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Colloidal Activated Carbon Barrier to Reduce PFAS Migration Into the Oakland Inner Harbor

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Site Overview

Site Background

- Installation Restoration (IR) Site 14 (Site) is located on former Naval Air Station (NAS) Alameda.
- NAS Alameda served as an active Navy Base from 1940 to 1997.
- Site was developed by dredge and fill operations.

Department of Veterans Affairs Property Boundary

IR Site 14 Boundary

Alameda Point Boundary

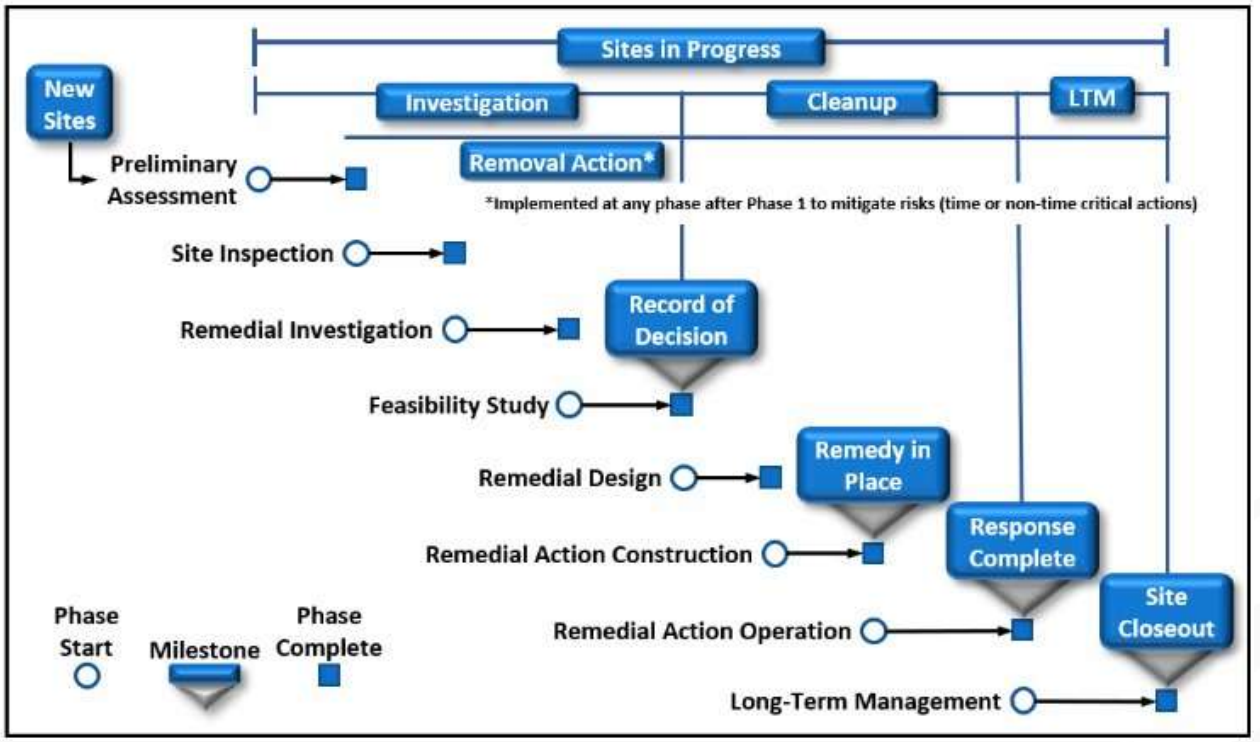
Site Overview

Per- and Polyfluoroalkyl Substances (PFAS) Concentrations

PFAS Source: Firefighting foam used historically during firefighter training.

- Initial Data Set
  - Highest Levels
- PFBS: 16,000 ng/L
- PFOA: 1,100,000 ng/L
- PFOS: 230,000 ng/L

CERCLA Process



Source: *https://exwc.navfac.navy.mil/Products-and-Services/Environmental-Security/NAVFAC-Environmental-Restoration-and-BRAC/Program-Support/CERCLA-Phases-and-Milestones/*

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Stakeholders

SF RWQCB

DTSC

APTIM

Bayside

EPA

Alameda County

CA Fish & Wildlife

US Navy

Citizens Group

Colloidal Activated Carbon (CAC)

Overview

PlumeStop Attributes

- Carbon particle sizes 1–2 µm
- Suspends as a colloid in polymer solution
- Distributes easily under low pressure
- Creates an in-situ purifying filter within the saturated zone
- Reduces concentrations of target compounds in groundwater

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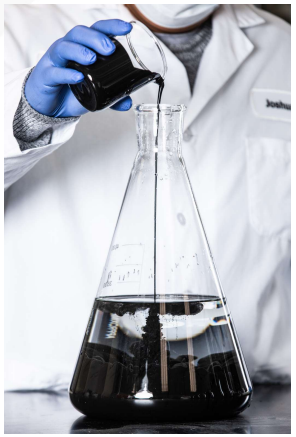
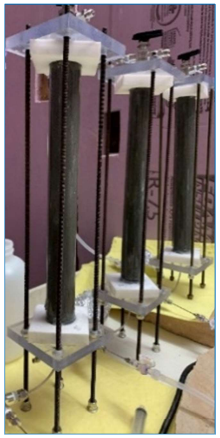
Conceptual Design

Create a Barrier to Reduce the Migration of PFAS in the Groundwater

- Injectable
- Permeable formation
- In-situ
- 720-feet long
- 288 direct push injection points





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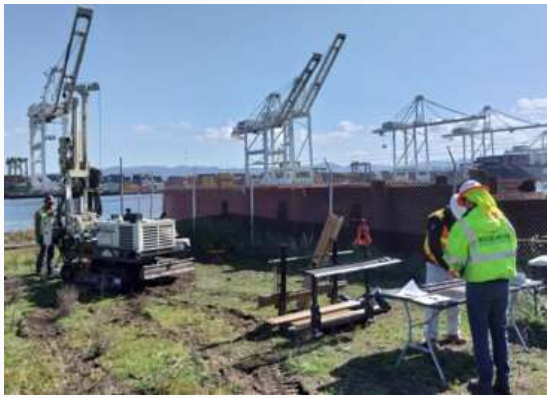
DVT: Upfront Work Dictates Performance



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Column Study

Three Columns

- C1 = 0.0% CAC
- C2 = 0.5% CAC
- C3 = 2.0% CAC

Setup

- 12 inches in length
- 3.6 milliliters/hour flow rate
- 1-ft flow every 28 hours

Operation

- Ran one month with site water, then added CAC
- Ran four months after CAC addition (9 liters water after CAC)
- Collected effluent into 1-L bottles
- Sampled soils and analyzed for PFAS and combustible carbon

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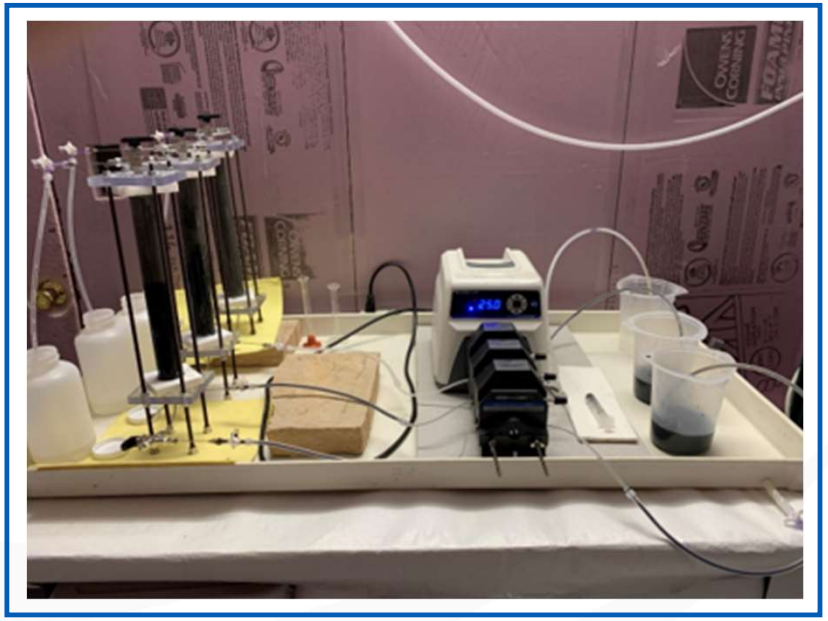
Column Study

Results

- **C1 = 0.0% CAC**
  - Little adsorption from the native aquifer soils observed
- **C2 = 0.5% CAC**
  - Reduced from 438,000 ng/L to 1,300 ng/L by Day 47
- **C3 = 2.0% CAC**
  - Reduced from 438,000 ng/L to <200 ng/L on Day 47 (slightly faster adsorption)

- Site groundwater that was collected to run the test had PFAS concentrations over 400,000 ng/L
- CAC can reduce groundwater PFAS concentration as expected
- Different concentrations of CAC can be matched to different PFAS concentrations along the barrier



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Passive Flux Meter (PFM) Study

PFM Phases

- **Phase 1:** Determine future well screen placement
- **Phase 2:** Collect pre-injection data
- **Phase 3:** Collect post-injection data (est. Q4-2024)

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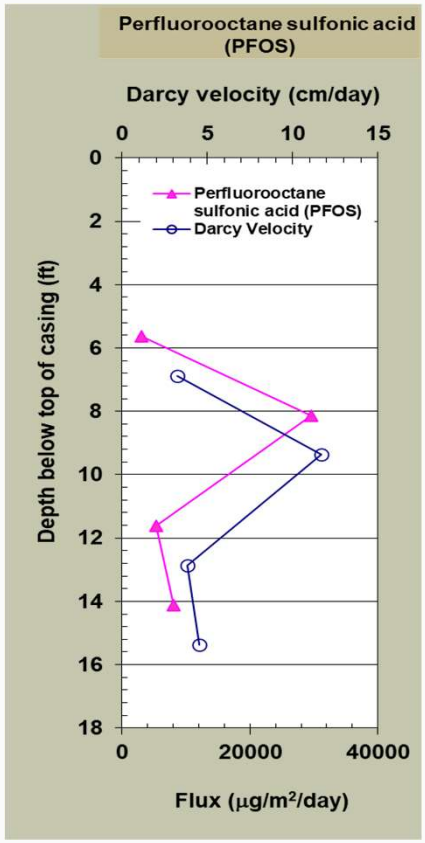
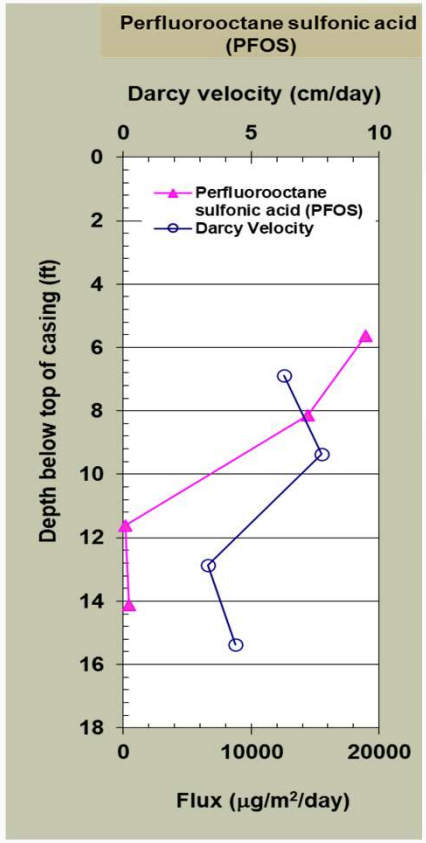
Passive Flux Meter (PFM) Study

M14–37S/D



M14–41S/D



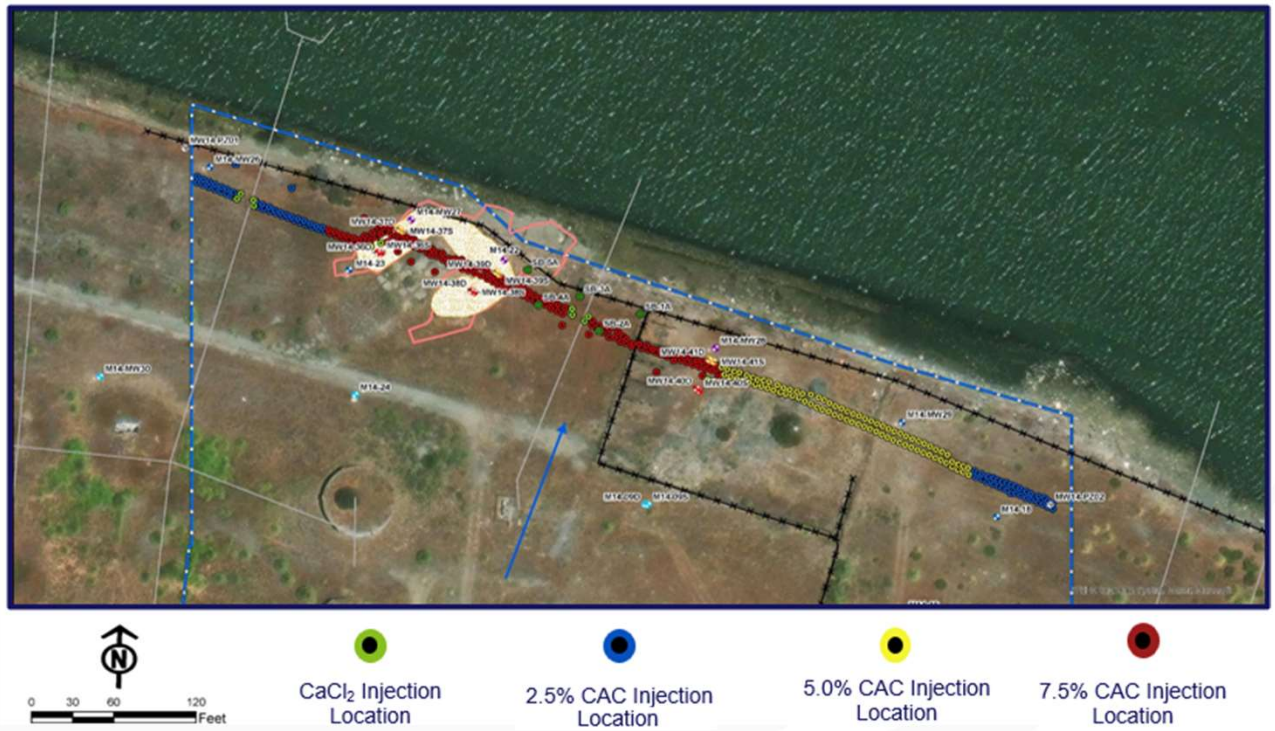
Final Design of CAC Permeable Barrier

Barrier Wall Overview

- 720-ft
- Two lines of injection borings parallel to the shoreline

Injection Overview

- Target Zone: 1–16 ft bgs
- Varying doses of CAC injected into each boring, depending on PFAS levels (2.5%, 5.0%, and 7.5%)



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Implementation of Work

- Schedule: June 20th - July 31st (28 Days on-site)
- 2 Injection & Drilling Crews
- 340,000 lbs. of PS Installed (170 IBC Totes)
- 10 Semitruck Deliveries
- 290 Injection Points (3-17 ft bgs)
- Barrier Length = 720’
- Daily Average: 14,000 lbs. Injected (26,399 lbs. Daily High)
- Injected on Average: 3,500–4,500 gallons each day

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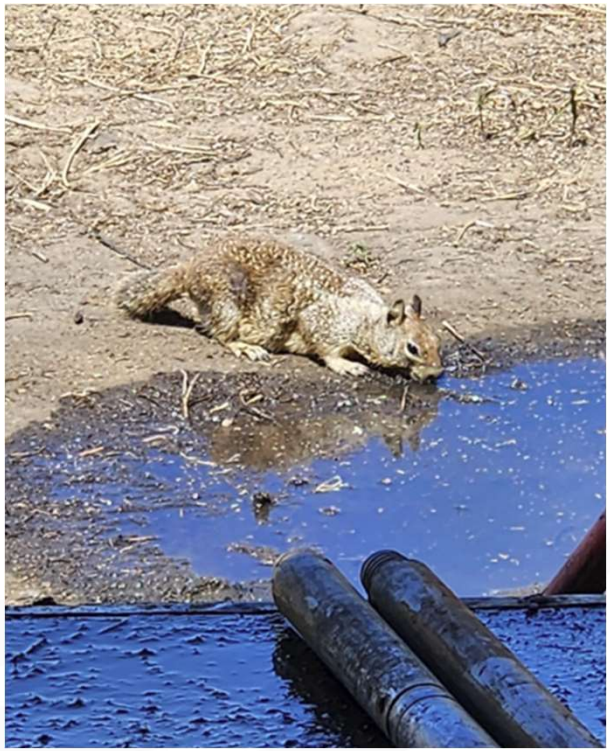
Site Challenges

- Birds
- Gophers/Squirrels
- Potholes
- Oh my!



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Performance Monitoring

Quarterly Sampling

- Sampling 18 wells
- All transect wells
- Cross gradient wells

CAC Observed in Samples

- Primarily in-barrier wells
- CAC was not observed in downgradient wells
- Samples were centrifuged in analytical laboratory

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Transect Sampling Locations 1-3

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PFOS Reductions

Transect 1 (West)	Units	Upgradient - Shallow					PRB Adjacent - Shallow					DG of PRB				
		M14-MW36S					M14-MW37S					M14-MW27				
Analyte		Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction
		6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%
Perfluorobutanesulfonic Acid (PFBS)	ng/L	1,680	738	495	1,100	35	2,410	100	20	50	98	5,930	245	438	704	88
Perfluorooctanesulfonic Acid (PFOS)	ng/L	215,000	97,300	57,900	115,000	47	167,000	140	9	188	100	36,700	15	186	842	98
Perfluorooctanoic Acid (PFOA)	ng/L	73,500	26,200	17,300	37,000	50	99,700	87	10	62	100	247,000	45	491	1,740	99
Transect 1 (West)	Units	Upgradient - Deep					PRB Adjacent - Deep									
		M14-MW36D					M14-MW37D									
Analyte		Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction					
		6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%					
Perfluorobutanesulfonic Acid (PFBS)	ng/L	1,490	1,090	1,020	1,440	3.4	2,670	100	8	9	98.1					
Perfluorooctanesulfonic Acid (PFOS)	ng/L	218,000	74,100	75,800	102,000	53.2	171,000	417	26	19	100					
Perfluorooctanoic Acid (PFOA)	ng/L	77,400	59,100	70,800	85,200	-10.1	123,000	118	10	13	100					

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PFOS Reductions

Transect 2 (Central)	Units	Upgradient - Shallow M14-MW38S					PRB Adjacent - Shallow M14-MW39S					DG of PRB M14-MW22				
Analyte		Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction
		6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%
Perfluorobutanesulfonic Acid (PFBS)	ng/L	1,810	1,730	1,100	935	48.3	3,120	100	21	15	99.5	3,600	2,530	1,240	1,630	54.7
Perfluorooctanesulfonic Acid (PFOS)	ng/L	141,000	149,000	107,000	154,000	-9.2	312,000	54	26	25	100	153,000	195,000	108,000	82,800	45.9
Perfluorooctanoic Acid (PFOA)	ng/L	126,000	128,000	95,500	102,000	19	282,000	31	15	9	100	152,000	139,000	38,700	34,900	77

Transect 2 (Central)	Units	Upgradient - Deep M14-MW38D					PRB Adjacent - Deep M14-MW39D				
Analyte		Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction
		6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%
Perfluorobutanesulfonic Acid (PFBS)	ng/L	1,710	33	240	376	78	2,970	100	11	37	98.8
Perfluorooctanesulfonic Acid (PFOS)	ng/L	90,900	18	761	8,640	90.5	392,000	232	49	36	100
Perfluorooctanoic Acid (PFOA)	ng/L	143,000	31	2,710	15,300	89.3	260,000	129	18	72	100

PFOS Reductions

Transect 3 (East)	Units	Upgradient - Shallow M14-MW40S					PRB Adjacent - Shallow M14-MW41S					DG of PRB M14-MW28				
Analyte		Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction
		6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%
Perfluorobutanesulfonic Acid (PFBS)	ng/L	2,840	2,960	1,170	1,430	49.6	4,740	100	21	1,820	61.6	5,980	5,850	3,410	865	85.5
Perfluorooctanesulfonic Acid (PFOS)	ng/L	101,000	81,300	42,100	72,600	28.1	97,500	100	21	10,900	88.8	37,700	37,100	34,300	11,900	68.4
Perfluorooctanoic Acid (PFOA)	ng/L	230,000	169,000	67,600	117,000	49.1	301,000	162	32	72,200	76	252,000	254,000	168,000	28,600	88.7

Transect 3 (East)	Units	Upgradient - Deep M14-MW40D					PRB Adjacent - Deep M14-MW41D				
Analyte		Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction	Baseline	Qtr. 1	Qtr. 2	Qrt. 3	Reduction
		6/5/2023	10/23/2023	1/23/2024	4/24/2024	%	6/5/2023	10/23/2023	1/23/2024	4/24/2024	%
Perfluorobutanesulfonic Acid (PFBS)	ng/L	4,400	3,680	1,630	1,450	67	6,210	4,200	2,060	15	99.8
Perfluorooctanesulfonic Acid (PFOS)	ng/L	91,700	73,300	39,500	31,000	66.2	47,200	12,800	9,260	25	99.9
Perfluorooctanoic Acid (PFOA)	ng/L	230,000	227,000	90,400	81,500	64.6	301,000	115,000	69,300	27	100

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Project Team

BAYSIDE Engineering Construction

- Abram Eloskof
- Sridhar Palakur
- Gary Cronk

APTIM

- Nels Johnson
- Paul Hatzinger. PhD
- Michael Lightner

REGENESIS®

- Craig Sandefur
- Dan Nunez

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SourceStop®

60+

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178

Sites in Design and Review Phase

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Questions?

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