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Memo

To:	John Roberts, TMAC Resources	**Client:**	TMAC Resources
From:	Ashley Landriault Lisa Barazzuol Kelly Sexsmith	**Project No:**	1CT022.001
Cc:		**Date:**	March 13, 2015
Subject:	Boston Ephemeral Stream Monitoring 2014		

1 Introduction

At the Boston site, ore and waste rock were generated as part of a 1996/1997 BHP Billiton underground exploration program. The ore was placed in a number of stockpiles on the camp pad whereas waste rock was used to construct a camp pad, roads and an airstrip at Boston. The ore/waste rock and associated runoff are managed as part of Water License 2BB-BOS1217 (Nunavut Water Board (NWB) 2012), and the Water and Ore/Waste Rock Management Plan for the Boston Site (SRK 2009).

As recommended in the management plan (SRK 2009), ephemeral streams downgradient of the waste rock pile have been monitored during spring freshet since 2009 to monitor the attenuation capacity of the tundra and to provide an indication of whether contaminants from the ore and waste rock piles are reaching the shoreline of Aimaokatalok Lake. This memo presents the results of the 2014 monitoring program.

The results indicate that over the period from 2009 to 2014, concentrations of potential contaminants of concern have been low and that trends over time are stable in the ephemeral streams downstream of the Boston ore stockpiles and camp. The results suggest that the tundra continues to effectively attenuate these constituents, ensuring that there is no impact along the shoreline of Aimaokatalok Lake.

2 Methods

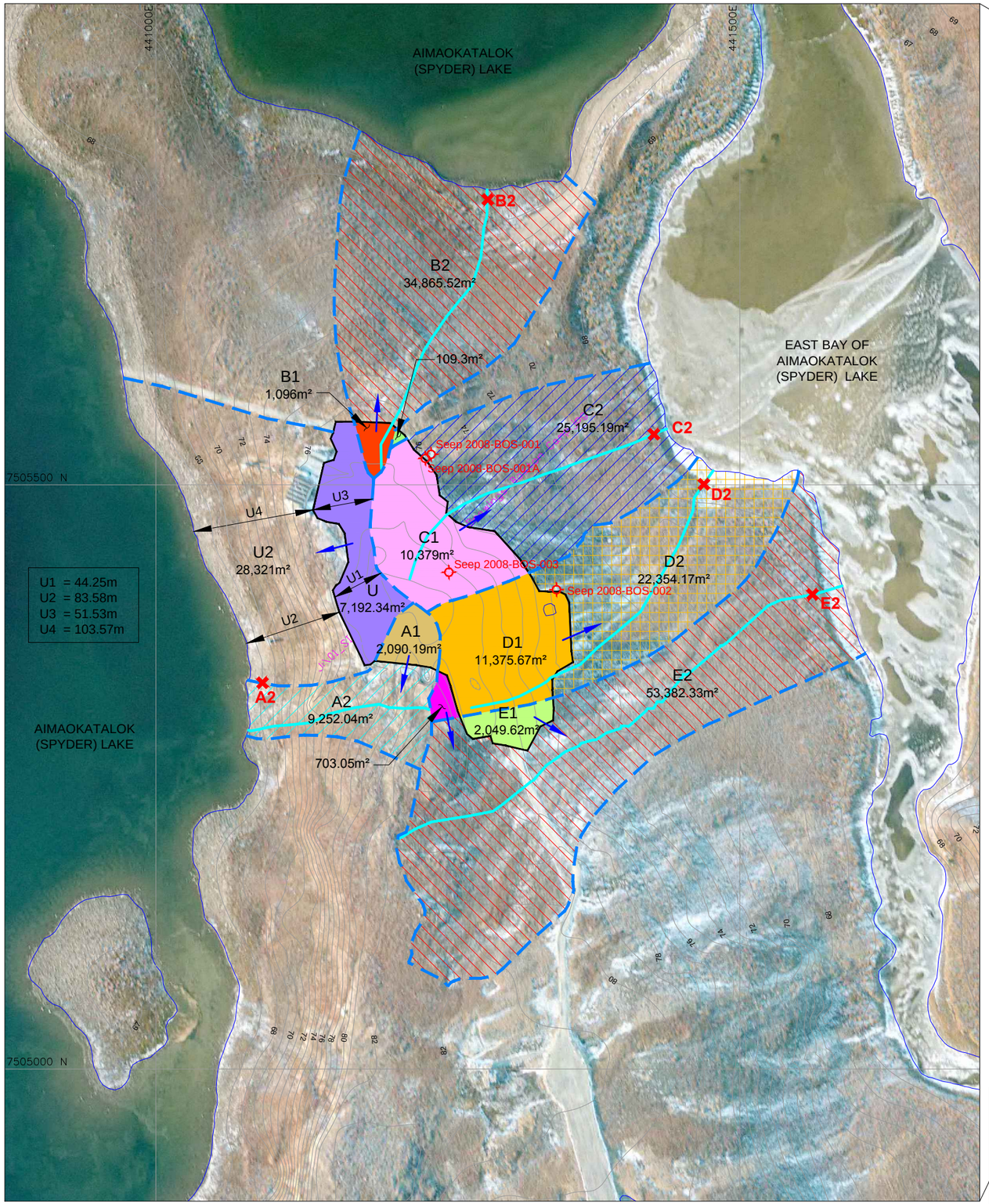
2.1 Sample Collection

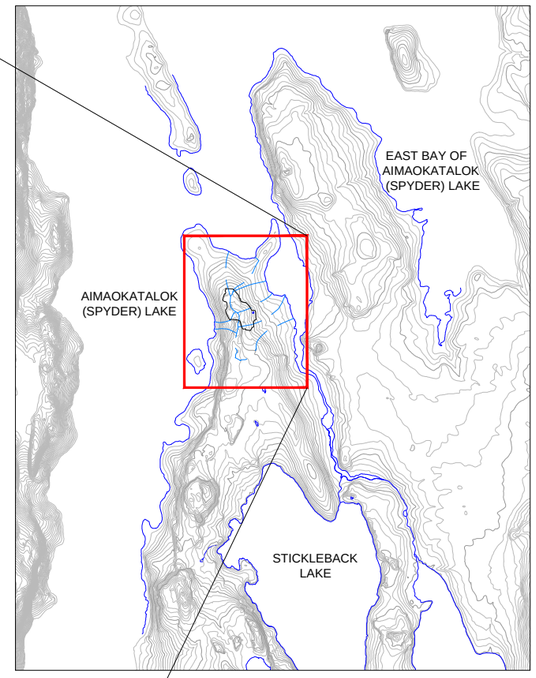
Five ephemeral streams have been identified in previous surveys at the site, as shown in Figure 1. Each of these sites were surveyed for flow in June 2014. Flow was observed at and samples collected from stations A2, C2 and E2. Field measurements included pH, conductivity, ORP and temperature. The water quality samples were submitted for laboratory testing at ALS

Environmental in Burnaby, BC for pH, hardness, conductivity, total dissolved solids, alkalinity and species, anions, nutrients and dissolved metals (field filtered).

2.2 Quality Assurance and Quality Control

One field duplicate, one field blank and one travel blank were collected as part of SRK's QA/QC program. QA/QC review of all data was conducted by SRK and deemed acceptable. For the field blank, parameters were below detection limits indicating appropriate field filtration and sampling methods were employed. Similarly, parameters were below the detection limits for the travel blank. The field duplicate results were within ±10% relative percent difference (RPD) for all parameters except zinc. The levels of zinc were within the range of analytical uncertainty (within 10 times the detection limit of <0.001) and therefore could not be assessed.





SITE LOCATION

Legend

	Contours (1m)		Catchment Boundary
	Ephemeral streams		Flow direction
	Camp pad perimeter		Seepage Sampling Station
A2, B2, C2, D2, E2, U2	Dilution Zone (Hatch)	25,195.19m²	Catchment Areas

1:4000

0 50 100 150 200 Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CH008.022
FILE NAME: Boston Catchments.dwg

HOPE BAY MINING LTD.

Hope Bay Project

Boston Waste Rock Management Plan

Boston Camp Drainage Areas

DATE: March 2011
APPROVED:
FIGURE: 1

J:\01_SITES\Hope Bay\MCAD\2010 Drawings\Boston Catchments.dwg

3 Results

3.1 Field Observations

Field parameters are presented in Table 1. Field conductivity in stream A2 and E2 has decreased since 2013, conductivity of stream C2 increased in 2014. All values remain within one order of magnitude from the 2013 reported values. Field pH values were neutral to alkaline, consistent with the 2013 results.

Table 1: 2014 Field Observations

Sample ID	Field pH	Field Conductivity µS/cm	ORP mV	Temperature ^{0}C	Flow L/s	Comments
A2	7.9	352	286	16	Shallow sheet flow	Same approximate location as 2010-2013
C2	7.2	804	310	13	2	Same approximate location as 2010-2013
E2	7.4	504	316	9.4	very slight	Same approximate location as 2010-2013

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3.2 Laboratory Results

A summary of water quality results for 2014 is provided in Table 2. Full results of the 2014 water quality data are presented in Attachment A. A summary of the water quality data is as follows:

- Levels of sulphate in stream A2 in 2014 were 50% lower as compared to 2013. Concentrations of chloride and nitrate decreased by one order of magnitude from 2013 to 2014. Ammonia concentrations were lower in 2014 and were below detection limits.
- Sulphate in stream C2 was 25% lower in 2014 than 2013. Chloride and nitrate also decreased by one order of magnitude. Levels of ammonia decreased by 15% in 2014 as compared to 2013.
- Concentrations of sulphate and chloride in stream E2 decreased by one order of magnitude from 2013 to 2014. Ammonia concentrations remained stable from 2013 to 2014 and nitrate levels were less than detectable.
- Alkalinity remained stable from 2013 to 2014 for all samples.
- Concentrations of dissolved metals remained consistent between 2013 and 2014 with any small fluctuations within the same order of magnitude.

Table 2: Summary of Water Quality Results for Stations A2, C2 and E2, 2009-2014

Sample ID	Year	Anions and Nutrients					Dissolved Metals								
		Alkalinity, Total	Ammonia	Chloride	Nitrate	Sulphate	Aluminum	Arsenic	Cadmium	Copper	Iron	Lead	Nickel	Selenium	Zinc
		mg/L as $CaCO_3$	mg/L as N	mg/L	mg/L as N	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
A2	2012	44	0.0077	179	0.31	43	0.0045	0.018	<0.00001	0.0009	<0.01	0.0001	0.004	<0.0001	0.0029
	2013	33	0.013	131	0.052	57	0.020	0.021	<0.00001	0.0014	0.052	0.000068	0.0047	<0.0001	0.0018
	2014	38	<0.005	58	<0.005	27	0.0027	0.036	<0.00001	0.0013	<0.01	<0.00005	0.018	<0.0001	0.0022
C2	2009	42	<0.02	166	<0.005	48	0.014	<0.0015	<0.000017	0.0017	<0.03	<0.00005	0.003	<0.001	0.0014
	2010	44	0.083	197	3	223	0.011	0.0021	<0.00005	0.002	0.071	0.0002	0.0084	0.0018	0.0071
	2011	29	0.05	42	1.2	85	0.02	0.006	<0.00005	0.001	<0.03	<0.00005	0.0049	<0.001	<0.003
	2012	44	0.01	105	1.4	220	0.012	0.0017	0.000012	0.0016	0.033	<0.00005	0.006	0.00038	0.0021
	2013	64	0.0093	143	1.5	304	0.014	0.0026	0.00002	0.002	0.035	<0.00005	0.0076	0.0004	0.0028
	2014	61	0.0078	66	0.46	227	0.016	0.0038	0.000013	0.0025	0.012	<0.00005	0.0097	0.00033	0.0025
E2	2009	43	0.022	210	2.2	137	0.016	<0.002	0.000063	0.003	<0.03	0.000068	0.006	<0.001	0.0055
	2010	59	<0.005	137	<0.005	50	0.0076	0.0016	<0.00005	0.001	<0.03	<0.00005	0.0029	<0.001	<0.001
	2011	36	0.023	48	0.02	34	0.01	0.002	<0.00005	0.001	<0.03	<0.00005	0.0018	<0.001	<0.003
	2012	43	<0.005	59	<0.005	50	0.013	0.00099	<0.00001	0.0018	0.014	<0.00005	0.003	<0.0001	0.0015
	2013	47	0.0055	124	<0.005	108	0.0075	0.0013	<0.00001	0.0012	0.01	<0.00005	0.0028	<0.0001	0.0011
	2014	46	0.0051	62	<0.005	83	0.0089	0.0013	<0.00001	0.0013	0.012	<0.00005	0.0026	<0.0001	0.0037

Source: P:\01_SITES\Hope.Bay\1CH008.023_Geochem_Monitoring\C_Seep_Surveys\June2014 Seepage Survey\Working File\[Hope Bay_WorkingFile_2014_AML_Rev00.xlsx]

4 Discussion

Seepage chemistry predictions were made as part of the Water and Ore/Waste Rock Management Plan (SRK 2009). The report calculated predicted and maximum predicted concentrations of sulphate, chloride, nitrate, arsenic, copper, iron, nickel and selenium that were expected to discharge from the ore stockpile. Table 3 presents these model predictions compared to the 2014 reported concentrations of these parameters. A comparison of the 2014 data with the model predictions is summarized as follows:

- Sulphate was below the predicted concentrations for stream A2, and exceeded the maximum predictions for C2 and E2 (but remained within the same order of magnitude).
- Chloride concentrations in stream A2 and C2 were below the predicted value whereas concentrations in stream E2 exceeded the predicted concentration, but remained below the maximum predicted.
- Nitrate concentrations for all samples were below predicted levels.
- Concentrations of arsenic, copper, iron, nickel and selenium in all of the samples were below predicted values.
- Overall, concentrations of sulphate, chloride, nitrate, arsenic, copper, iron, nickel and selenium have oscillated from year to year, but do not show definitive increasing trends over time.

It should be noted that there are old drill sites upstream of all sampling locations that may also influence results in this area, particularly for chloride.

Table 3: Comparison of 2014 Water Quality Results to Model Predictions (SRK 2009)

Parameters	Units	Predicted Value			Max Predicted Value			2014		
		A2	C2	E2	A2	C2	E2	A2	C2	E2
Chloride	mg/L	95	144	27	357	559	79	58	66	62
Nitrate (as N)	mg/L	3.4	5.4	0.68	9.2	15	2.0	<0.005	0.46	<0.005
Sulfate	mg/L	70	111	15	121	190	25	27	227	83
Arsenic	mg/L	0.030	0.05	0.01	0.06	0.10	0.01	0.036	0.0038	0.0013
Copper	mg/L	0.0026	0.0026	0.0017	0.0033	0.0040	0.0020	0.0013	0.0025	0.0013
Iron	mg/L	0.41	0.43	0.37	0.89	1.2	0.46	<0.01	0.012	0.012
Nickel	mg/L	0.095	0.15	0.02	0.32	0.51	0.07	0.018	0.0097	0.0026
Selenium	mg/L	0.0015	0.0021	0.0007	0.0035	0.0053	0.0011	<0.0001	0.00033	<0.0001

Source: P:\01_SITES\Hope.Bay\1CH008.023_Geochem_Monitoring\C_Seep_Surveys\June2014 Seepage Survey\Working File\[Hope Bay_WorkingFile_2014_AML_Rev00.xlsx]

5 Conclusions and Recommendations

Monitoring of the ephemeral streams A2, B2, C2, D2 and E2 (Figure 1) was initiated in 2009. In 2014, flow was observed and samples collected from A2, C2 and E2.

The analysis of the water quality trends for ephemeral streams A2, C2 and E2 indicated that concentrations of potential contaminants of concern (nitrate, aluminum, arsenic, cadmium, copper, iron, nickel and selenium) are stable in the ephemeral streams downstream of the Boston ore stockpiles and camp area. This suggests that the tundra continues to effectively attenuate contaminants of concern and breakthrough of the effectiveness of the attenuation process has not occurred. Sulphate and chloride levels have fluctuated but have not exhibited increasing trends. These parameters are not attenuated by the tundra and the stable levels validate the 2009 water and load balance. Overall, the water quality from the ephemeral streams is stable. Ongoing monitoring is recommended for the routine ephemeral stream sampling sites.

6 References

Nunavut Water Board, 2012. Water Licence No: 2BB-BOS1217. August 7, 2012.

SRK Consulting (Canada) Inc., 2009. Water and Ore/Waste Rock Management Plan for the Boston Site Hope Bay Project, Nunavut. Report 1CH008.022 for Hope Bay Mining Ltd. July 2009.

Attachment A: Field Observations and Water Quality Results

Attachment A: Field Observations and Water Quality Results

Station	Date	Time	Sampled (y/n)	Description	Field pH	Field EC	ORP	Temperature	Flow	Conductivity	Hardness (as CaCO3)	pH	Total Suspended Solids	Total Dissolved Solids	Acidity (as CaCO3)	Alkalinity, Total (as CaCO3)	Ammonia, Total (as N)	Bromide (Br)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Nitrite (as N)
						uS/cm	mV	'C	L/s	uS/cm	mg/L	pH	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
14-EPH-A2	6/15/2014	15:32	Y	widely dispersed sheet flow, >5 L/s. pool sampled from is 0.5 L/s. Yellow tint to water, bird feces, mossy growth and mud in pools. Squishy and muddy tundra, wide path down to lake.	7.93	352	286	16.3	--	308	120	7.82	<3	221	1.1	38.4	<0.005	<0.05	57.6	<0.02	<0.005	<0.001
14-EPH-B2	#N/A	#N/A	N	dry. No evidence of flow. Over grown.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14-EPH-C2	6/15/2014	14:17	Y	flow originates at ore stockpile snow melt. Traels across tundra, distrivuted in pols, dispersed flow. Pool is ~15cm deep at sample point (Not this deep the whole stream). Water yellow tinted, ~2L/s.	7.23	804	310	13.3	2	728	324	7.54	<3	502	2.8	60.5	0.0078	0.093	66	0.032	0.459	0.0022
14-EPH-D2	#N/A	#N/A	N	Several stagnant pools, not connected. Can see flow path from last year, or maybe from warm period last week. More snow to be melted on ore stockpile, perhaps will be flowing next week.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14-EPH-E2	6/15/2014	14:44	Y	slow dispersed flow through tundra, flow originates at ore stockpile from snow melt, travels across tundra to lake, dusty, OM in water, grassy bottom. DUPLICATE collected here.	7.38	504	316	9.4	--	443	195	7.56	<3	318	2.3	46.3	0.0051	0.092	61.7	0.044	<0.005	<0.001

Station	Phosphorus (P)-Total	Sulfate (SO4)	Aluminum (Al)-Dissolved	Antimony (Sb)-Dissolved	Arsenic (As)-Dissolved	Barium (Ba)-Dissolved	Beryllium (Be)-Dissolved	Bismuth (Bi)-Dissolved	Boron (B)-Dissolved	Cadmium (Cd)-Dissolved	Calcium (Ca)-Dissolved	Chromium (Cr)-Dissolved	Cobalt (Co)-Dissolved	Copper (Cu)-Dissolved	Iron (Fe)-Dissolved	Lead (Pb)-Dissolved	Lithium (Li)-Dissolved	Magnesium (Mg)-Dissolved	Manganese (Mn)-Dissolved
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
14-EPH-A2	0.0076	27.1	0.0027	0.00156	0.0364	0.00567	<0.0001	<0.0005	0.046	<0.00001	35	<0.0001	0.00022	0.00126	<0.01	<0.00005	0.00626	7.8	0.000516
14-EPH-B2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14-EPH-C2	0.0209	227	0.016	0.00127	0.00384	0.0337	<0.0001	<0.0005	0.068	0.000013	72.7	0.00013	0.00039	0.00245	0.012	<0.00005	0.00196	34.6	0.00648
14-EPH-D2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14-EPH-E2	0.0122	83.1	0.0089	0.00094	0.00133	0.023	<0.0001	<0.0005	0.038	<0.00001	53.8	0.00017	0.00018	0.0013	0.012	<0.00005	0.00619	14.7	0.000458

Station	Mercury (Hg)-Dissolved	Molybdenum (Mo)-Dissolved	Nickel (Ni)-Dissolved	Phosphorus (P)-Dissolved	Potassium (K)-Dissolved	Selenium (Se)-Dissolved	Silicon (Si)-Dissolved	Silver (Ag)-Dissolved	Sodium (Na)-Dissolved	Strontium (Sr)-Dissolved	Sulfur (S)-Dissolved	Thallium (Tl)-Dissolved	Tin (Sn)-Dissolved	Titanium (Ti)-Dissolved	Uranium (U)-Dissolved	Vanadium (V)-Dissolved	Zinc (Zn)-Dissolved
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
14-EPH-A2	<0.00001	0.000247	0.0181	<0.05	1.89	<0.0001	0.418	<0.00001	13.1	0.254	8.87	<0.00001	<0.0001	<0.01	0.000015	<0.001	0.0022
14-EPH-B2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14-EPH-C2	<0.00001	0.0005	0.00969	<0.05	6.85	0.00033	1.45	0.000041	32	0.272	77.3	<0.00001	<0.0001	<0.01	0.000028	<0.001	0.0025
14-EPH-D2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14-EPH-E2	<0.00001	0.000588	0.0026	<0.05	2.11	<0.0001	1.02	<0.00001	13.4	0.358	27.6	<0.00001	<0.0001	<0.01	0.000011	<0.001	0.0037