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January 17, 2010

Mr. Ravi Sanga  
US Environmental Protection Agency (EPA) – Region X  
Office of Environmental Cleanup  
1200 Sixth Avenue – ECL 113  
Seattle, WA 98101

**SUBJECT: FINAL LOW-TIDE GROUNDWATER SAMPLING AND ANALYSIS PLAN FOR FORMER SHIPYARD NO. 1, HARBOR ISLAND, SEATTLE WASHINGTON**

Dear Mr. Sanga:

Lockheed Martin Corporation (LMC) is pleased to submit four (4) hard copies and one (1) CD-ROM of the Final Low-Tide Groundwater Sampling and Analysis Plan for the former Lockheed Shipyard No. 1. LMC has prepared this technical memorandum to support a recent EPA request for a low-tide sampling event at LMC's former Shipyard No. 1 located on Harbor Island, Seattle, Washington. This sampling event will serve to fulfill the Spring 2010 semi-annual groundwater monitoring requirement for both the Yard 1 Uplands and Yard 1 Shoreline Monitoring Programs.

If you have any questions or concerns, please feel free to contact me at 303-977-3997.

Sincerely,

A handwritten signature in cursive script that reads "Bill Bath".

Bill Bath  
Project Coordinator  
Environmental Remediation  
Lockheed Martin Corporation

cc: Gene Matsushita  
David Liu, Tetra Tech  
Rick Osgood, Tetra Tech

BUR015 Yard 1 Low-tide sampling and analysis plan

TETRA TECH, INC.

TECHNICAL MEMORANDUM

January 17 2010

**TO:** Mr. Bill Bath

**FROM:** Ms. Mary Diesel, Tetra Tech, Inc.

**CC:** Mr. Gene Matsushita  
Mr. Rick Osgood

**RE:** **FINAL LOW-TIDE GROUNDWATER SAMPLING AND ANALYSIS PLAN FOR FORMER SHIPYARD 1, HARBOR ISLAND, WASHINGTON.**

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Tetra Tech, Inc. (Tetra Tech), on behalf of the Lockheed Martin Corporation (LMC), has prepared this Sampling and Analysis Plan (SAP) memorandum to support a recent EPA request for additional study at LMC's former Shipyard 1 located on Harbor Island, Washington.

On 26 October 2009, LMC met with EPA to discuss the third Harbor Island Superfund Site 5-Year Review which is being prepared for publication in 2010. During this meeting, EPA requested LMC to conduct a low-tide groundwater sampling effort at both the Yard 1 Uplands Operable Unit (Uplands OU) and the Yard 1 Sediment OU (LSSOU) in support of the 5-Year Review. The EPA requested that both the Uplands OU and LSSOU monitoring well networks be sampled for those chemical constituents specified as groundwater cleanup goals in the Record of Decision (ROD) for each OU. During the meeting, EPA and LMC agreed that the low-tide groundwater sampling activity would serve to fulfill the Spring (wet season) 2010 semi-annual groundwater monitoring requirement for each OU.

This technical memorandum represents the SAP for low-tide groundwater sampling and is organized into three sections, including Section 1.0 – Analytical Program and Data Quality Objectives, Section 2.0 - Field Activities and Sampling Procedures, and Section 3.0 – Reporting. The Final Source Control Report/Sampling and Analysis Plan Errata Sheet is provided in Attachment A and Graphic Tidal Cycle Predictions are provided in Attachment B.

## **1.0 ANALYTICAL PROGRAM AND DATA QUALITY OBJECTIVES**

The analytical program and data quality objectives for the low-tide sampling effort are discussed for each OU in the following sections.

### **1.1 LSSOU Shoreline Groundwater Monitoring Program**

The ROD for LSSOU did not identify groundwater as a significant pathway and does not include groundwater cleanup objectives. However, the EPA required LMC to address the groundwater pathway through an evaluation of source control. An EPA-approved "*Final Source Control Report (SCR) and Sampling and Analysis Plan (SAP) for the Shoreline Groundwater Monitoring Program, Seattle Yard 1 Property, Harbor Island, Washington*," was prepared in September 2005. Nine new "shoreline" monitoring wells (LMW30, LMW31, LMW32S, LMW32D, LMW33, LMW34, BG-01, BG-02, and

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BG-03) were installed in November 2005. An ERRATA to the Final SCR/SAP was prepared and approved by EPA in July 2006.

The Final SCR/SAP specified a comprehensive suite of analyses to be sampled over a one-year baseline period, and again every five years in support of ongoing CERCLA 5-Year Reviews. In the 26 October 2009 meeting, EPA and LMC agreed to perform the required comprehensive suite six months sooner than was specified in the SCR/SAP so the results could be available for the 5-year review. Table 1 provides an analytical summary for those LSSOU wells to be sampled for the comprehensive suite analyses in support of the “low-tide” groundwater sampling effort that is now proposed for the spring rather than the fall. Attachment A provides the Errata Sheet with the list of the compounds to be analyzed during the sampling event. Figure 1 shows the locations of the LSSOU shoreline monitoring wells. Figure 1 also shows the location of the existing Upland monitoring well network discussed in the following section.

The analytical methods, associated reporting limits, and data quality objectives (DQOs) for the low-tide sampling event will be the same as those specified in the Final SCR/SAP.

## 1.2 Uplands OU Groundwater Monitoring Program

The standard methods to conduct groundwater sampling for the Uplands OU are presented in the Operation and Maintenance Plan included as Appendix B of the EPA-approved *Remedial Action Work Plan (100% Design) for Lockheed Martin Shipyard No. 1, Harbor Island, Seattle, Washington*, prepared by ICF Kaiser Engineers in June 1995. The Operation and Maintenance Plan was modified to incorporate low-flow purging and sampling techniques, as approved by EPA in March 1998.

The ROD-specified groundwater cleanup goals for the Yard 1 Uplands including benzene, tetrachloroethene (PCE), copper, lead, and zinc are as follows:

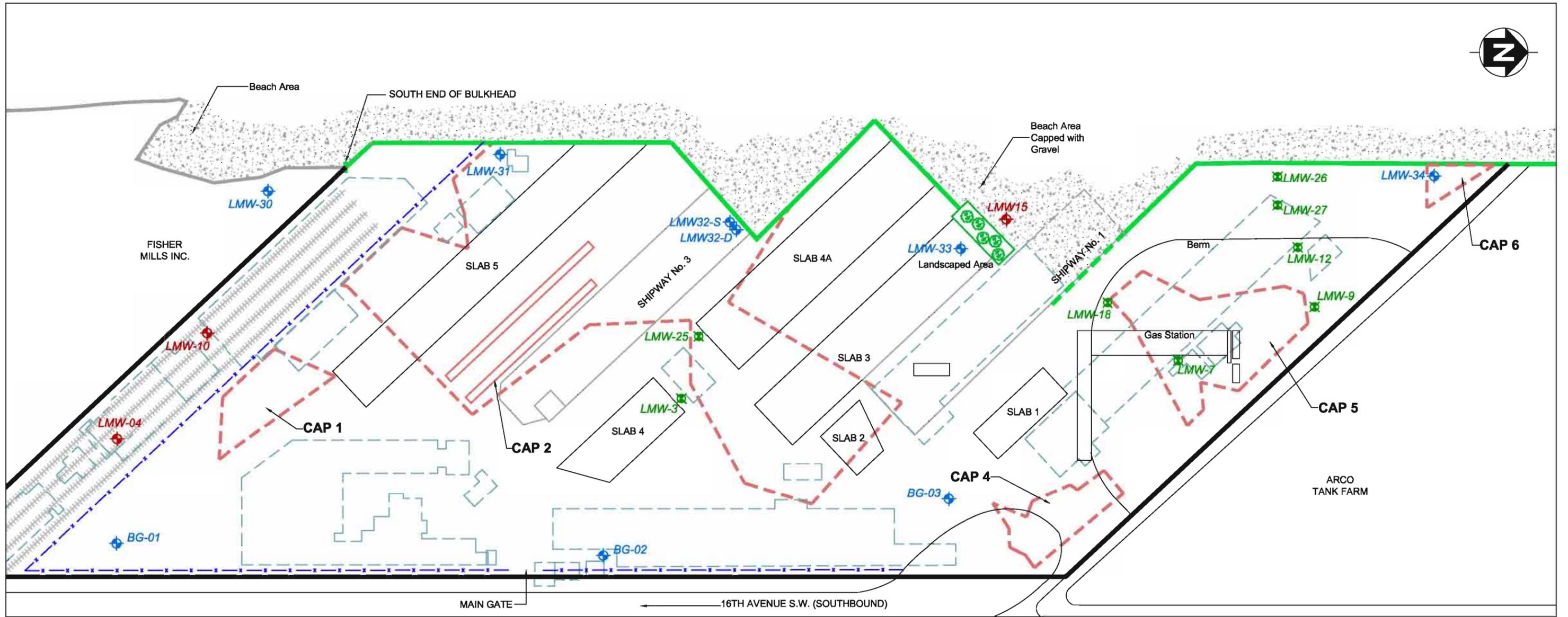
Benzene	71 micrograms per liter (µg/L)
PCE	8.8 µg/L
Copper	2.9 µg/L
Lead	5.8 µg/L
Zinc	76.6 µg/L

The Operation and Maintenance Plan details the rationale for selection of monitoring constituents on a well-by-well basis. However, at the request of EPA the analytical methods, associated reporting limits, and data quality objectives for the proposed low-tide sampling effort will be the same as those specified for the LSSOU. Also at EPA’s request, cyanide analysis will be total and available, consistent with the most recent Harbor Island Group Monitoring Plan. Table 2 provides an analytical summary for those Upland OU wells to be sampled in support of the “low-tide” groundwater sampling effort. Figure 1 shows the location of the existing Upland monitoring well network, as well as those wells associated with LSSOU as discussed above.

**TABLE 1. ANALYTICAL SUMMARY FOR LOW-TIDE GROUNDWATER SAMPLING EFFORT  
LSSOU (Shoreline Program), HARBOR ISLAND, WASHINGTON**

Sample Identification	Media	Analytical Methods									
		Volatile Organic Compounds (EPA Method 8260B)	Semivolatile Organic Compounds (EPA Method 8270C)	Organochlorine Pesticides (EPA Method 8081A)	Polychlorinated Biphenyls (EPA Method 8082)	Total Petroleum Hydrocarbons		Metals (EPA Method 6010/6020/7000 Series)		Cyanide	
						Ecology Method NWTPH-Gx	Ecology Method NWTPH-Dx	Total	Dissolved	Total <sup>a</sup>	Available <sup>b</sup>
LMW18 <sup>c</sup>	Groundwater		1	1	1	1	1	1	1	1	1
LMW26 <sup>c</sup>		1	1	1	1	1	1	1	1	1	1
LMW30		1	1	1	1	1	1	1	1	1	1
LMW31		1	1	1	1	1	1	1	1	1	1
LMW32S		1	1	1	1	1	1	1	1	1	1
LMW32D		1	1	1	1	1	1	1	1	1	1
LMW33		1	1	1	1	1	1	1	1	1	1
LMW34		1	1	1	1	1	1	1	1	1	1
BG-01		1	1	1	1	1	1	1	1	1	1
BG-02		1	1	1	1	1	1	1	1	1	1
BG-03 <sup>1</sup>	1	1	1	1	1	1	1	1	1	1	
<b>Quality Assurance/Quality Control</b>											
Duplicates	Groundwater	1	1	1	1	1	1	1	1	1	1
Trip Blanks		2	NA <sup>d</sup>	NA	NA	2	NA	NA	NA	NA	NA

- a Total cyanide will be analyzed using analytical method SM 4500-CN E.  
b Available cyanide will be analyzed for using analytical method OIA 1677.  
c Wells LMW18 and LMW26 are included in both the Uplands OU and LSSOU (shoreline) groundwater monitoring programs.  
d NA = Not applicable.



**NOTES**

Wells LMW 18 and LMW 26 are included in both the uplands and LSSOU Groundwater Monitoring Programs.

**LEGEND**

-  Shoreline
-  Property Boundary
-  Beach/Gravel Area
-  Former Building Footprint
-  Upland Groundwater Well Locations
-  LSSOU (Shoreline) Groundwater Monitoring well Locations
-  Decommissioned Well
-  Remaining CAP Areas
-  Fence
-  Railroad Tracks
-  Bulkhead-New 2003
-  Bulkhead-Constructed Prior To 2003



**FIGURE 1**

UPLANDS OU AND LSSOU (SHORELINE)  
MONITORING WELL LOCATION MAP  
FORMER LOCKHEED SHIPYARD No. 1  
SEATTLE, WASHINGTON

**TABLE 2. ANALYTICAL SUMMARY FOR LOW-TIDE GROUNDWATER SAMPLING EFFORT  
UPLANDS OU, HARBOR ISLAND, WASHINGTON**

Sample Identification	Media	Analytical Methods									
		Volatile Organic Compounds (EPA Method 8260B)	Semivolatile Organic Compounds (EPA Method 8270C)	Organochlorine Pesticides (EPA Method 8081A)	Polychlorinated Biphenyls (EPA Method 8082)	Total Petroleum Hydrocarbons		Metals (EPA Method 6010/6020/7000 Series)		Cyanide	
						Ecology Method NWTPH-Gx	Ecology Method NWTPH-Dx	Total	Dissolved	Total <sup>a</sup>	Available <sup>b</sup>
LMW3	Groundwater	1	1	1	1	1	1	1	1	1	1
LMW7		1	1	1	1	1	1	1	1	1	1
LMW9		1	1	1	1	1	1	1	1	1	1
LMW12		1	1	1	1	1	1	1	1	1	1
LMW18 <sup>c</sup>		1	1	1	1	1	1	1	1	1	1
LMW25		1	1	1	1	1	1	1	1	1	1
LMW26 <sup>c</sup>		1	1	1	1	1	1	1	1	1	1
LMW27		1	1	1	1	1	1	1	1	1	1
<b>Quality Assurance/Quality Control</b>											
Duplicates	Groundwater	1	1	1	1	1	1	1	1	1	1
Trip Blanks		2	NA <sup>d</sup>	NA	NA	2	NA	NA	NA	NA	NA
<p>a Total cyanide will be analyzed using analytical method SM 4500-CN E.</p> <p>b Available cyanide will be analyzed for using analytical method OIA 1677.</p> <p>c Wells LMW18 and LMW26 are included in both the Uplands OU and LSSOU (shoreline) groundwater monitoring programs.</p> <p>d NA = Not applicable.</p>											

## 2.0 FIELD ACTIVITIES AND SAMPLING PROCEDURES

The field and sampling procedures to be employed in support of the low-tide groundwater sampling effort will be consistent with those specified in the existing EPA-approved monitoring plans (see Section 1.0 above).

Tide predictions for the former LMC Shipyard 1 were evaluated based on the Seattle (Madison St.) Elliot Bay, Washington (NOAA Station). Low-tide sampling period selection was based on identification of lower-low, semi-diurnal tides occurring during daylight hours. Based on the evaluation of tide predictions for former Shipyard 1, the low-tide sampling effort will be conducted during the week of 01 March 2009. Table 3 provides a summary of predicated lower-low tide times for the recommended sampling period. Attachment B includes a graphical representation of the predicted tide cycles over this recommended sampling period.

A tidal study, incorporating many of the existing monitoring wells at former Shipyard 1, was conducted in May 2006. Results of this study summarized tide to groundwater lag times for semi-diurnal highs and lows. The lag times for select wells during lower-low tide conditions ranged between 0.82 hours to 2.57 hours. Based on the predicted lower-low tide cycles provided in Table 3, sampling will occur over a 4-day period [Tuesday through Friday (3/2/2010-3/5/2010)]. Sampling will occur each day over a 4-hour period (1-hour before / 3-hours after lower low tide).

**TABLE 3. SUMMARY OF TIDE CYCLE TIMING AND ELEVATION DATA FOR THE WEEK OF MARCH 01, 2009**

Date	Tide Cycle <sup>a</sup>							
	Low Water		High-High Water		Low-Low Water		High Water	
	Time	Elevation	Time	Elevation	Time	Elevation	Time	Elevation
Tuesday (3/2/2010)	NA	NA	05:46am	12.7	<b>12:05pm</b>	<b>1.3</b>	6:09pm	11.2
Wednesday (3/3/2010)	12:08am	2.1	06:19am	12.6	<b>12:50pm</b>	<b>0.4</b>	7:09pm	10.9
Thursday (3/4/2010)	12:54am	3.6	06:55am	12.3	<b>1:36pm</b>	<b>0.0</b>	8:11pm	10.5
Friday (3/5/2010)	01:42am	5.1	07:33am	11.7	<b>2:24pm</b>	<b>0.0</b>	9:21pm	10.1

<sup>a</sup> Semi-diurnal tide cycle. Tide data taken from the Lockheed Shipyard, Harbor Island based on Seattle (Madison St.) Elliot Bay, Washington NOAA Tide Station (Station ID: 1075)

**Bolding** = Indicates the selected daily low tide target for groundwater sample collection.

## 3.0 REPORTING

Reporting of the low-tide groundwater sampling effort for both the Uplands OU and LSSOU will be consistent with the semi-annual groundwater monitoring reports routinely prepared for each OU. These reports shall be delivered to EPA by May 14, 2010, assuming sampling is completed as specified above. These reports will clearly document the unique aspects of the low-tide monitoring event, such as incorporation of additional analyses and well sampling times relative to associated tide stage.

Validated analytical summary tables and associated figures can be provided in advance of the groundwater monitoring reports at EPA's request.

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**ATTACHMENT A**  
**FINAL SCR/SAP ERRATA SHEET**

# ATTACHMENT A

## ERRATA

Final Source Control Report and Sampling and Analysis Plan for the Shoreline  
Groundwater Monitoring Program, Seattle Yard 1 Property (Uplands OU and  
LSSOU), Harbor Island, Seattle, Washington  
September 2005

Replace Pages	Notes
<b>Section 5</b>	
Table 5-2	Replace page 49
Table 5-3	Replace pages 50 to 53

- Those constituents not-detected (ND) during the initial Year 1 sampling event (depending on the method specific reporting requirements) will not be sampled for again until the 5-year review period of the sampling program. Further details on the ongoing update of the sampling program are provided in more detail in Section 5.2.3.

Table 5-2 below outlines the EPA approved methods that will be utilized during the baseline evaluation events and all subsequent groundwater monitoring events, as applicable.

<b>Analyte</b>	<b>Test Method</b>
Metals (total and dissolved)	6020/6010B
Mercury	7471A
PCBs	8082
Pesticides	8081A
Total Petroleum Hydrocarbons	NWTPH-Gx and Dx-Extended
Volatile Organic Compounds	8260B
Semi-Volatile Organic Compounds	8270C

Table 5-3 that follows provides the basis for initial screening level comparisons for all groundwater data collected during the proposed shoreline groundwater monitoring efforts. As discussed previously, initial screening levels are based on applicable Ambient Water Quality Criteria standards established by EPA and used during both initial investigations at the Uplands OU and derivation of EPA's Risk Assessment. Table 5-3 includes EPA's current recommended ambient water quality criteria for the protection of aquatic life and human health, including Saltwater Criterion Continuous Concentrations (CCC) and Human Health for Consumption of Organisms. These criteria are based on EPA's published revision in 2002 (EPA-822-R-02-047) and revised human health water quality criteria in 2003 (EPA-822-F-04-010), as appropriate.

Note: Detected constituents will be reported after each monitoring event regardless of the existence of an applicable and appropriate initial screening level standard.

<b>Table 5-3. Initial Analytical Screening Standards (µg/L)</b>			
<b>Analyte</b>	<b>Ambient Water Criteria</b>		<b>Comments</b>
	<b>Saltwater Criterion Continuous Concentration (CCC)</b>	<b>Human Health for Consumption of Organisms</b>	
<b>METALS</b>			
Antimony		640	
Arsenic	36	0.14	
Cadmium	8.8		
Copper	3.1 <b>(2.9)</b>		RAO for Copper is 2.9
Cyanide	1	140	
Lead	8.1 <b>(5.8)</b>		RAO for Lead is 5.8
Mercury	0.94	0.3	
Nickel	8.2	46,000	
Selenium	71	4,200	
Thallium		0.47	
Zinc	81 <b>(76.6)</b>	26,000	RAO for Zinc is 76.6
<b>PCBs</b>			
Polychlorinated Biphenyls	0.03	0.000064	
<b>PESTICIDES/HERBICIDES</b>			
alpha-BHC		0.0049	
beta-BHC		0.017	
gamma-BHC		1.8	
Heptachlor	0.0036	0.000079	
Aldrin		0.000050	
Heptachlor epoxide	0.0036	0.000039	
Endosulfan I	0.0087	89	
Dieldrin	0.0019	0.000054	
4,4'-DDE		0.00022	
Endrin	0.0023	0.060	
Endosulfan II	0.0087	89	
4,4'-DDD		0.00031	
Endosulfan sulfate		89	
4,4'-DDT	0.001	0.00022	
Endrin aldehyde		0.30	
Chlordane	0.004	0.00081	
Toxaphene	0.0002	0.00028	
<b>TOTAL PETROLEUM HYDROCARBONS</b>			
NWTPH/Diesel and Residual		500*	*MTCA Method A
NWTPH/Gasoline		800*	*MTCA Method A
<b>VOLATILE ORGANIC COMPOUNDS</b>			
1,1,1-Trichloroethane		200*	*MTCA Method A
1,1,2,2-Tetrachloroethane		4.0	
1,1,2-Trichloroethane		16	
1,1-Dichloroethene		7,100	
1,2,4-Trichlorobenzene		70	
1,2-Dichlorobenzene		1,300	
1,2-Dichloroethane		37	
1,2-Dichloropropane		15	
1,3-Dichlorobenzene		960	
1,4-Dichlorobenzene		190	
Benzene		51 <b>(71)</b>	RAO for Benzene of 71
Bromoform		140	
Carbon Tetrachloride		1.6	

<b>Table 5-3. Initial Analytical Screening Standards (µg/L)</b>			
<b>Analyte</b>	<b>Ambient Water Criteria</b>		<b>Comments</b>
	<b>Saltwater Criterion Continuous Concentration (CCC)</b>	<b>Human Health for Consumption of Organisms</b>	
<b>VOLATILE ORGANIC COMPOUNDS (Continued)</b>			
Chlorobenzene		1,600	
Chloroform		470	
Dichlorobromomethane		17	
Ethylbenzene		2,100	
Hexachlorobutadiene		18	
Methylene Chloride		590	
Tetrachloroethene (PCE)		3.3 <b>(8.8)</b>	ROA for PCE of 8.8
Toluene		15,000	
Trans-1,2-Dichloroethene		10,000	
Trichloroethene (TCE)		30	
Vinyl Chloride		150	
<b>SEMI-VOLATILE ORGANIC COMPOUNDS</b>			
1,2-Dichlorobenzene		1,300	
1,3-Dichlorobenzene		960	
1,4-Dichlorobenzene		190	
2,4,6-Trichlorophenol		2.4	
2,4-Dichlorophenol		290	
2,4-Dimethylphenol		850	
2,4-Dinitrophenol		5,300	
2,4-Dinitrotoluene		3.4	
2-Chloronaphthalene		1,600	
2-Chlorophenol		150	
Hexachlorocyclopentadiene		1,100	
4,6-Dinitro-2-methylphenol		280	
Acenaphthene		990	
Anthracene		40,000	
Benzo(a)anthracene		0.018	
Benzo(a)pyrene		0.018	
Benzo(b)fluoranthene		0.018	
Benzo(k)fluoranthene		0.018	
bis(2-Chloroethyl) ether		0.53	
bis(2-Chloroisopropyl) ether		65,000	
bis(2-Ethylhexyl) phthalate		2.2	
Butylbenzylphthalate		1,900	
Chrysene		0.018	
Di-n-butylphthalate		4,500	
Dibenzo(a,h)anthracene		0.018	
Diethylphthalate		44,000	
Dimethylphthalate		1,100,000	
Fluoranthene		140	
Fluorene		5,300	
Hexachlorobenzene		0.00029	
Hexachlorobutadiene		18	
Hexachloroethane		3.3	
Indeno(1,2,3-cd)pyrene		0.018	
Isophorone		960	
N-Nitrosodi-n-propylamine		0.51	
N-Nitrosodimethylamine		3.0	
N-Nitrosodiphenylamine		6.0	
Nitrobenzene		690	
Pentachlorophenol	7.9	3.0	

<b>Table 5-3. Initial Analytical Screening Standards (µg/L)</b>			
<b>Analyte</b>	<b>Ambient Water Criteria</b>		<b>Comments</b>
	<b>Saltwater Criterion Continuous Concentration (CCC)</b>	<b>Human Health for Consumption of Organisms</b>	
<b>SEMI-VOLATILE ORGANIC COMPOUNDS (Continued)</b>			
Phenol		1,700,000	
Pyrene		4,000	

### 5.2.3 Frequency and Schedule of the Ongoing Monitoring Program

As discussed previously, shoreline groundwater monitoring well network sampling events will be scheduled initially on a semi-annual basis. The constituents of concern and the overall schedule for sampling will be adjusted throughout the completion of the monitoring program depending on ongoing results of the effort and coordination and negotiations with EPA. Table 5-4 below briefly outlines the proposed sampling, analysis, and reporting schedules to be used for monitoring of the shoreline network and newly installed background reference wells.

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**ATTACHMENT B**

**GRAPHIC TIDAL CYCLE PREDICTIONS**  
**WEEK OF 01 MARCH 2010**

Moonset: 7:16 am  
Moonrise: 9:16 pm

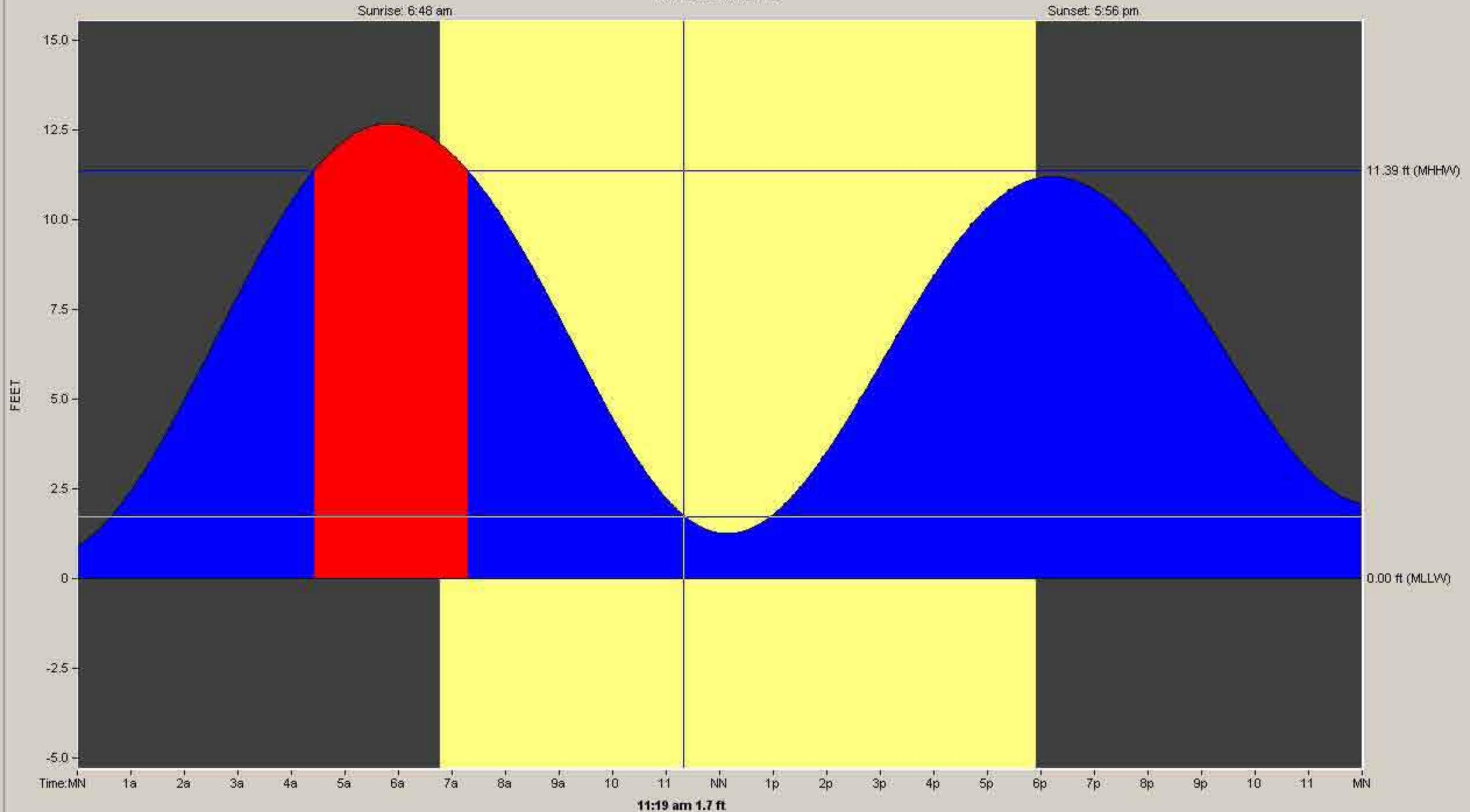
Daily Highs & Lows:  
High 5:46 am 12.7 ft  
Low 12:05 pm 1.3 ft  
High 6:09 pm 11.2 ft

Average Tides:  
Mean Range 7.67 ft  
MHHW 11.39 ft  
Mean Tide 6.68 ft



3rd Qtr. moon in 5 days

**Tuesday, March 2, 2010**  
Pacific Standard Time



Moonset: 7:41 am  
Moonrise: 10:36 pm



3rd Qtr moon in 4 days

Daily Highs & Lows:

Low 12:08 am 2.1 ft  
High 8:19 am 12.6 ft  
Low 12:50 pm 0.4 ft  
High 7:09 pm 10.9 ft

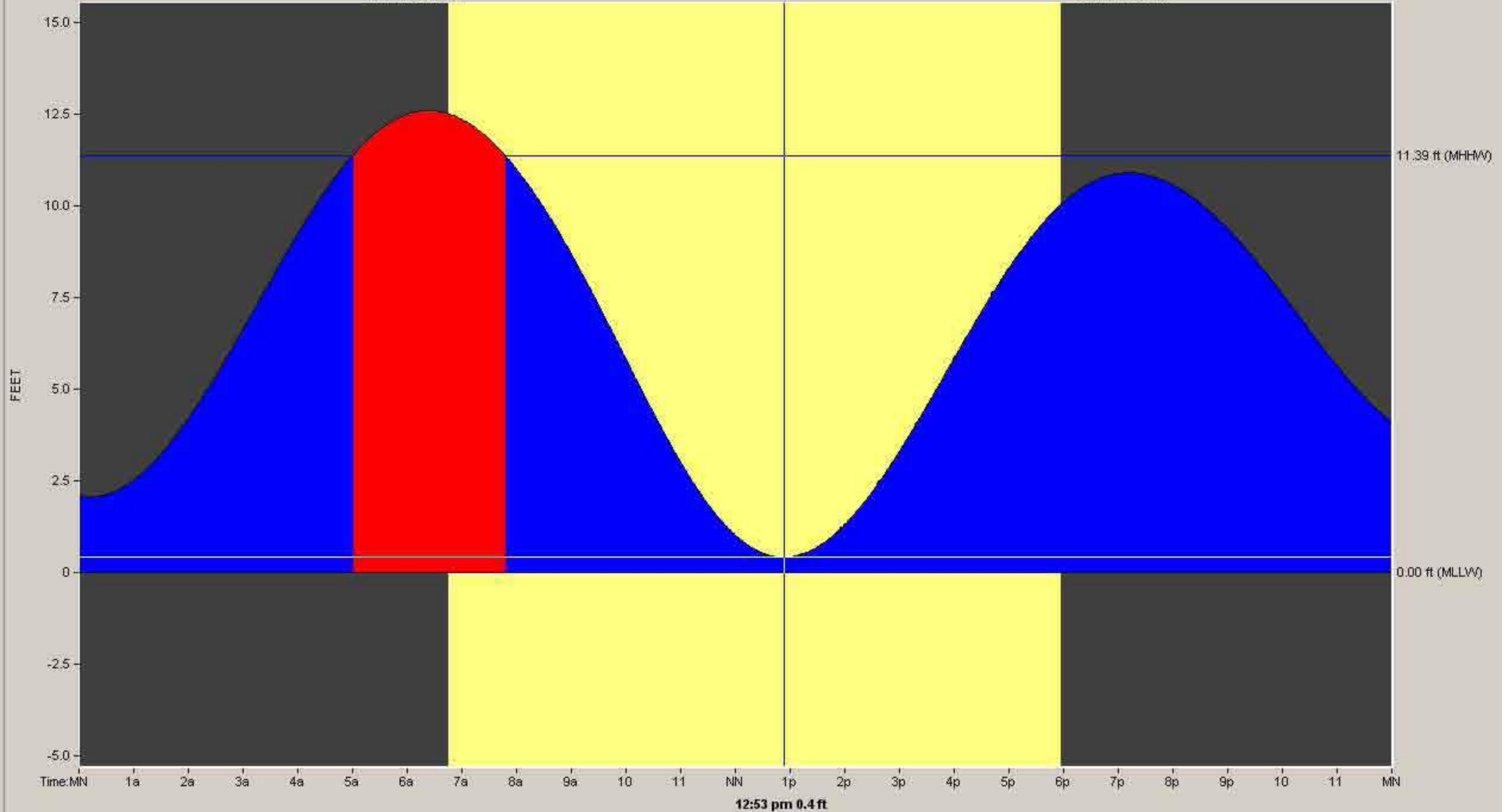
Average Tides:

Mean Range 7.67 ft  
MHHW 11.39 ft  
Mean Tide 6.68 ft

Wednesday, March 3, 2010  
Pacific Standard Time

Sunrise: 6:46 am

Sunset: 5:58 pm



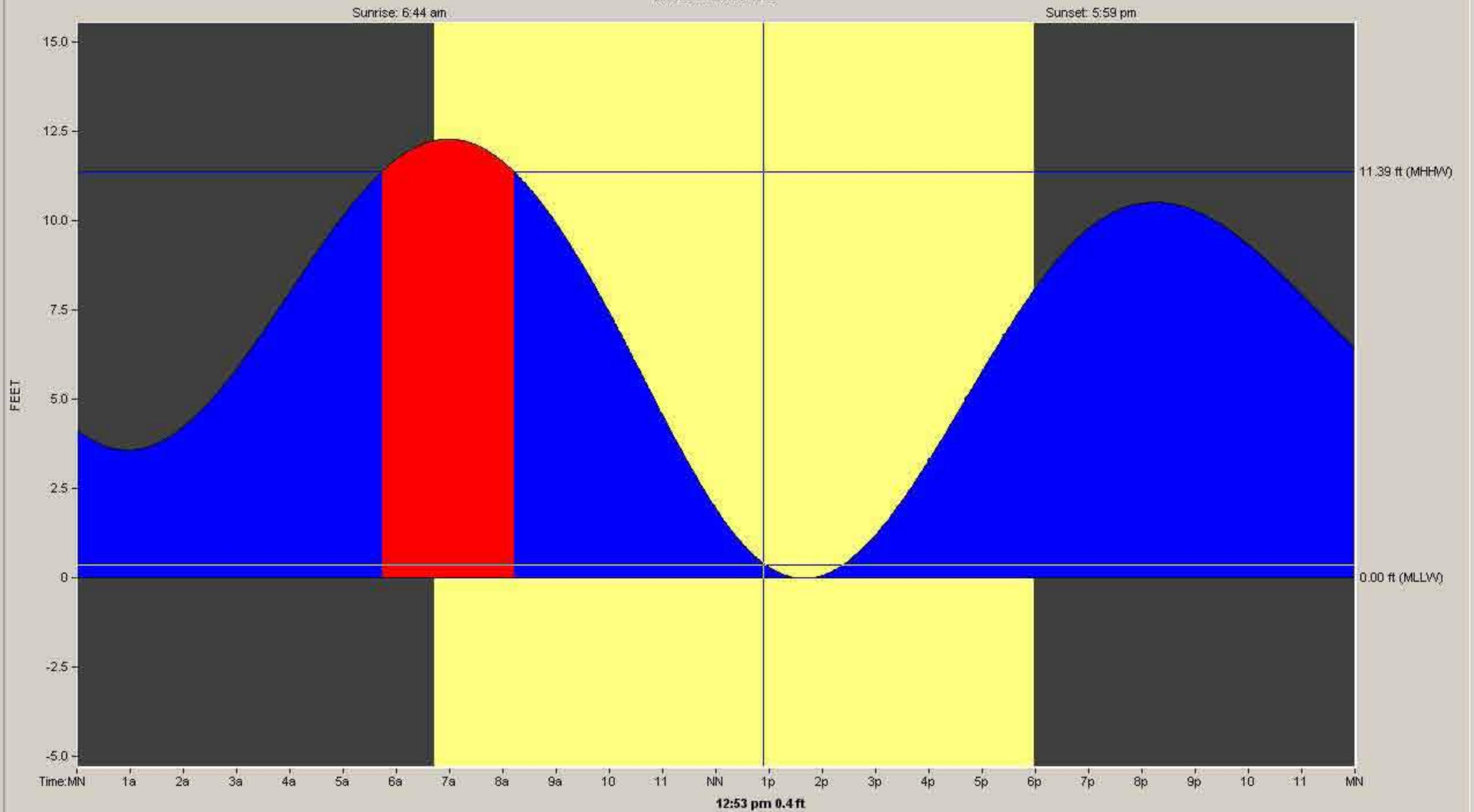
Moonset: 8:08 am  
Moonrise: 11:52 pm



Daily Highs & Lows:  
Low 12:54 am 3.6 ft  
High 8:55 am 12.3 ft  
Low 1:36 pm 0.0 ft  
High 8:11 pm 10.5 ft

Average Tides:  
Mean Range 7.67 ft  
MHHW 11.39 ft  
Mean Tide 6.68 ft

**Thursday, March 4, 2010**  
Pacific Standard Time



Moonset: 8:41 am  
Moonrise: 1:03 am (Tomorrow)



Daily Highs & Lows:  
Low 1:42 am 5.1 ft  
High 7:33 am 11.7 ft  
Low 2:24 pm 0.0 ft  
High 9:21 pm 10.1 ft

Average Tides:  
Mean Range 7.67 ft  
MHHW 11.39 ft  
Mean Tide 6.68 ft

**Friday, March 5, 2010**  
Pacific Standard Time

