

## **5.0 WATER RESOURCES**

### **5.1 Surface Water**

#### **5.1.1 Flooding**

Flooding is usually a brief rise in water level in a stream to a peak from which the water level recedes at a slower rate.

The main Moho River channel is monitored near the bridge crossing at Jordan Village (8917). This monitoring station excludes the headwater flows from the Blue Creek Branch and Roaring River, however it captures the inflow from the Guatemalan portion of the watershed. The mean annual stage and flow at 8917 is 1.91 metres and 37.2 cumecs respectively. The maximum and minimum stage and flow at 8917 is 7.07 metres (2005) and 128 cumecs (2005), and 0.78 metres (2004) and 12.56 cumecs (2004) respectively. Average floods at 8917 on the Moho exceed 6.35 metres and 10% of all floods exceeded 6.99 metres and 90% exceeded 5.19 metres.

Flow data for the Temash is virtually nonexistent. A point measurement during a major flood event on 17 July 2003 indicates that Sunday Wood Creek contributed 1.07% of the Temash total flow of 170.31 cumecs.

#### **5.1.2 Surface Water Quality**

Surface water quality information is virtually nonexistent, except for SATIIM'S baseline information. Attempts to secure a copy of this baseline water quality information were unsuccessful. No historical water quality information was secured for the Temash and Sarstoon watersheds, however, two 1986 water quality analyses results for Blue Creek and Jordan on the Moho were provided by the Hydrology Unit.

Tunich-Nah conducted a preliminary water quality investigation on 23 May 2007. The analyses results indicate that for the Blue Creek and Jordan sites there have been little

changes in the pH since 1986. Hardness has decreased since 1986; however there has been little change in the sulphates concentration.

The results of Tunich-Nah water quality investigations reveal that there is no anomalous behavior in the Moho, Temash and Sarstoon watersheds. As is normally the case, conductivity, salinity, total dissolved solids and hardness increased downstream. Phosphates levels decreased while sulphates increased downstream. The increasing hardness is attributed to the calcareous nature of the terrains of the watersheds under consideration. High phosphate levels near the sampling sites can be attributed to the use of laundry detergents in the communities. Considering that there are no municipal or industrial discharges within these watersheds the increasing downstream sulphates is attributed to the accumulation of organic substances consequent of the breakdown of the abundant vegetative cover in these watersheds (see **Appendix B**).

## **5.2 Groundwater**

The project area lies within the Toledo Groundwater Province. This Province includes the central and southern Toledo district. The main aquifers are cretaceous Campur, Coban and Sepur formations overlain by the Eocene and Quaternary alluvium Toledo Formation<sup>1</sup>. Formations are generally tertiary limestone overlain with tertiary inferior sedimentary deposits except in the extreme southeastern region where it is overlain with quaternary alluvial deposits.

The Toledo formation is composed of shales, sandy shales, mudstones and calcareous sandstones that gradually become coarse grained with local conglomerate beds containing large carbonate boulders towards the Guatemalan border (ibid).

Near the Temash River the Campur formation is exposed and has been intensely karstified (ibid). Near the Sarstoon River the Campur grades into the Sepur forming a complex sequence of alternating sandstones and limestones (ibid).

**Table 5.1:** 1986 water analysis results.

Location	pH	Alkalinity	Chlorides	Total Hardness	Calcium	Magnesium	Fe	SO <sub>4</sub>
JORDAN 1986	7.7	155 mg/L	35 mg/L	350 mg/L	00 mg/L	50 mg/L	<.5mg/L	124 mg/L
Blue Creek 1986	7.6	150 mg/L	35 mg/L	330 mg/L	2.7 mg/L	60 mg/L	<.5mg/L	120 mg/L

**Table 5.2:** Water quality results for the main river systems.

**BELIZE BREWING COMPANY LIMITED  
WATER and WASTEWATER LABORATORY**

Sample ID: US Capitol

DATE: 28 May, 2007

**INORGANIC CHEMISTRY**

PHYSICAL	UNIT	METHOD	RESULTS							
			1	2	8	3	4	7	5	6
			Blue Creek	Jordan	Moho Mouth	Corazon	Temash	Temash Mouth	Graham Creek	Sarstoon Mouth
CONDUCTIVITY	µs/cm	CONDUCTIVITY (probe)	400	333	31,400	539	365	38,900	1,757	21,100
pH***	unit	pH/ISE meter (probe)	7.76	7.86	7.7	7.76	7.89	7.75	7.41	7.84
SALINITY	ppt	Mercuric Nitrate titration	0.08	0.09	19.3	0.09	0.07	24.6	1	12.8
SUSPENDED SOLIDS (SS)***	ppm	Colorimeter	8	2	3	4	28	20	17	9
TOTAL DISSOLVED SOLIDS (TDS)***	ppm	CONDUCTIVITY (probe)	199.9	166.6	15,710	270	182.3	19,430	879	10,540
<b>NON-METALS</b>	<b>UNIT</b>	<b>METHOD</b>	<b>RESULTS</b>							
PHOSPHATE, TOTAL (PO4)***	ppm	PhosVer / Orthophosphate/ UV VIS Spectro	2.1	1.8	1	1.6	1.6	1.1	1.7	0.7
<b>INORGANIC COMPOUNDS</b>	<b>UNIT</b>	<b>METHOD</b>	<b>RESULTS</b>							
TOTAL HARDNESS (as CaCO ) ***	ppm	EDTA Titration/ UV VIS Spectro	226	173	3,470	270	202	4,340	289	2,360
TOTAL NITRATE (NO )***	ppm	Cadmium Reduction/ UV VIS Spectro	1.8	0.8	1.9	1.5	1.7	1.9	0.9	1.4
SULPHATE (SO4)	ppm	Sulfa Ver 4/ UV VIS Spectro	10	11	1,000	65	5	1,100	118	400

N.B

- 1 = Blue Creek
- 2 = Jordan (Moho River)
- 3 = Corazon (Go to Hellgate Creek)
- 4 = Temash River
- 5 = Graham Creek Mouth/Sarstoon River
- 6 = Sarstoon River Mouth
- 7 = Temash River Mouth
- 8 = Moho River Mouth

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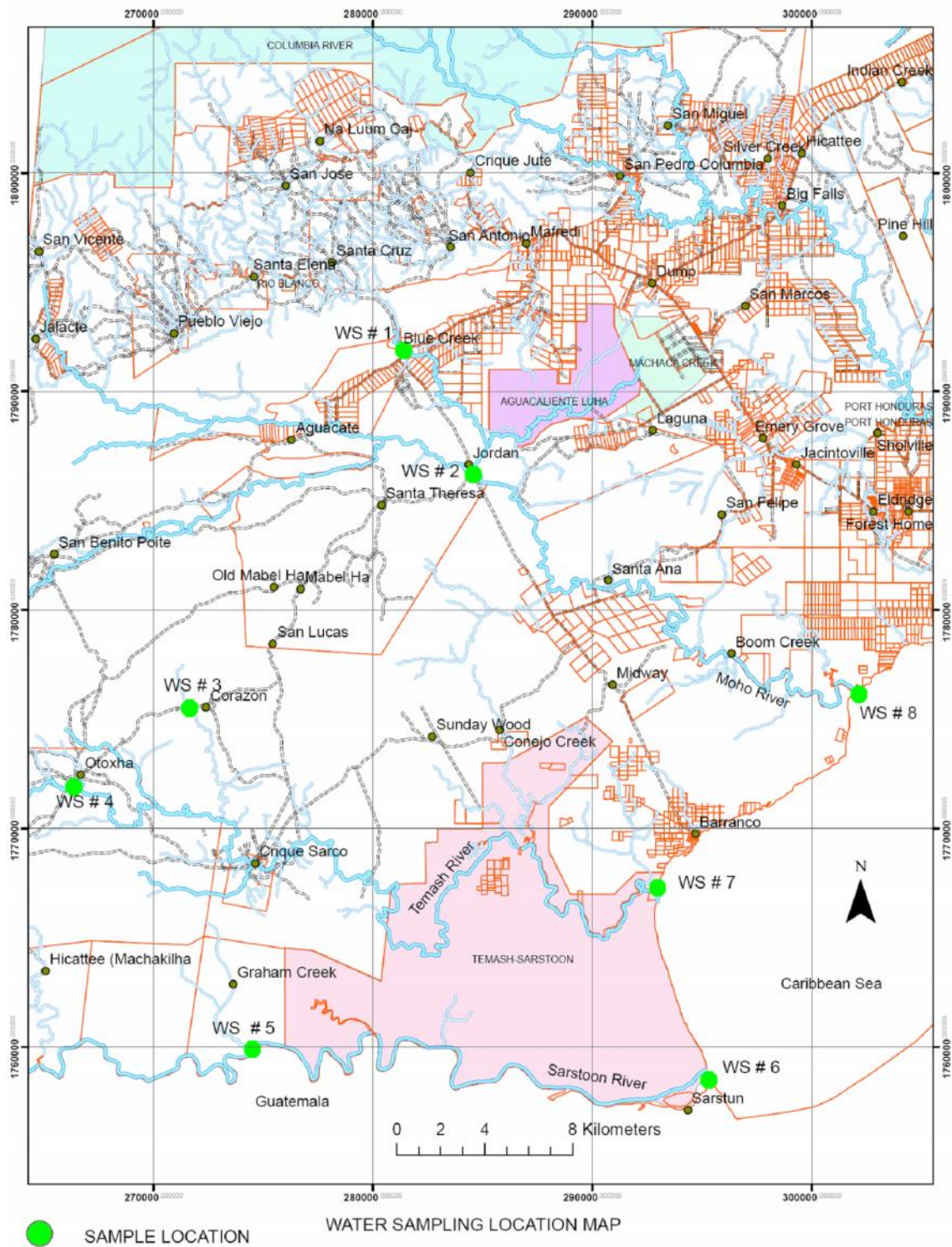
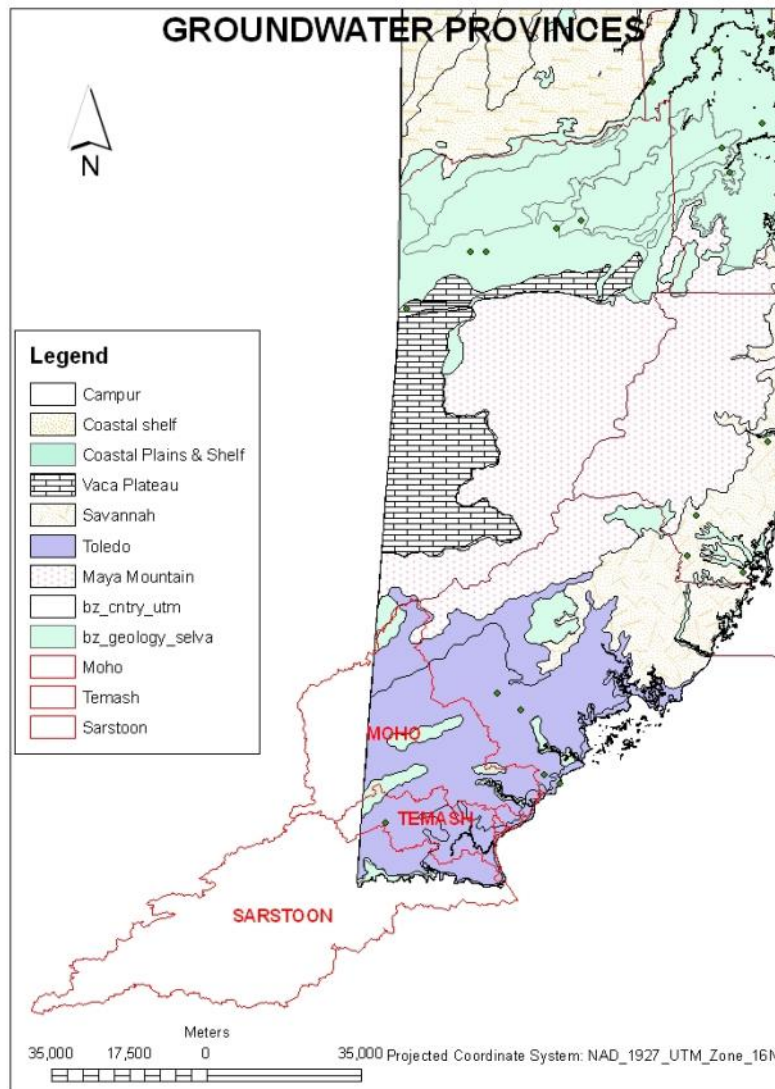


Figure 5.1: Water sampling locations.

In this Province, well depths are less than 60 metres and depths to water table are between 6 and 26 metres. Static water levels were reported between 2 and 8 metres below the surface. Maximum well yield along the coast is 867L/min and inland is 67 L/min with average hardness of 258mg/L.



**Figure 5.2:** Groundwater Provinces Impacted by the Project

Groundwater quality analyses by Trumbach<sup>ii</sup> indicate that the water alkalinity (309mg/L CaCo<sub>3</sub>, pH 6.9) and hardness (>300mg/L CaCo<sub>3</sub>) are associated with the carbonate formation that is prevalent in the project area. The groundwater in the Moho River watershed exceeded the 400mg/L standard for alkalinity. Trumbach (ibid) also determined the groundwater quality in Temash watershed to be of average alkalinity and hardness, however in the communities near the Belize Guatemalan border of the Temash river watershed, hardness exceeded the 500mg/L standard.

No groundwater quality was identified for the Sarstoon watershed however groundwater quality is expected to be similar to those of the Moho and Temash watersheds.

Seismic testing is a standard procedure in the exploration of water and oil, consequently no depletion of groundwater supplies or the lowering of groundwater levels is expected from the construction of the cut lines, access roads, or the modification of the existing roads is expected.

## **5.3 Potential Impact on Water Resources**

### **5.3.1 Surface Waters**

Subcatchments were delineated using ArcGIS 9 ArcHydro 9 component and runoff computed using the Rational Method. Due to the lack of meteorological data for the project area, watersheds' rainfalls were determined using the inverse distance weighting feature in the Geo-Statistical component of ArcGIS 9. It should be noted that only 1 meteorological and 2 hydrological stations are within the project area and are within the least affected watershed, Moho river watershed, and on the extreme north northwestern periphery of the project area. No analyses and computations were conducted for the portions of watershed outside of Belize. Vegetation data from Lee and Stednick<sup>iii</sup> was used to determine the runoff coefficients. Runoff coefficients were taken from US Army Corps of Engineers Engineer Manual 1110-2-1417<sup>iv</sup>. Composite subcatchments' and watersheds' runoff coefficients were calculated using the weighted average method. Watersheds runoffs were simulated using the Rational Method  $Q = ciA$  where Q is the peak runoff, A is the area of the contributing watershed and i is the average monthly rainfall intensity. The Rational Method is used to estimate runoff when data is not readily available and when the rainfall intensity is equal or

less than the time of concentration for the subcatchments and watersheds. The times of concentrations were calculated using the Kirpich Method  $t_c = 0.0195 \left[ \frac{L}{S^{0.5}} \right]^{0.77}$  where  $t_c$  is the time of concentration, L is length of the longest flow path within the project area and S is the slope between the outlet and the hydraulically most remote point of the watershed under consideration. Time of concentrations for flow within the Belize portion of the project watersheds are listed in **Table 5.3**.

**Table 5.3:** Time of concentrations of flow.

Watershed Name	Time of concentration		L [m]	$(L/(S^{0.5}))^{0.77}$ [m]	$H_1 - H_2$ [m]	S = $(H_1 - H_2)/L$ [m/m]	$S^{0.5}$ [m/m]
	$t_c$ [min]	$t_c$ [Days]					
SARSTOON	726.313	0.504384	52421	37246.8079	193	0.004	0.061
TEMASH	1030.014	0.715288	77634	52821.243	253	0.003	0.057
MOHO	672.409	0.466951	79613	34482.5353	826	0.010	0.102

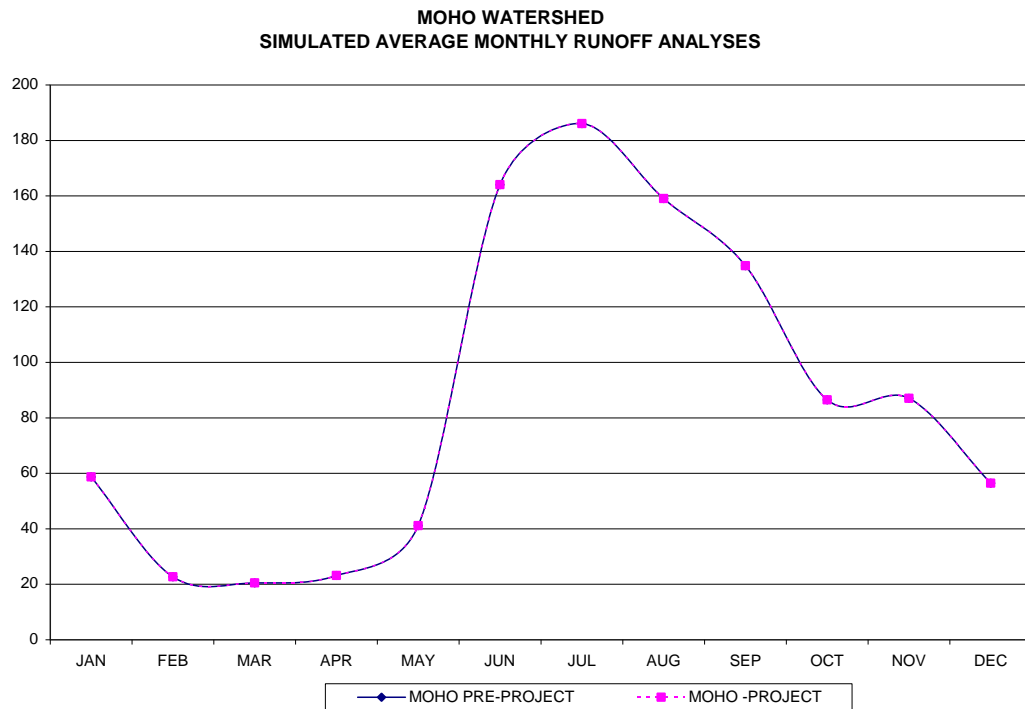
The combination of the Kirpich and Rational Methods result in short times of concentration and high peak runoffs. Considering the limited availability of data and the extension of data sets to estimate the rainfall for these unmonitored watersheds in the project area, this combination of methods is deemed reasonable.

### 5.3.2 Surface Runoff

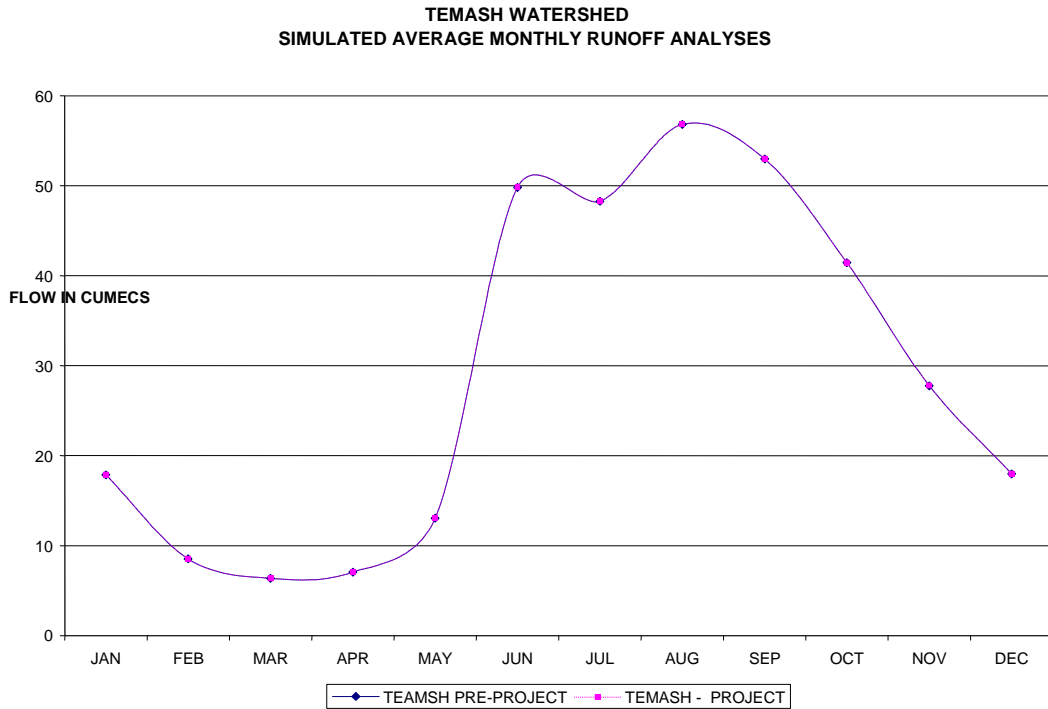
The cut lines newly constructed access roads and modification of the existing roads will reduce the vegetative cover, redirect surface runoff towards the main river channels (See Figs. 5.3, 5.4, 5.5). An increase in the surface runoff coefficient of the watersheds will result in an increase in runoff. In the Moho River watershed an average flood event is 58 cumecs while a 100-year flood event is 289 cumecs. Due to the lack of data no flood frequency analyses were done for the Temash and Sarstoon rivers. Flood events on the Temash and Sarstoon rivers are characteristics of those on the Moho.

Considering the fact that the project area lies entirely within Belize and that the impact of the cutlines and access roads will impact flows from within territorial Belize, surface runoff analyses did not include portions of the watersheds within Guatemala.

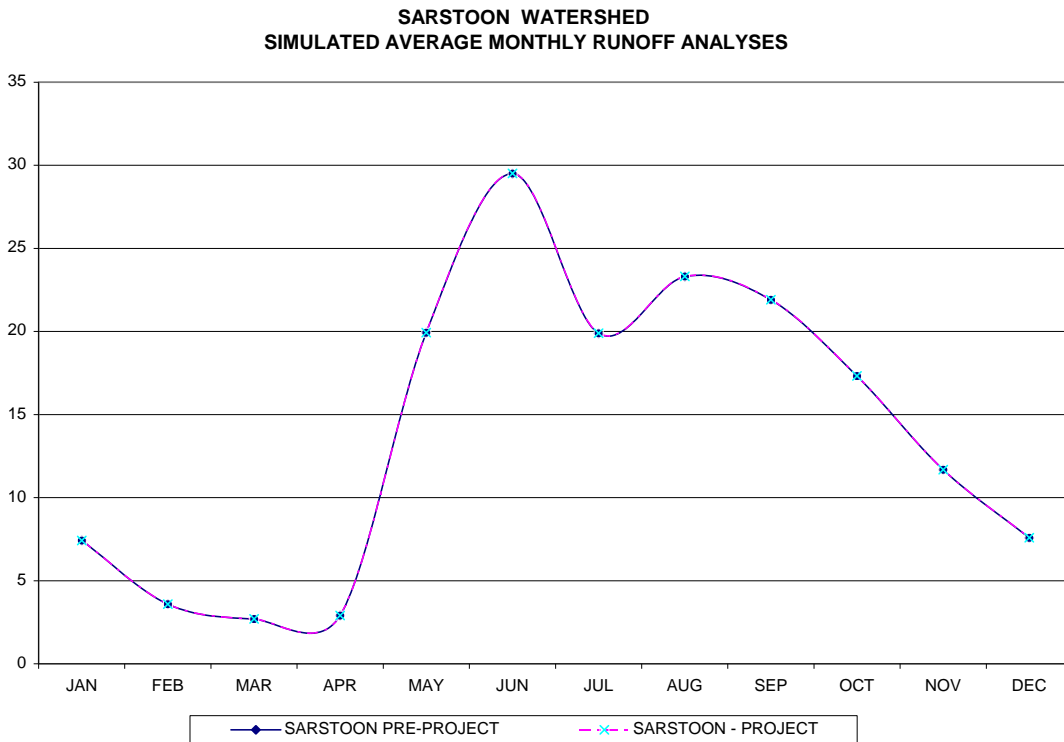
Six northeasterly and 10 southwesterly 5-foot wide cut lines and associated access roads will remove approximately 0.074 % of the Sarstoon, 0.0887% of the Temash and 0.0013 % of the Moho watersheds. The removed vegetative cover is primarily agricultural cover, lowland broadleaf wet and deciduous broadleaf forests. Under average monthly rainfall conditions the vegetative changes consequent of the cutlines and access roads will increase surface runoff in the Moho watershed by 0.0006 %, the Temash watershed by 0.0593% and 0.0468% in the Sarstoon watershed.



**Figure 5.3:** Moho River Watershed Runoff Analyses



**Figure 5.4 :** Temash River Watershed Runoff Analyses



**Figure 5.5:** Sarstoon River Watershed Runoff Analyses

No exploratory drilling will be conducted during phase I of the exploration therefore no drilling impacts on the surface and groundwater resources is expected.

#### **5.4 Proposed Mitigation Measures**

US Capital Energy will incorporate into contract specifications the requirement that the contractor(s) prepare and implement a construction Storm Water Pollution Prevention Plan. The plan will specify Best Management Practices to prevent construction pollutants from contacting stormwater as well as measures for erosion and sediment control, methods for construction waste handling and disposal, and post-construction erosion and sediment control strategies.

The contractor or US Capital Energy will obtain approval from the Department of the Environment and comply with all requirements of the effluent discharges regulations with respect to stormwater, including specific requirements for the Storm Water Pollution Prevention Plan. The plan will also include protection and spill prevention measures for the temporary onsite storage of diesel fuels used during the testing and a requirement for the use of environmentally friendly hydraulic fluids in heavy and drilling equipment. The protection measures will include requirements for secondary containment and berming of the diesel storage areas or any chemical storage areas to contain a potential release and to prevent any such release from reaching any surface water channels and groundwater reservoirs.

US Capital Energy will incorporate into contract specifications the requirements that:

- The construction staging areas will be graded to contain surface runoff so that contaminants such as oil, grease, and fuel products do not drain towards receiving waters.
- If heavy-duty construction equipment is stored overnight at the construction staging areas, drip pans will be placed beneath the machinery engine block and hydraulic systems to prevent any leakage from entering runoff or receiving waters.

**Table 5.4:** US Capital Energy watershed runoff coefficient analyses

VEGETATION TYPE	% WATERSHED			RUNOFF COEFFICIENT	WEIGHTED RUNOFF COEFFICIENT			ADJUSTED VEGETATION COVER			ADJUSTED WEIGHTED COEFFICIENT		
	sarstoon	temash	moho		sar	temash	moho	sar	temash	moho	sar	temash	moho
ARGICULTURE	9.3	20.6	31	0.8	7.44	16.48	24.8	9.287	20.57663	30.9997	7.42955	16.46130	24.79979
LOWLAND BROADLEAFWET FOREST	64.6	70.2	67.8	0.6	38.76	42.12	40.68	64.587	70.17663	67.7997	38.75216	42.10598	40.67984
EVERGREEN PEAT	0.03	0	0	0.4	0.012	0	0	0.017	0.0000	0.0000	0.00678	0.00000	0.00000
MANGROVE, LITTORAL Forest	13	1.4	0.4	0.3	3.9	0.42	0.12	12.987	1.3766297	0.3997	3.89608	0.41299	0.11992
Shrubland	1.9	3.8	0.2	0.35	0.665	1.33	0.07	1.887	3.7766297	0.1997	0.66043	1.32182	0.06991
Deciduous BROADLEAF	11.169	3.998	0.6	0.38	4.24422	1.51924	0.228	11.156	3.9746297	0.5997	4.23926	1.51036	0.22790
utlines/roads	0.001	0.002	0.002	0.8	0.0008	0.0016	0.0016	0.0794	0.1189	0.0033	0.06349	0.09508	0.00267
	100	100	100	Composite Coeff.	0.550220	0.6187084	0.6589960	100.000	100.000	100.002	0.5504775	0.61908	0.6590002

**Table 5.5:** US Capital Energy runoff analyses

MONTHS	RAINFALL			RUNOFF			PROJECT RUNOFF			% RUNOFF CHANGE		
	SAR	TEAMSH	MOHO	SARSTOON PRE-PROJECT	TEAMSH PRE-PROJECT	MOHO PRE-PROJECT	SARSTOON - PROJECT	TEAMSH - PROJECT	MOHO - PROJECT	SAR	TEAMSH	MOHO
JAN	0.1845	0.187	0.1935	7.3529	15.5509	58.7304	7.3563	15.5601	58.7307	0.00047	0.00059	0.00001
FEB	0.0805	0.0805	0.0675	3.5519	7.4116	22.6824	3.5536	7.4160	22.6826	0.00047	0.00059	0.00001
MAR	0.067	0.0665	0.0675	2.6702	5.5301	20.4873	2.6714	5.5334	20.4875	0.00047	0.00059	0.00001
APR	0.07	0.0715	0.074	2.8827	6.1441	23.2089	2.8841	6.1478	23.2090	0.00047	0.00059	0.00001
MAY	0.4955	0.1365	0.1355	19.7472	11.3513	41.1264	19.7565	11.3580	41.1267	0.00047	0.00059	0.00001
JUN	0.71	0.504	0.523	29.2389	43.3096	164.0302	29.2526	43.3353	164.0313	0.00047	0.00059	0.00001
JUL	0.4945	0.5045	0.613	19.7074	41.9541	186.0554	19.7166	41.9790	186.0565	0.00047	0.00059	0.00001
AUG	0.5795	0.594	0.524	23.0949	49.3969	159.0424	23.1057	49.4262	159.0434	0.00047	0.00059	0.00001
SEP	0.527	0.536	0.43	21.7027	46.0594	134.8623	21.7129	46.0867	134.8632	0.00047	0.00059	0.00001
OCT	0.4305	0.4335	0.285	17.1568	36.0497	86.5021	17.1648	36.0711	86.5026	0.00047	0.00059	0.00001
NOV	0.281	0.281	0.2775	11.5720	24.1468	87.0332	11.5774	24.1611	87.0338	0.00047	0.00059	0.00001
DEC	0.1885	0.188	0.186	7.5123	15.6340	56.4540	7.5158	15.6433	56.4544	0.00047	0.00059	0.00001
<b>TOTAL</b>	<b>4.1085</b>	<b>3.583</b>	<b>3.3765</b>	<b>166.1900</b>	<b>302.5386</b>	<b>1040.2150</b>	<b>166.2677</b>	<b>302.7180</b>	<b>1040.2216</b>	<b>0.0468%</b>	<b>0.0593%</b>	<b>0.0006%</b>

- Maintenance and fueling activities will be conducted in an area that meets the criteria set forth in the spill prevention plan (e.g., away from the creeks).

US Capital Energy will incorporate into contract specifications requirement that the construction of access roads, and modifications to existing roads include features to minimize erosion and sedimentation due to stormwater runoff.

Exposed slopes will be vegetated or otherwise mechanically protected from erosion. Construction of access roads, and modification of existing roads will consider long-term effects following the completion of the proposed project.

US Capital Energy will incorporate into contract specifications requirement that only roads and lines that are deemed integral to the seismic testing will be constructed. Modifications to existing roads will be minimized to reduce the likelihood of a higher composite basin runoff coefficient and the consequent increase in surface runoff.

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<sup>i</sup> United States Corps of Engineers, Mobile District, Bucalew, James O., Collinsworth, Sepsen R., Makley Bruce: Water Resources Assessment of Belize, March 1998

<sup>ii</sup> Trumbach MSPH ENHS, Denise , ANALYSIS OF GROUNDWATER QUALITY AND MONITORING PROGRAM OF THE PUBLIC HEALTH BUREAU OF BELIZE, PAHO/MASICA/PROAGUA, PAHO/BLZ/94.1HPE, OCTOBER 1994

<sup>iii</sup> Lee, Michael D., Stednick, John D., Environmental Water Quality Monitoring Program Final Report United States Agency for International Development, Project NARMAP, Cooperative Agreement 596-0150-A-00-9781-00, June 1995.

iv US Army Corps of Engineers