Dam Site Analysis El Chavon, Dominican Republic

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April 13, 2014

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Dr. E. James Nelson,

The report following this letter is a comprehensive analysis of the El Chavon-Javilla Dam site located in the Dominican Republic. This report provides a hydrologic overview by way of engineering calculations for the watershed upstream of the dam sight.

This report was a collaborative effort including students at INTEC and engineers at INDRHI in Santo Domingo, Dominican Republic. The report is not a professional design, rather an analysis given available data.

The resulting analysis from calculations will allow representatives at INDRHI to make concise informed decision for the El Chavon region. Recommendations were given based on hydrologic analysis and not necessarily economic considerations. Results provided will assist in the decision making process as hydrologic models, volume capacity curves, flood analysis for probable maximum storm, and flow duration curves were produced and provide in the following report.

Sincerely,

Hannah Polanco
Rebecca Pister
Preston Merrell

Executive Summary

The region of El Seibo is located in the northeastern part of the Dominican Republic. Within the last thirty years there has been an increase in population as well as an increase in …. Land. With such increase the demand for water is also higher. As it is currently, El Seibo suffers from many dry periods because of the great fluctuation of rain. The people of Seibo have learned to adapt and conserve water when needed. With the ever growing population however, this is becoming increasingly more difficult. As difficult as it is to adapt to times with little water it is just as difficult to adapt to the season of flooding. June to August is known as the time with the most rainfall, during these times it is common for the rivers to flood over and destroy property. If possible it would be helpful to properly store the water during the heavy rain season to help out during the months of drought. Because of this great fluctuation of rainfall Instituto Nacional de Recursos Hidraulicos (INDRHI) has proposed three different locations for a dam within the region of Seibo. The locations are: Presa Soco en el Cabao, Presa Javilla-Chavon, and Presa Senate. The location our group was chosen to analyze was Presa Javilla-Chavon.

Introduction

The Chavon River is located on the eastern part of Dominican Republic. The land surrounding the river is both rural and urban. There is a growing need for water in this region. To satisfy the ever increasing demand for water it has been proposed that a dam be placed on the river. The location of the dam would be at 18˚ 41' 36” N 68˚ 49' 58'' W. This is a very rural part of the country where a dam would present great benefits. A city close to the dam is El Seibo. El Seibo is a rural area with a growing population. Table 1 shows the population statistics for El Seibo from 1981 to 2010. The population has increased by 50% over the past 30 years (Table1).

Table 1 Population

Year	Population
2003	39,748
2005	43,487
2010	66,867
2012	87,159

As the population expands the demand for water increases. It is vital to have an adequate water supply for this region not only for the people there, but for the many other people who rely on the crops produced for this region. The breakout of crops in this region is shown in Table 2.

Table 2 Land Use

Crop	Land Use
Marsh	59
Rice	67
Scarce Vegetation	55
Intensively Cultivated	61
Sugar Cane	70
Pasture	39
Cacao	72
Coco	63
Coffee	65

As can be seen from the table this is a heavy agricultural area. Our group went with INDHRI and Intec to visit the site where the dam would be located. While we were there we saw many farms, most everyone there farms not only to feed their families, but many people in the city as well. Where there are farms there is a high demand for water and the demand is only increasing as the population grows. Where we visited there were many empty fields that could easily become farmland as the city expands. There is more to consider than just the demand for water however. In order to properly determine if this region would benefit from a dam we had to further analyze the precipitation of the area, the effects of a flood, and the power a dam would generate.

Problem Description

El Seibo is a thriving city that has continually increasing population over the past few decades. The city of Seibo and many cities surrounding the Chavon River are green with great soil. Because of this there is a great amount of farming that surrounds the

Chavon River. The climate also makes this area ideal for farming. In general, the climate is consistently warm throughout the year. The only thing that greatly fluctuates in this climate is the rainfall.

Table 3 shows the rainfall at location near by the proposed dam site. The months with the highest rainfall are May-August and November-December, while the others months have comparatively very little rainfall (Table3). This presents a problem as the demand for water is consistent, but the rainfall is not.

Table 3 Rainfall Near Chavon

Las precipitaciones de datos cerca del río Chavón											
ENE	**FEB**	**MAR**	**ABR**	**MAY**	**JUN**	**JUL**	**AGO**	**SEP**	**OCT**	**NOV**	**DIC**
75.7	74	71.7	74.6	80.8	71.5	73.3	73.8	75.4	77.5	73.6	76.5

The problem goes beyond a mere need for water during the drier months. Another major concern is the flooding during the rainy season. As we were out visiting the site in February (a dry month) we were shocked to see the water line during the rainy season. There was as much as an eight meter difference! The fluctuation is water levels is frustrating because one month you are worried if your crops will be destroyed from flooding and the next you are worried you won't have enough water to hydrate your crops. A simple solution is to properly store the water during the rainy season so it doesn't flood and will provide water during the dry season. There are many different factors to consider when building a dam however, those factors will be discussed throughout the portion of this paper.

Description of Site

The proposed dam site is located about 8 kilometers north and 21 kilometers east of the city of Higuey. The region is subtropical and experiences an average amount of rainfall compared to the rest of the country. The following picture shows the vegetation and topography of the area around the proposed dam sight:

Figure 1 Proposed Dam Site

The proposed dam sight and its watershed delineation are demonstrated in Figure 2. The watershed has an area of 220 km^2 which is factored into the analysis. The area will help determine how much precipitation will be considered to determine the feasibility of the dam. The topography will allow the construction of a dam up to 9 m high.

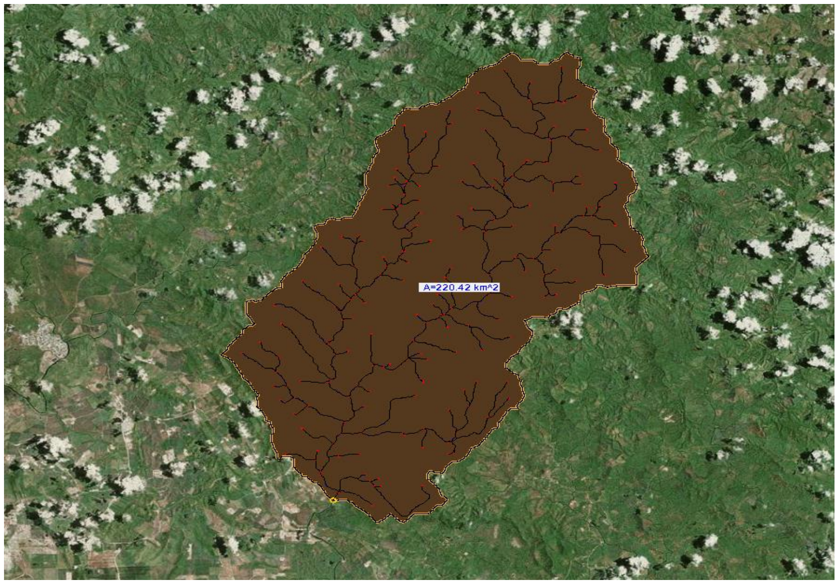


Figure 2 Watershed Delineation of Chavon Dam Sight

Hydrologic Analysis

Storm PMP

The Probable Maximum Precipitation (PMP) is the highest predicted amount of rainfall an area can receive within a 24-hour period. For Chavon, this would occur during an intense hurricane passing slowly over the region. The PMP is an important factor to consider for designing a dam because the spillway needs to be able to handle the flow under PMP conditions in order to prevent overtopping of the dam. Unfortunately, there is a high degree of uncertainty in the methods used to statistically calculate the PMP because of the lack of insufficient data and amount of variables involved. For this study a Probabilistic Frequency Analysis was performed using the Hershfield Method (also called the Frequency Factor Method). In this method the PMP depth (x) is calculated as the average annual daily maximum (x-bar) for several decades, plus the frequency factor (k) times the standard deviation of the annual deviation of the annual daily maximums (σ) as shown in the equation below.

$$x = xbar + (k\sigma)$$

The data used came from the INDHRI Naranjo de Chino weather station (located at 18° 41' 36" N 68° 49' 58'' W), which is the nearest station to the proposed sites that has sufficient rain data for the required analysis. Daily rain gauge depths for 24-hour periods over 26 years from 1973 to 2003 were obtained and sorted. The annual maximum daily value was then found for each year and all the annual maximums were averaged to obtain an average of (x) = 107 mm and a standard deviation of (σ) = 23.9 mm. The PMP was then calculated by adding Hershfield's recommended (k) = 15 standard deviations to the average found as shown in Figure 3 (the k-value is from Hershfield 1961). The analysis yielded an estimate of 467 mm for the PMP (467 = 107 + 15*23.9).

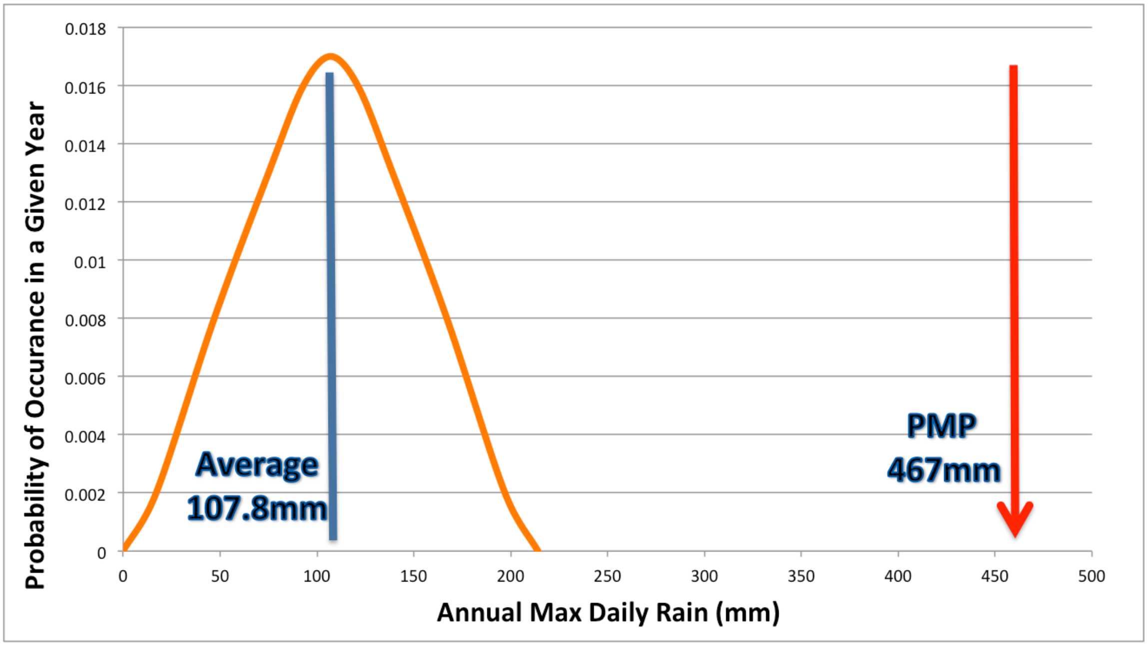


Figure 3 Distribution Graph of Average Rainfall and PMP

Storage Capacity Curve

Storage capacity curves can easily be created using WMS. This estimate is a good way to determine the amount of water storage possible within your watershed based on the height of the impending structure. For the Chavon Dam this was useful to help determine how much water could be stored and in turn see if constructing a dam will actually be feasible.

The storage capacity curve for the sight is shown in Figure 3. The curve was developed at the initial state of analysis and was based on a standard 23-meter dam at the outlet. This height was determined using the Digital Elevation Data (DEM) in WMS and creating a surface profile at the point of the dam. WMS also uses the DEM to calculate the Storage Capacity Curve for the watershed. This data may not always be accurate and it is important to go back and evaluate heights around the dam to see what height would be most logical.

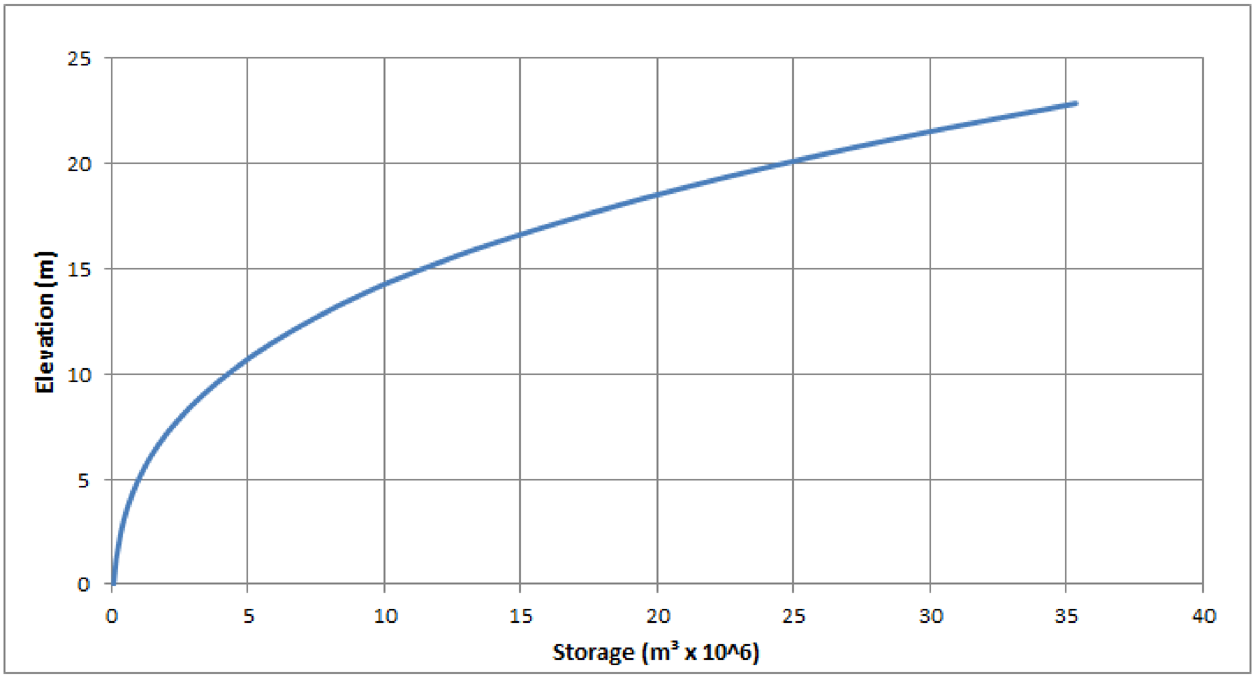


Figure 4 Storage Capacity Curve

Examining the slope of the curve can give a good idea of how the watershed can store water. A higher slope means more water. (Interpret the SCC)

Flow Duration Curve

The flow duration curve (FDC) is a cumulative frequency curve that shows the percent of the time during which specified discharges were equaled or exceeded in a given period. The FDC is another means of representing stream means of representing streamflow data showing the range of discharges for a given period. Typically flow duration curves are used to determine hydrologic and geologic characteristics of a particular drainage and the shape of the curve is used to compare different types of distribution parameters. Curve shapes can hint at basin storage, whether the stream is a direct result of surface runoff or supplemented by groundwater.

The flow duration curve was created using equations developed by Blake Buhler to estimate the flow at locations where data does not exist in the Dominican Republic. In order to use these equations the Curve Number needs to be calculated, and in our case WMS was used to obtain the value of 69 for our watershed. The area, average precipitation, and slope were also used which were 220.42 km^2, .467m and .028, respectively.

The Flow Duration Curve was used to obtain Q85 or the 85% exceedance flow rate for our proposed dam location. Q85 values represent the base flow that can be expected 85% of the time at the specified point. The following table shows the Q85 and the values used for calculation:

Table 4 Flow Duration

Área, Precipitación, Número de Curva, Pendiente		
A	220,420,000.00	m^2
P	0.107	m
CN	69	
S	0.028	

The FDC can be used to represent variability of flow for hydropower evaluation and to estimate surface water resources.

Hydrologic Models

Introduction

The model for the Chavon watershed was constructed using WMS, an HEC-HMS based program, analyzed using both HMS and a Gridded Surface Subsurface Hydrologic Analysis (GSSHA). The models were run based on an average precipitation and several return period precipitations applied to uniform 24 hour storms and a Type II 24 hour storm respectively. The average precipitation has around a 4-year return period or has a 25% probability of occurring in any given year. This return period was estimated using return period precipitation data from Table __, values of which are based on data from (the atlas).

Table 5 Chavon Return Period Precipitations

Return Period (yrs)	Depth (mm)
2.33	85
5	115
10	140
25	175
50	185
100	225

Model Calibration

The purpose of calibrating a model through HEC-HMS is to assure the results are more accurate. However, to calibrate a model corresponding precipitation and streamflow data are required. This would calibrate future models to adjust for factors that cannot be simulated by a computer such as local discrepancies or unique situations. Required data for the Chavon watershed is unavailable, so no calibration was performed, but models shown are still a good estimation of watershed performance.

Model Parameters

Using soil type and land use data from INDRHI, see Figure ___(get the soils map picture I put on the powerpoint but isn't there anymore), a curve number of 70.3 was calculated through WMS for the Chavon watershed. This value was used for the diffusive wave routing that the model used to gather water and bring it into the nearest point in the river to flow downstream to the dam site. The curve number was also used to calculate the lag time. For conservative results, the GSSHA model was set with no infiltration, modelling a scenario of average precipitation following a previous storm that has left the watershed's soil fully saturated. The HMS models were based on a Type II SCS storm with different return period scenarios, the precipitations taken from Table 4, also set to very little infiltration to be conservative.

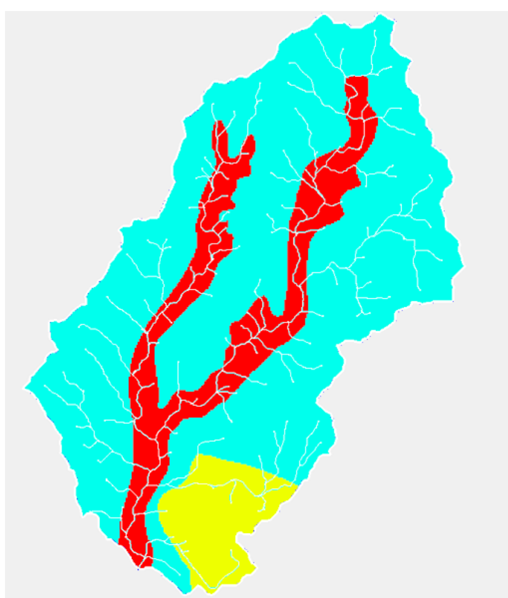


Figure 5 Soil Type Map

HMS Model

A model was run using HEC-HMS to demonstrate the differences in outflows between various return period precipitations, values which came from Table 4, and the Probable Maximum Precipitation, which was calculated to be 467 mm. The HMS models assumed very little infiltration for consistency between models and the results are shown in Figure 6.

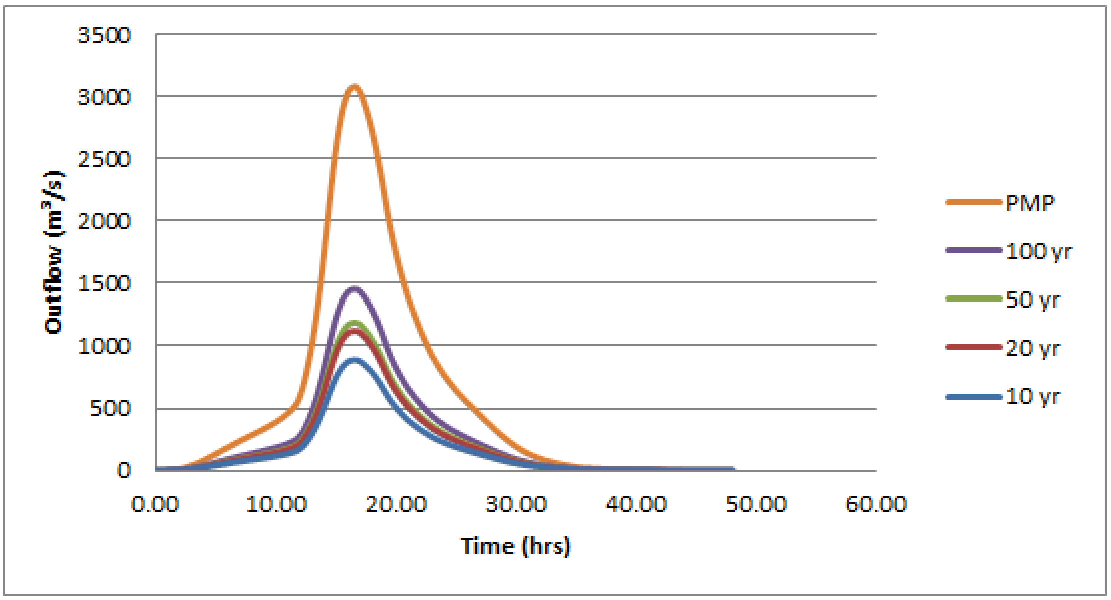


Figure 6 HMS Return Period Models

GSSHA Model

The GSSHA model based on average precipitation, 107 mm over the course of 24 hours, and allowing for another 24 hours for the water to runoff, produced results shown in Figure 7. Average precipitation produced a peak of approximately 240 cms, a value which plateaus due to the time it takes for the flow to gradually start decreasing from its peak. The HMS models have less detailed watershed delineation and result in higher, more conservative peaks.

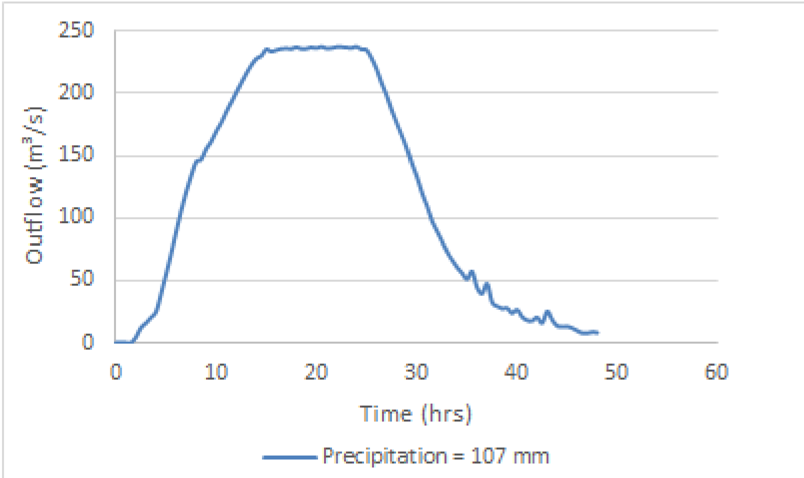


Figure 7 GSSHA Average Precipitation Model

GSSHA and HMS Model Summary

The volumes in corresponding GSSHA and HMS models, shown in Figure 8, are comparable, and the time of peaks are similar, but the accumulation occurs much quicker in the GSSHA model, creating a significantly lower peak flow since they have similar volumes. The average precipitation, equating to around a 4.3 year storm, is shown in Figure 8 beside storms with 10, 20, 50 and 100 year return periods, the corresponding cumulative precipitations shown in Table 4.

The volumes of the models run are shown in Table 5. According to these volumes and the storage capacity curve, Figure 4, the proposed reservoir cannot hold a 20 year storm or more when the ground is mostly saturated, which is a likely scenario given the amount of precipitation that gathers in the region. The storage capacity curve shows that the reservoir at the Chavon dam site can hold approximately 35.5 x 10^6 m^3. A conservatively run model with a 20 year storm requires 36.7 x 10^6 m^3 of storage.

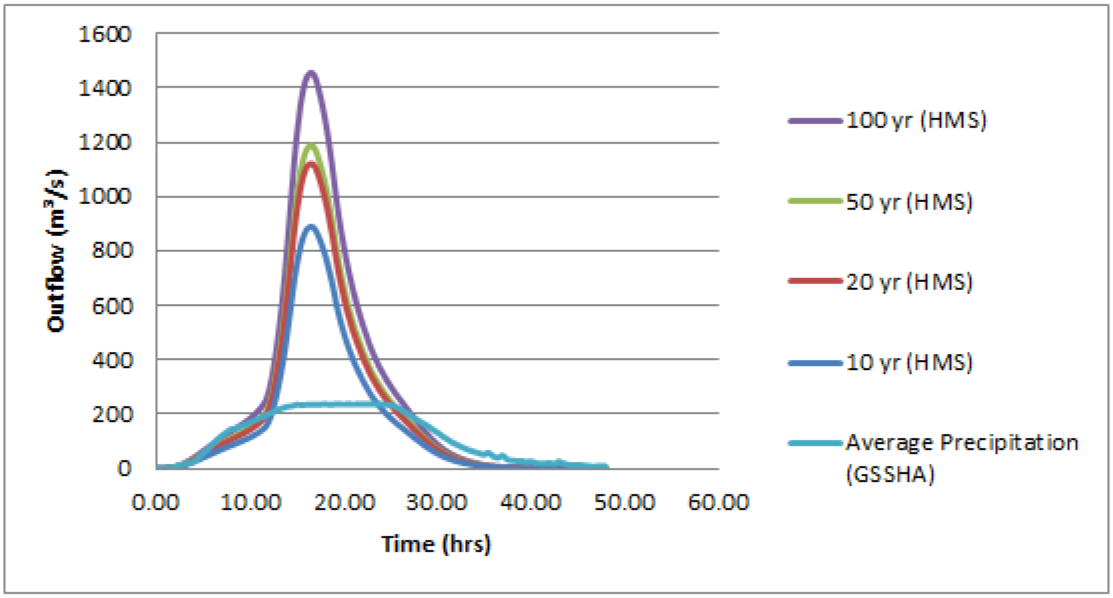


Figure 8 HMS and GSSHA Comparison

Table 6 Volumetric Analysis

	Volume (m^3 x 10^6)
Average	20.7
10 yr	29.1
20 yr	36.7
50 yr	38.9
100 yr	47.6
Max. Storage Capacity	35.5

Dam Break Analysis

A scenario was run through WMS, showing what damage could occur should the dam break if the reservoir were full. The pictures below in Figure _ demonstrate that the reach of any flooding would not be significant enough to cause severe damage below the Chavon watershed.

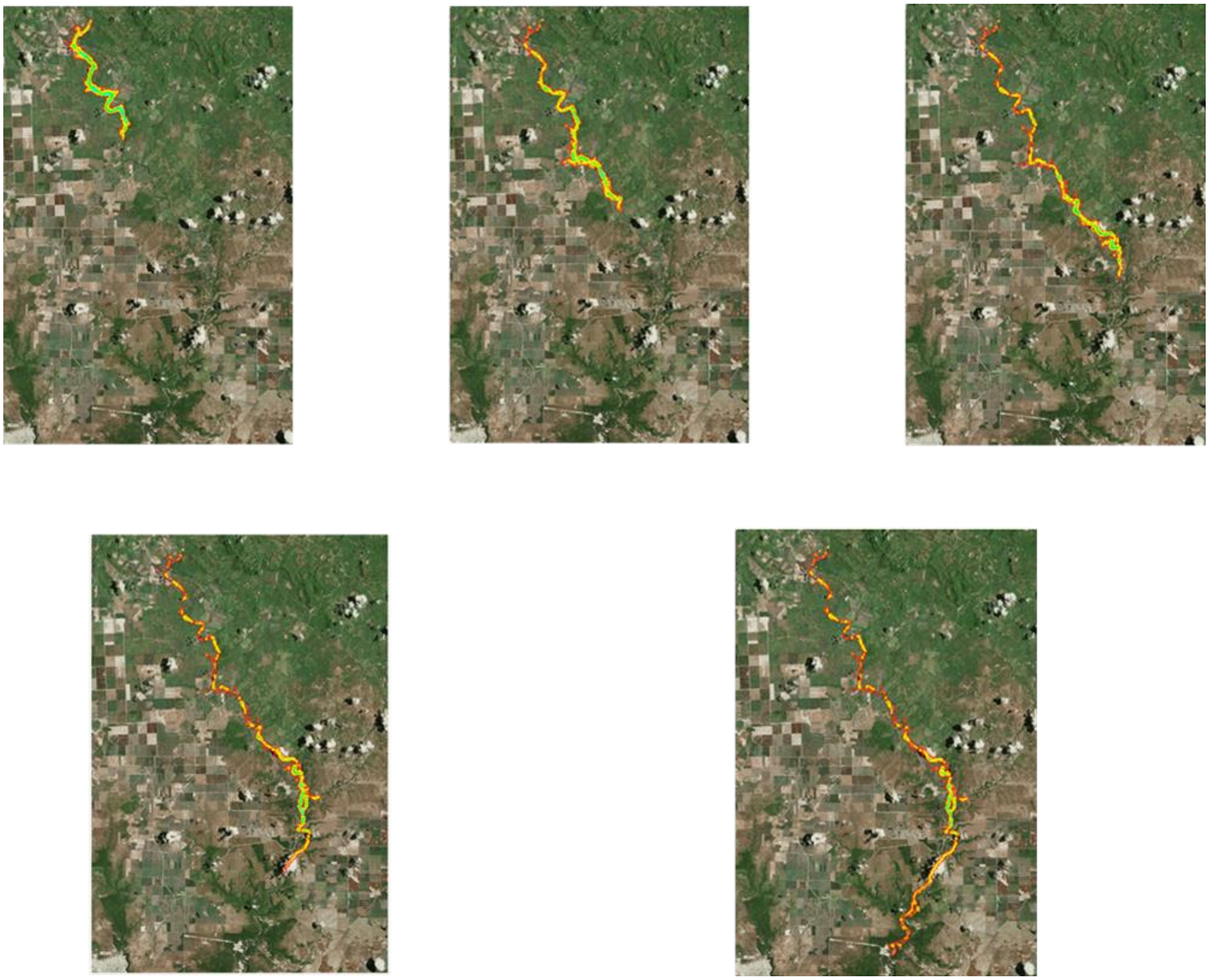


Figure 9 Dam Break Analysis

Environmental Impact

Before deciding if a dam would be helpful on the Chavon River, it first must be decided what impact a dam would have on the environment. The way that dams affect the environment the most is they can increase sediment buildup in one place and it can act as a blockade for fish.

Sediment is a very big concern for building a dam here. Figure one shows a picture of where the dam would be located. As seen in the Figure, the region by the dam is very tropical with lots of vegetation. Because of the many trees surrounding the site, evaporation is not a concern, but sedimentation is. This is an area where there is rich soil, Table 6 shows the soil breakup around the region.

Table 7 Vegetation

Vegetation	Land Use
Dense Conifer Forest	46
Cloudy Broadleaf Forest	36
Humid Broadleaf Forest	15
Open Conifer Forest	56
Semi-Humid Broadleaf Forest	26
Dry Forest	45
Dry Thicket	51
Broadleaf Thicket	50
Marsh	59

As seen in Table 6 the area surrounding the dam is an area where sedimentation would be a concern. The region by the dam is all forest, except for a small marsh that still has some vegetation. Most dams are designed to last at least fifty years. The accumulation of sediment can be quite severe. As this is a common problem, there are multiple solutions.

To fully understand the solution of sedimentation it is important to first understand why sedimentation is a problem. Sedimentation often collects near a dam and falls to the bottom of the reservoir. It can become a problem when it starts to change the characteristics of the reservoir because the properties of the reservoir change such as amount of flow that it can carry or the velocity of that flow. Sedimentation can also cause a problem by plugging up water systems. This was the tragedy of the last dam built in Dominican Republic, when they accidently opened the wrong gates to release water. There were gates underneath meant for sediment and another meant to release water. Because of this confusion there was flooding in the region.

The solutions to reduce the problem with sedimentation should be handled very carefully. If you were to reduce all the sediment it would make the reservoir what they call hungry-or want sediment. To get this sediment the river would cause erosion and scour the existing bed and structure. If there is too much sediment however, there are the problems previously discussed. To solve this problem we first suggest taking advantage of all the vegetation in the area. A great way to reduce sediment is to have stabilization by ensuring there is coverage if that is either paved or with vegetation. Along with stabilization we recommend a drainage system that can be used during the dry season to flush out any excess sediment. This will be an environmental friendly way to ensure that there isn't sediment buildup.

The other concern on the environment is what will happen to the fish. Often the fish need to swim upstream or need to go to a new location for food. A problem seen in many dams is that once all the fish get downstream from the dam they are unable to get back upstream and the population of fish downstream is too great, while there are very little to no fish upstream. The solution for this is quite simple and has been quite successful in other places. The simple solution is to install what is referred to as a latter. A latter works similar to the ladders that you are used to. We use a ladder to climb to higher elevations, well a ladder in a dam enables fish to get over the dam to the upstream side. Ladders are typically, off to the side of the dam and are designed so if needs be it can be a level surface where fish can feasibly get back upstream. This would be more of a safety regulation we would recommend, just in case, but we do not the dam being a burden to the fish population.

Conclusion

After analyzing many different factors of a dam, we have concluded that the benefits of a dam on the Chavon River in the proposed location would not outweigh the cost. The benefits it would bring to the community would be- control of flooding, steady water supply year round, and the potential for power. As discussed earlier the dam break is not that severe and would be a minor concern, the building on a dam would have an impact on the environment, but not enough to be a problem. However, the life of a dam should be at least 50 years, but since a dam of this height could not even sustain a 20 year storm, it would not last nearly long enough to be worth it. The dam could not be raised, either, due to geological restrictions. A dam in the Chavon region is not recommended.

References

Hershfield, DM (1961) *Estimating the probable maximum precipitation*. Proceedings American Society of Civil Engineers. J Hydraulics Division 87(HY5):99-106

"Sedimentation Problems with Dams." *International Rivers*. Web. 14 Apr. 2015. <http://www.internationalrivers.org/sedimentation-problems-with-dams>.

Appendix

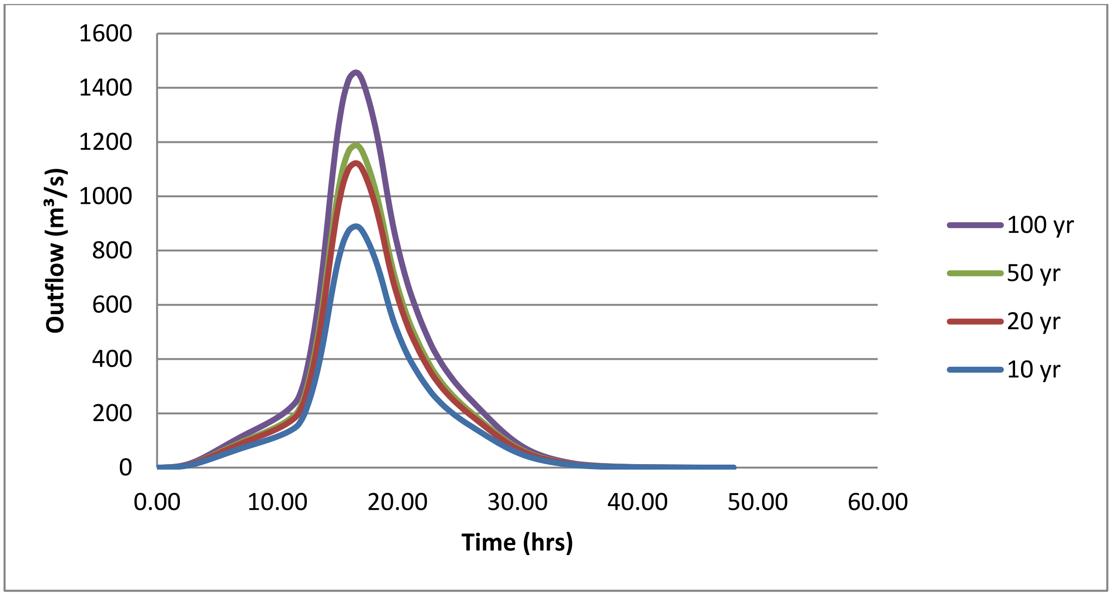
outflow (cfs)						
Time min	10 yr	20	50	100	PMP	ave hms
0.00	0	0	0	0	0	0
15.00	1.7	2.2	2.3	2.8	5.8	1.3
30.00	5.6	7.1	7.5	9.1	18.8	4.3
45.00	13.7	17.2	18.2	22.1	45.8	10.5
60.00	26.5	33.2	35.1	42.7	88.5	20.3
75.00	44.9	56.2	59.4	72.2	149.9	34.3
90.00	69.8	87.3	92.3	112.3	233	53.4
105.00	102.4	128	135.3	164.6	341.7	78.2
120.00	144.1	180.2	190.4	231.8	480.9	110.1
135.00	196.3	245.5	259.4	315.7	655	150
150.00	260.4	325.6	344	418.7	868.8	198.9
165.00	337.1	421.6	445.5	542.1	1125	257.6
180.00	425.5	532.1	562.2	684.3	1419.9	325.1
195.00	525.4	657	694.1	844.8	1753.1	401.4
210.00	634.2	793.1	838	1019.8	2116.3	484.6
225.00	751.8	940	993.2	1208.8	2508.4	574.4
240.00	875.5	1094.7	1156.7	1407.7	2921.3	668.9
255.00	1004.7	1256.4	1327.5	1615.6	3352.7	767.7
270.00	1137.5	1422.4	1502.9	1829.1	3795.9	869.2
285.00	1273.2	1592.1	1682.2	2047.3	4248.9	972.8
300.00	1411.4	1764.9	1864.8	2269.6	4710.5	1078.4
315.00	1550.6	1939	2048.7	2493.4	5175.7	1184.8
330.00	1689.5	2112.6	2232.2	2716.7	5640.3	1290.9
345.00	1827.7	2285.4	2414.8	2938.9	6103.1	1396.5
360.00	1965.1	2457.3	2596.4	3159.8	6564.1	1501.5
375.00	2101.4	2627.6	2776.4	3378.9	7022.1	1605.6
390.00	2236.5	2796.6	2954.9	3596.2	7477.4	1708.8
405.00	2369.6	2963	3130.7	3810.2	7927.2	1810.5
	2500.6	3126.8	3303.8	4020.9	8371.6	1910.6
435.00	2628.3	3286.6	3472.6	4226.3	8806.8	2008.2
450.00	2753.2	3442.8	3637.6	4427.2	9234.4	2103.6
465.00	2876	3596.3	3799.9	4624.7	9657	2197.4
480.00	2997.4	3748.2	3960.3	4820.3	10077.3	2290.2
495.00	3118.7	3899.8	4120.5	5015.6	10499.1	2382.9
510.00	3240.5	4052.1	4281.6	5212.1	10925.5	2476

525.00	3363.6	4206.1	4444.4	5411	11358.7	2570
540.00	3489.3	4363.4	4610.6	5614.3	11803.1	2666
555.00	3618.3	4524.9	4781.4	5823.6	12261.9	2764.6
570.00	3751.7	4692.2	4958.4	6040.6	12738.5	2866.6
585.00	3890.7	4866.4	5142.8	6267.2	13236.7	2972.7
600.00	4036.1	5049.1	5336.3	6505.2	13760	3083.7
615.00	4189.9	5242.6	5541.2	6757.6	14315	3201.1
630.00	4355.1	5450.7	5761.7	7029.6	14912.1	3327.1
645.00	4534.9	5677.4	6002	7326.2	15562.3	3463.9
660.00	4733.4	5928.3	6268	7654.6	16280.5	3614.9
675.00	4956.4	6210.3	6567.1	8023.9	17086	3784.2
690.00	5212.4	6534.5	6910.9	8448.4	18008.8	3978.2
705.00	5561.9	6977.2	7380.3	9027.3	19260.1	4242.6
720.00	6154.2	7726.7	8174.7	10004.7	21353.7	4689.9
735.00	6906.6	8678.8	9183.7	11245.3	24004.3	5257.8
750.00	7944.3	9991.1	10574.2	12953.6	27641.7	6040.6
765.00	9113.1	11469.2	12140.1	14876.9	31732.3	6922.1
780.00	10456.6	13167.9	13939.6	17086.3	36425.8	7935.2
795.00	11967.8	15078.4	15963.5	19570.6	41698.4	9074.5
810.00	13685.1	17248.9	18262.6	22392.2	47681.3	10369.2
825.00	15619.5	19693.4	20851.8	25568.9	54411.4	11827.4
840.00	17745	22379	23696.2	29058	61797.6	13429.9
855.00	20033.9	25270.5	26758.5	32813.5	69741.6	15155.5
870.00	22342.1	28185.8	29845.9	36598.9	77741.4	16895.9
885.00	24465.4	30867.4	32685.5	40080	85092.1	18496.7
900.00	26408	33320.3	35282.9	43263.3	91806.4	19961.3
915.00	27973.5	35296.9	37375.9	45827.7	97208.7	21141.5
930.00	29312.1	36986.6	39164.9	48018.8	101817	22150.4
945.00	30246	38165.3	40412.7	49546.4	105020.3	22854.1
960.00	30931.4	39030	41327.9	50665.8	107357.8	23370.4
975.00	31255.8	39438.8	41760.4	51193.5	108444	23614.2
990.00	31404.6	39625.8	41957.9	51433.1	108920.3	23725.6
1005.00	31332.3	39533.7	41859.9	51310.2	108629.6	23670.3
1020.00	30977	39084	41383.3	50723.1	107357.2	23401.5
1035.00	30359.5	38303.6	40556.4	49706.9	105178.9	22935
1050.00	29613.4	37360.7	39557.5	48480	102556.7	22371.4
1065.00	28760.6	36283.2	38416.2	47078.5	99566.6	21727.3
1080.00	27797.8	35067	37127.9	45497	96197.5	21000.4
1095.00	26733.8	33723	35704.4	43749.9	92479.1	20197.1
1110.00	25510.5	32178	34068	41742.1	88211.7	19273.6
1125.00	24192.9	30514.2	32305.9	39580.1	83620.2	18279

1140.00	22731.9	28669.4	30352.2	37183.8	78536.4	17176.2
1155.00	21299.6	26861.1	28437.2	34835.4	73557.7	16094.9
1170.00	19987.1	25204.2	26682.6	32683.7	68997.6	15104
1185.00	18780.4	23681.1	25069.7	30706.1	64808.2	14192.9
1200.00	17734.3	22360.6	23671.4	28991.7	61176.2	13402.9
1215.00	16750.5	21119	22356.6	27379.7	57762.1	12660
1230.00	15835.1	19963.7	21133.3	25880	54586.3	11968.8
1245.00	14982.4	18887.5	19993.8	24483.1	51628.8	11324.8
1260.00	14194.9	17893.8	18941.5	23193.2	48898.6	10730.1
1275.00	13490.6	17005.1	18000.5	22039.7	46457.4	10198.1
1290.00	12832.6	16174.8	17121.4	20962.1	44176.8	9701.2
1305.00	12191.5	15365.8	16264.8	19912.1	41955	9216.9
1320.00	11574.9	14587.7	15441	18902.5	39819.2	8751.2
1335.00	11009.3	13874.2	14685.4	17976.5	37860.6	8324
1350.00	10461.1	13182.5	13953	17078.9	35962.5	7909.9
1365.00	9930.9	12513.6	13244.8	16211	34127.5	7509.4
1380.00	9441.6	11896.3	12591.2	15410.1	32434.7	7139.8
1395.00	9014.7	11357.8	12021.2	14711.6	30958.5	6817.3
1410.00	8604.3	10840.1	11473	14040	29539.2	6507.3
1425.00	8211.8	10345	10948.8	13397.7	28182.1	6210.8
1440.00	7850.9	9889.7	10466.8	12807.2	26934.6	5938.1
1455.00	7516.2	9467.6	10019.9	12259.7	25778.1	5685.3
1470.00	7191.6	9058.3	9586.5	11728.7	24656.7	5440.1
1485.00	6878.7	8663.6	9168.7	11216.9	23576.2	5203.6
1500.00	6591.2	8301.1	8784.9	10746.8	22584	4986.4
1515.00	6314.8	7952.6	8416	10295	21630.7	4777.5
1530.00	6042.1	7608.7	8052	9849.2	20690.4	4571.4
1545.00	5777.2	7274.8	7698.5	9416.3	19777.8	4371.2
1560.00	5532.7	6966.6	7372.3	9017	18936.3	4186.4
1575.00	5287.3	6657.3	7044.9	8616.1	18092.1	4000.8
1590.00	5038.9	6344.3	6713.6	8210.7	17238.4	3813
1605.00	4791.3	6032.3	6383.4	7806.6	16388.2	3625.8
1620.00	4548.5	5726.4	6059.7	7410.5	15555	3442.1
1635.00	4302.1	5416.1	5731.2	7008.6	14710	3255.7
1650.00	4056	5106.1	5403.2	6607.3	13866.6	3069.6
1665.00	3814.9	4802.6	5081.9	6214.3	13040.9	2887.2
1680.00	3579.9	4506.6	4768.7	5831.2	12236.2	2709.4
1695.00	3347	4213.4	4458.4	5451.7	11439.2	2533.2
1710.00	3120.1	3927.6	4156.1	5081.9	10662.6	2361.4
1725.00	2903.1	3654.5	3867	4728.4	9920.5	2197.2
1740.00	2692.8	3389.7	3586.8	4385.7	9201.2	2038.1

1755.00	2489.4	3133.7	3315.9	4054.4	8505.9	1884.2
1770.00	2296.6	2890.9	3059	3740.3	7846.7	1738.2
1785.00	2117.9	2665.9	2820.9	3449.2	7236	1602.9
1800.00	1947.9	2452.1	2594.6	3172.5	6655.4	1474.3
1815.00	1787.4	2250	2380.8	2911	6106.9	1352.8
1830.00	1638.2	2062.1	2182.1	2668.1	5597.2	1239.9
1845.00	1501.9	1890.6	2000.5	2446.1	5131.7	1136.7
1860.00	1375.3	1731.3	1831.9	2240	4699.3	1040.9
1875.00	1259.4	1585.4	1677.6	2051.2	4303.3	953.1
1890.00	1153.6	1452.2	1536.6	1878.9	3941.8	873.1
1905.00	1056.5	1330	1407.3	1720.8	3610	799.6
1920.00	967.4	1217.8	1288.6	1575.6	3305.2	732.1
1935.00	884.5	1113.5	1178.2	1440.6	3022	669.4
1950.00	807.7	1016.7	1075.8	1315.4	2759	611.2
1965.00	736.5	927.1	981	1199.5	2515.7	557.4
1980.00	671.5	845.3	894.4	1093.5	2293.3	508.2
1995.00	611.1	769.2	813.9	995	2086.5	462.5
2010.00	554.5	697.9	738.5	902.8	1892.9	419.7
2025.00	501.3	631	667.6	816.2	1710.9	379.4
2040.00	451.5	568.3	601.3	735	1540.5	341.8
2055.00	405.2	509.9	539.5	659.4	1381.8	306.7
2070.00	361.8	455.2	481.6	588.7	1233.3	273.9
2085.00	321.4	404.4	427.9	522.9	1095.1	243.3
2100.00	285.4	359	379.8	464.2	971.9	216.1
2115.00	257.1	323.4	342.2	418.2	875.5	194.7
2130.00	233.3	293.5	310.5	379.4	794.3	176.6
2145.00	211.9	266.5	282	344.6	721.3	160.4
2160.00	192.6	242.2	256.3	313.2	655.6	145.8
2175.00	175.1	220.2	233	284.7	596	132.6
2190.00	159.1	200.2	211.8	258.8	541.7	120.5
2205.00	144.6	181.9	192.5	235.2	492.3	109.5
2220.00	131.5	165.4	175	213.9	447.7	99.6
2235.00	119.6	150.4	159.1	194.4	407	90.5
2250.00	108.6	136.6	144.6	176.7	369.8	82.3
2265.00	98.7	124.2	131.4	160.5	336	74.7
2280.00	89.8	112.9	119.5	146	305.5	68
2295.00	81.5	102.6	108.5	132.6	277.5	61.7
2310.00	74	93.1	98.5	120.3	251.9	56
2325.00	67.1	84.5	89.4	109.2	228.5	50.8
2340.00	60.9	76.6	81.1	99	207.3	46.1
2355.00	55.2	69.4	73.4	89.7	187.8	41.8

2370.00	49.9	62.8	66.4	81.2	169.9	37.8
2385.00	45.2	56.8	60.1	73.4	153.7	34.2
2400.00	40.8	51.4	54.3	66.4	138.9	30.9
2415.00	36.8	46.3	49	59.9	125.4	27.9
2430.00	33.2	41.8	44.2	54	113	25.2
2445.00	29.9	37.7	39.8	48.7	101.9	22.7
2460.00	26.9	33.9	35.9	43.8	91.7	20.4
2475.00	24.2	30.5	32.2	39.4	82.4	18.3
2490.00	21.7	27.3	28.9	35.3	74	16.5
2505.00	19.5	24.5	26	31.7	66.4	14.8
2520.00	17.5	22	23.3	28.4	59.5	13.2
2535.00	15.6	19.6	20.8	25.4	53.1	11.8
2550.00	13.9	17.5	18.5	22.6	47.3	10.5
2565.00	12.4	15.5	16.4	20.1	42	9.4
2580.00	10.9	13.7	14.5	17.7	37.1	8.3
2595.00	9.6	12	12.7	15.5	32.5	7.2
2610.00	8.3	10.4	11.1	13.5	28.3	6.3
2625.00	7.2	9	9.5	11.6	24.3	5.4
2640.00	6.1	7.7	8.1	9.9	20.7	4.6
2655.00	5.1	6.5	6.8	8.3	17.5	3.9
2670.00	4.3	5.4	5.7	6.9	14.5	3.2
2685.00	3.5	4.4	4.6	5.7	11.9	2.6
2700.00	2.8	3.5	3.7	4.6	9.5	2.1
2715.00	2.2	2.8	2.9	3.6	7.5	1.7
2730.00	1.7	2.1	2.2	2.7	5.7	1.3
2745.00	1.2	1.5	1.6	2	4.1	0.9
2760.00	0.8	1	1.1	1.3	2.8	0.6
2775.00	0.5	0.6	0.7	0.8	1.7	0.4
2790.00	0.3	0.3	0.4	0.5	0.9	0.2
2805.00	0.1	0.1	0.2	0.2	0.4	0.1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1400
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10.00
20.00
30.00
40.00
50.00
60.00
Outflow (m³/s)
Time (hrs)
100 yr
50 yr
20 yr
10 yr