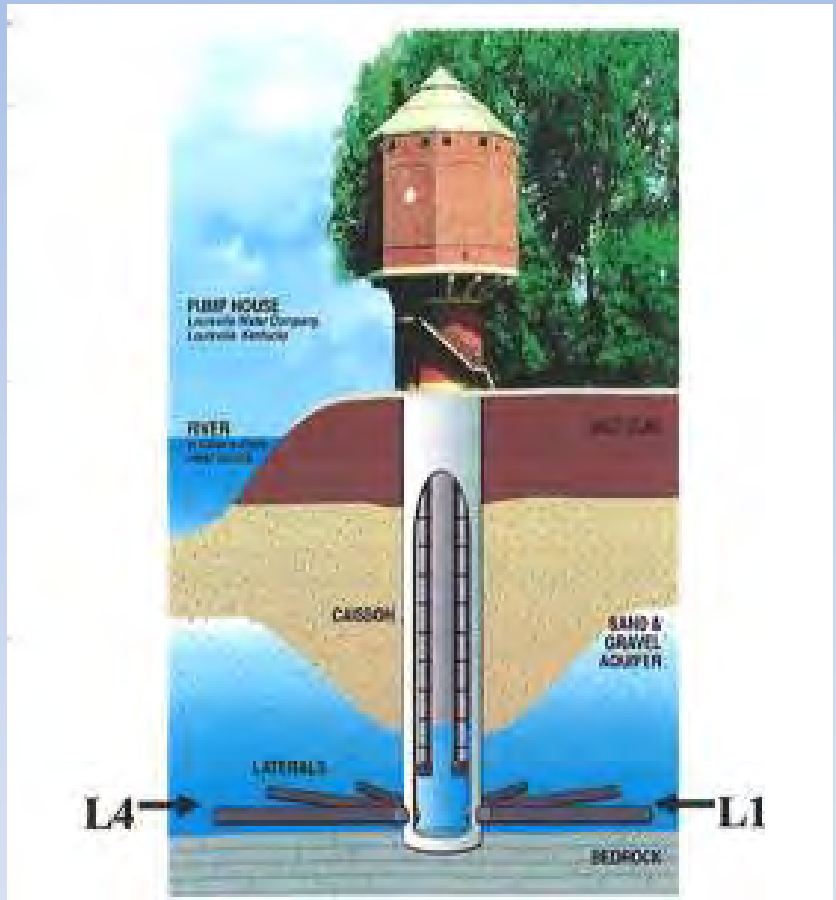
- wedge/inclined alluvial and coastal plain formations
- thin and lens-shaped formations
- remote alluvial units and extensive fracture zones
- formations influenced by hydraulically connected surface-water bodies/other formations



Horizontal Well/Infiltration Gallery

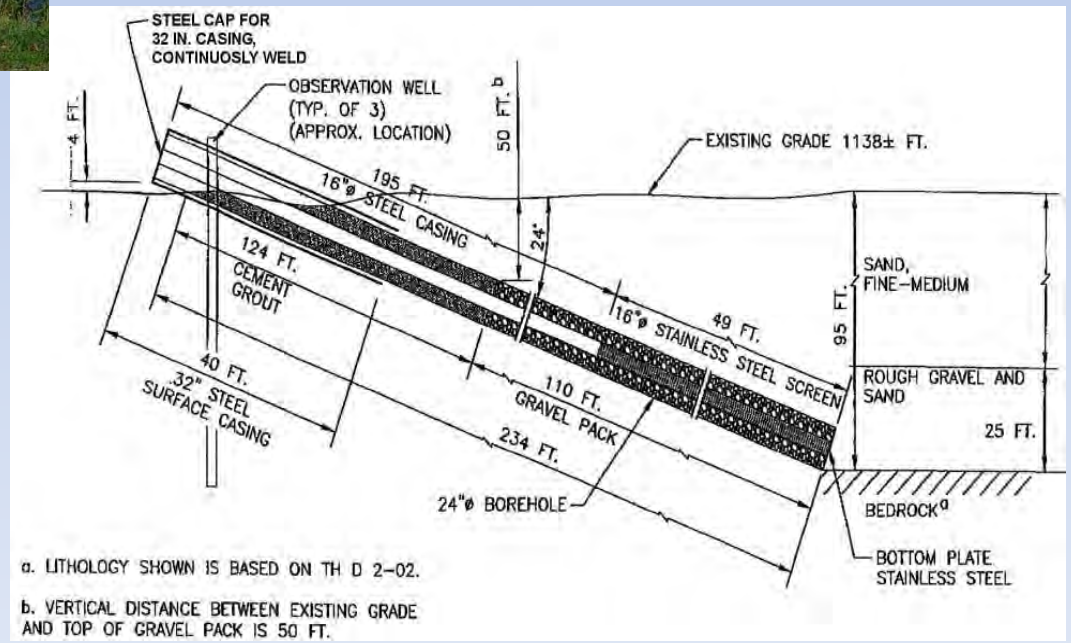


Collector Well Configuration

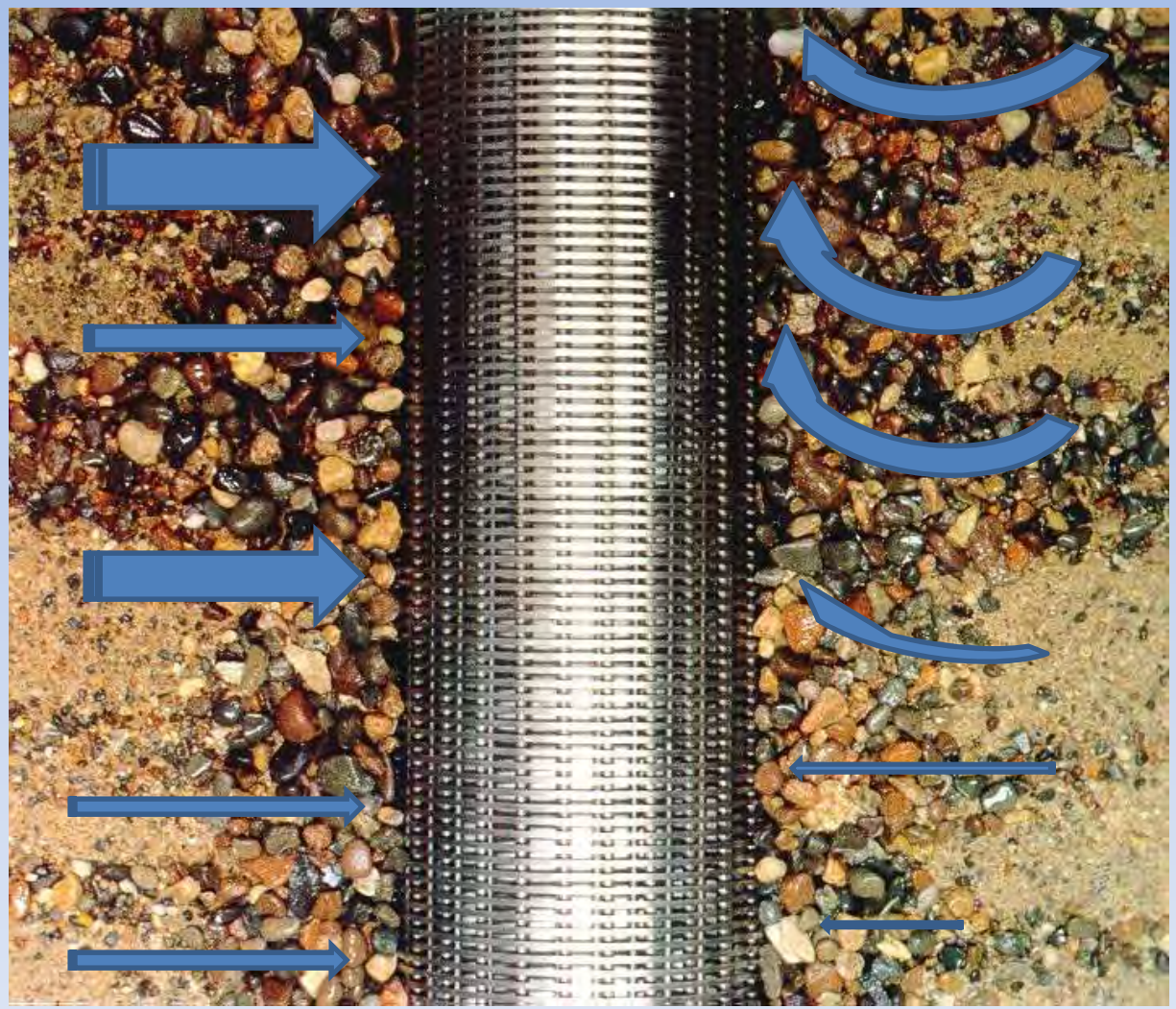


Angle Well


ANGLE WELL 4
VALVE BOX


STEEL CAP FOR 32 IN. CASING, CONTINUOSLY WELD
OBSERVATION WELL (TYP. OF 3) (APPROX. LOCATION)
4 FT.
50 FT. b
EXISTING GRADE 1138± FT.
16"ø STEEL CASING
195 FT.
24"
124 FT. CEMENT GROUT
16"ø STAINLESS STEEL SCREEN
49 FT.
95 FT.
SAND, FINE–MEDIUM
ROUGH GRAVEL AND SAND
25 FT.
40 FT. 32" STEEL SURFACE CASING
110 FT. GRAVEL PACK
234 FT.
24"ø BOREHOLE
BEDROCK a
BOTTOM PLATE STAINLESS STEEL
a. LITHOLOGY SHOWN IS BASED ON TH D 2–02.
b. VERTICAL DISTANCE BETWEEN EXISTING GRADE AND TOP OF GRAVEL PACK IS 50 FT.

Groundwater Flow Towards A Pumping Screened Well



Ideal

Actual

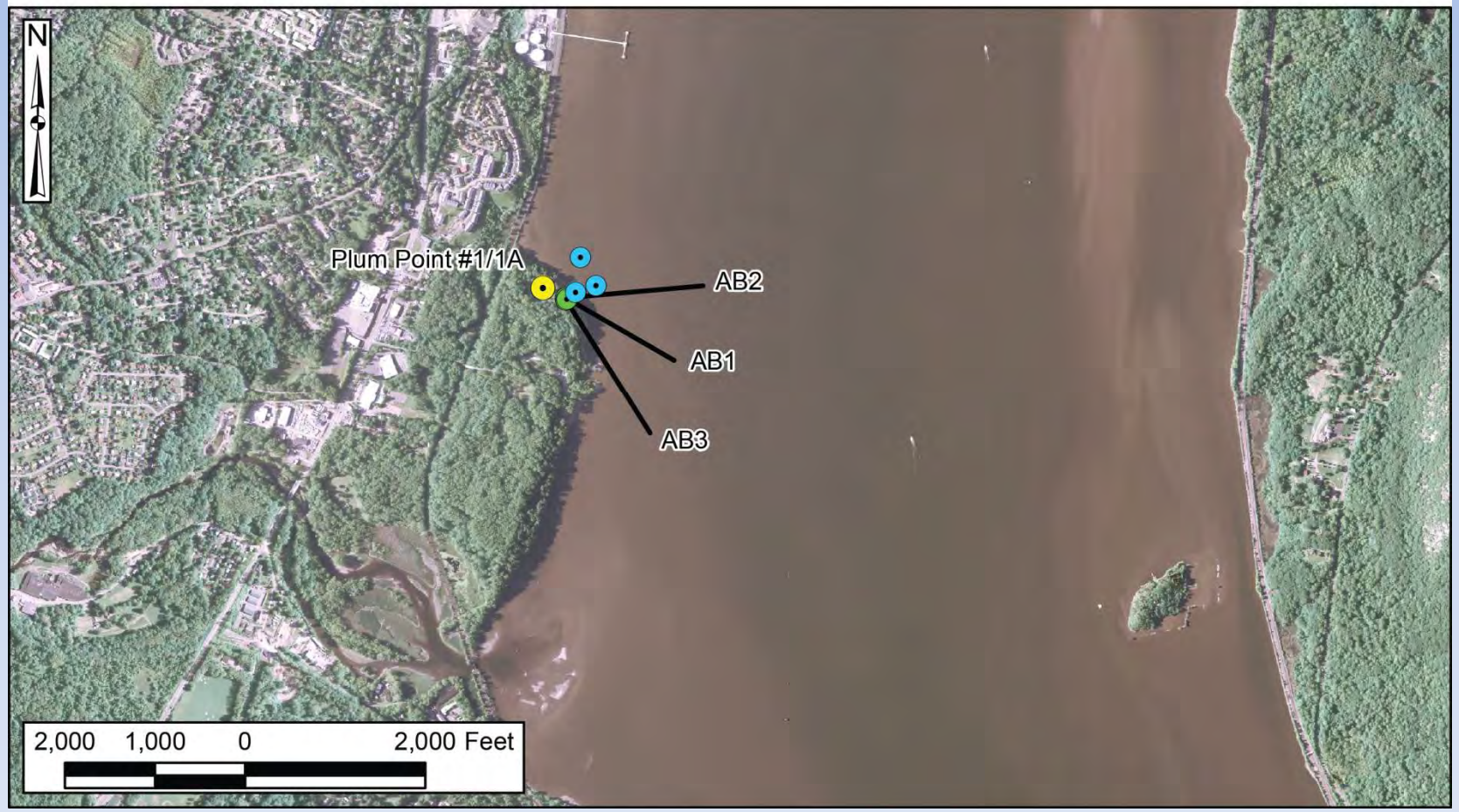
Inherent Benefits of Angle Well over Vertical Well

- Allows screen to “follow” the slope of the formation
- Extensive screen oriented away from vertical allows for lower entrance velocity potential and better efficiency
- Anticipated contrast between vertical and angle well performance:
  - specific capacity ratio of 1:2.1
  - yield ratio of 1:2.5

Phase Two - Focused Supplemental Exploration of Sub-River Aquifer from Shoreline

- Exploration under topographic constraints of site and lateral distance to sloping aquifer were accommodated by angle well drilling technique.
- Use of “sonic” rig allowed for:
  - high-quality sample collection necessary for refining aquifer configuration and makeup
  - attainment of “test” well design parameters
  - real-time yield and water-quality assessment

Exploration Borings and Well Layout



Angle Boring (Sonic) Rig Setup and Sampling to Maximize Limited Access Shoreline Conditions

Angle Boring Exploration Phase

Angle Boring #1 - 30° angle from horizontal

Chosen to explore aquifer and deltaic deposits

OWNER:	Town of New Windsor	
SOIL BORING NO.:	Angle Boring #1	PAGE: 3 OF 4 PAGES

ANGLE DEPTH (FT BG)		VERTICAL DEPTH (FT BG)		SIEVE TEST DEPTH (FT BG)	d_{50} (in)	U_c (d_{50}/d_{10})	DESCRIPTION
FROM	TO	FROM	TO				
308	309.5	154	154.75				SAND, c, and F GRAVEL; some f-m sand; few c gravel; trace cobbles; gray; saturated.
309.5	311	154.75	155.5	310-311	0.016	6.8	SAND, f-m; some f gravel; few subrounded cobbles; trace silt; gray; saturated.
311	312.5	155.5	156.25				SAND, c; some f gravel and f sand; trace silt and c gravel; gray; saturated.
312.5	314	156.25	157				SAND, m-c; little f gravel; trace subrounded cobbles; gray; saturated.
314	316	157	158	314-317	0.027	5.9	SAND, c, and F GRAVEL; trace f-m sand; trace subrounded c gravel; gray; saturated.
316	318	158	159				GRAVEL, f-c; few subrounded cobbles; trace silt; gray; saturated.
318	323	159	161.5	319-321	0.047	7.7	GRAVEL, f-c; little clay; trace silt and subrounded cobbles; gray; saturated.
323	324	161.5	162	323	0.031	5.2	GRAVEL, f-c; Some silt; trace f-m sand; gray; saturated.
324	326	162	163	324	0.156	16.6	GRAVEL, f-m; some c sand; little silt; trace subrounded c gravel; gray; saturated.
326	327.5	163	163.75	325-326	0.047	5.3	GRAVEL, f-m; some c gravel, cobbles, and m-c sand; little f sand; trace silt; gray; saturated.

Angle Boring Exploration

Angle Boring #2 - 25° angle from horizontal

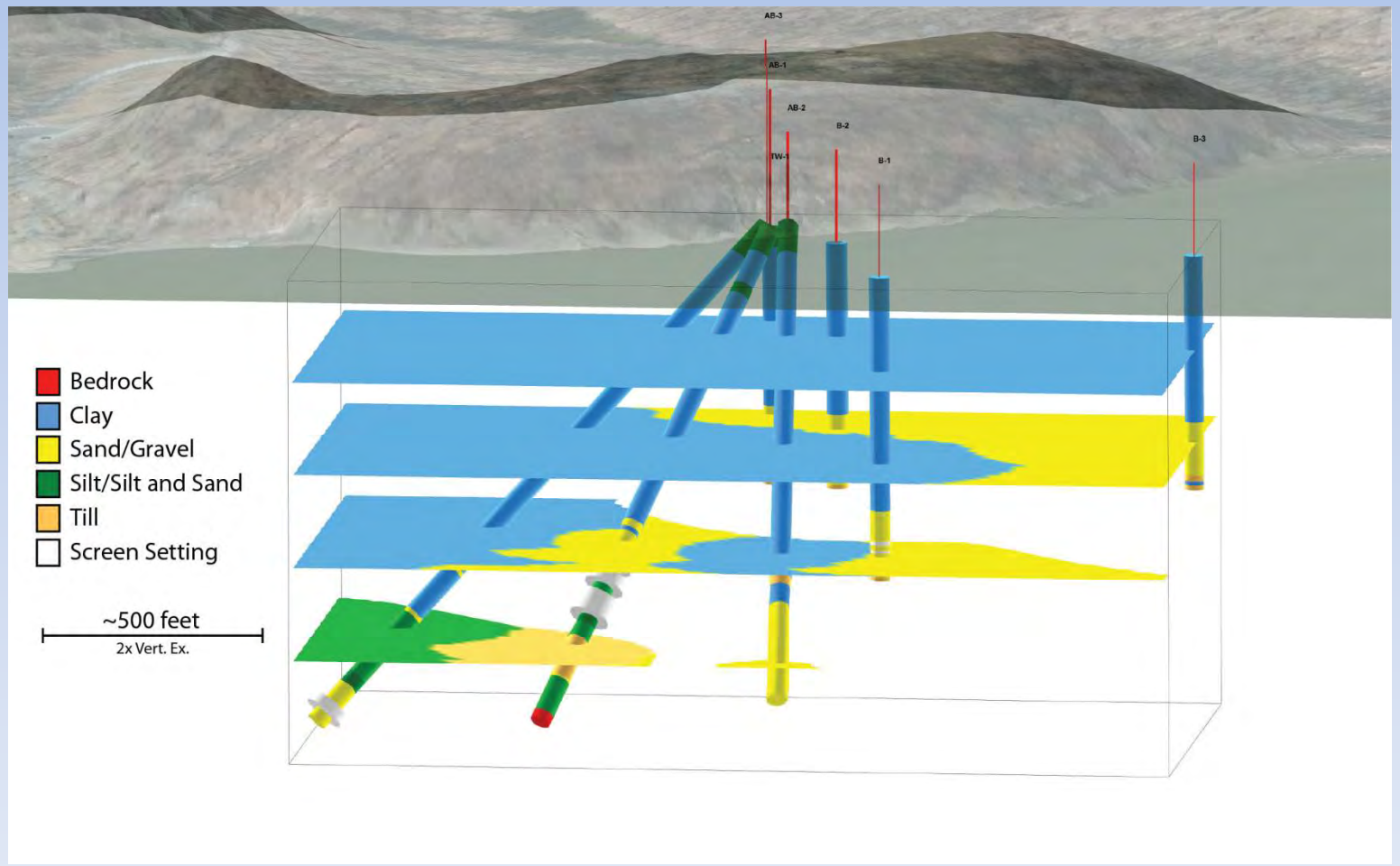
Chosen to explore anticipated max aquifer thickness

Angle Boring Exploration

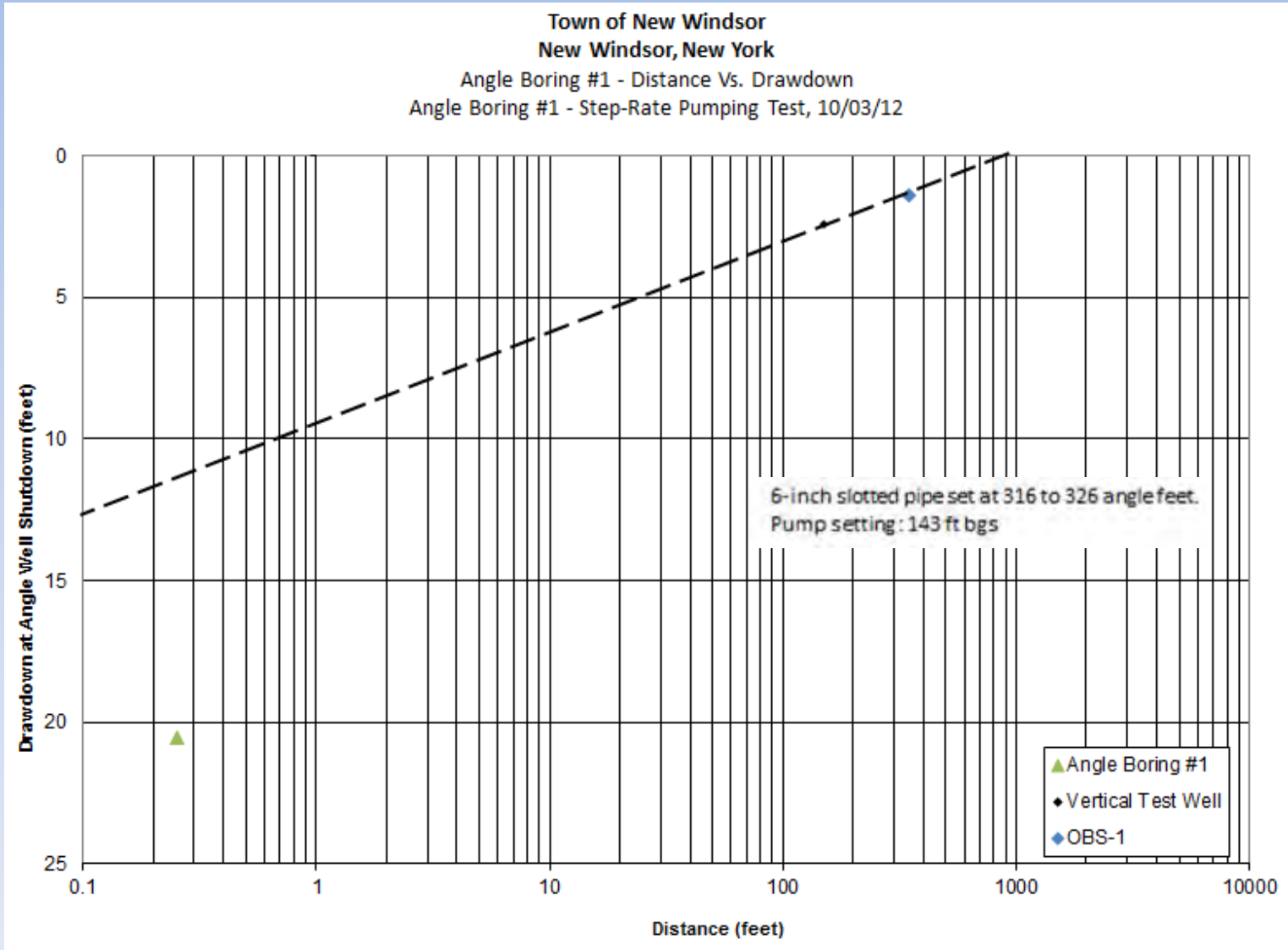
Angle Boring #3 - 25° angle from horizontal

Chosen to explore possible deltaic deposits

3-D Hydrogeologic Characterization of Sub-River Aquifer and Future Test Well Target



Angle Boring Real-Time Yield Testing



Angle Boring Real-Time Quality Testing

Date	4/4/2011	4/4/2011	4/5/2011	4/6/2011	4/7/2011	4/8/2011
Time	1145 hrs	1420 hrs	0945 hrs	0940 hrs	1010 hrs	0945 hrs
Temp.	12 C	12 C	12 C	12 C	12 C	12 C
pH	7.6	7.7	7.8	7.9	8	7.4
ORP	39.6	41.5	47	50.1	57	26.1
DO	4.7 mg/l	2.4 mg/l	1.7 mg/l	0.6 mg/l	0.6 mg/l	1.6 mg/l
NTU	5.45	3.3	1.57	0.38	0.19	0.19
BARTS (IRB)	P day 6	P day 6	P day 6	P day 6	P day 6	P day 6
BARTS (SRB)	P day 8	P day 7	P day 7	P day 7	P day 7	P day 7
Total Iron	.44 mg/l	.44 mg/l	.56 mg/l	.50 mg/l	.45 mg/l	.39 mg/l
Ferrous Iron	.44 mg/l	.42 mg/l	.57 mg/l	.52 mg/l	.43 mg/l	.41 mg/l
Ferric Iron	.40 mg/l	.40 mg/l	.40 mg/l	.40 mg/l	.40 mg/l	.40 mg/l
Total Manganese	.259 mg/l	.277 mg/l	.256 mg/l	.255 mg/l	.257 mg/l	.233 mg/l
Chloride	73.9 mg/l	74.4 mg/l	74.5 mg/l	68.5 mg/l	61.3 mg/l	55.8 mg/l
Sodium	16.1 mg/l	16.2 mg/l	16.1 mg/l	16.3 mg/l	17.4 mg/l	17.3 mg/l
Potassium	2.00 mg/l	1.99 mg/l	1.90 mg/l	1.84 mg/l	1.89 mg/l	1.85 mg/l
Magnesium	19.2 mg/l	19.4 mg/l	18.7 mg/l	18.4 mg/l	19.4 mg/l	18.3 mg/l
Bromine	.05 mg/l	.05 mg/l	.05 mg/l	.05 mg/l	.05 mg/l	.05 mg/l
Hardness	314 mg/l	313 mg/l	310 mg/l	300 mg/l	276 mg/l	278 mg/l
Calcium	87.6 mg/l	88.5 mg/l	85.4 mg/l	84.1 mg/l	78.3 mg/l	72.4 mg/l
Bicarbonate	176 mg/l	176 mg/l	180 mg/l	181 mg/l	183 mg/l	182 mg/l
Hydrogen Sulfide	<1 mg/l	<1 mg/l	<1 mg/l	<1 mg/l	<1 mg/l	<1 mg/l
Odor	4 TON	1 TON	1 TON	1 TON	1 TON	1 TON
Color	<5 Pt Co	<5 Pt Co	<5 Pt Co	13 Pt Co	11 Pt Co	8 Pt Co

Findings to Date

- Targeted aquifer is on the order of tens of feet thick and thickens towards river channel. Best way to access aquifer from shoreline proximal to steep slope is with angle drilling.
- Locally occurs under confined conditions below a thick sequence of clay and silt of at least 100 feet thick.
- Groundwater quality does not appear to be influenced by overlying brackish river water.
- The results of the angle borings/test wells indicate potentially favorable subsurface conditions. The results are currently being used to design a full scale angle/horizontal "test well" installation geared to pump at least 0.5 MGD from the desired aquifer materials under the Hudson River.
- Depending on long-term yield, at least 3 permanent angle/horizontal wells capable of yielding 1 MGD each are proposed for installation from same shoreline area.

Phase Three

- The results of the angle borings/test wells indicate potentially favorable subsurface conditions. The results are currently being used to design a full scale angle/horizontal “test” well installation geared to pump at least 0.5 MGD from the desired aquifer materials under the Hudson River.
- Cost Estimate for installation of 10 to 16-inch diameter angle “test” well between $200,000 and $250,000, with potential for modification to “permanent” well construction.

Summary/Questions

Contact Info:
Frank.Getchell@lbgnj.com
KBenson@lbgnj.com

(800) 818-8LBG