

Water Availability

The policy approach to evaluating water availability resulting from instream flow requirements is currently in a transition phase in Texas. Traditionally instream flow requirements have been included in water rights permits as special conditions which limited diversions subject to the maintenance of these “minimum” flows. With the passage of SB3; the TCEQ was directed to determine a flow reservation through rule making.

On the scientific side, a general understanding has developed that the concept of a minimum flow is not sufficient to protect the ecological health of a river. This view, supported by the recent National Academy of Sciences review of the Texas Instream Flow Program recognizes that healthy rivers require a full range of flows, including natural variability.

The Environmental Flows Project for the Cypress Basin recognizes the current science and policy perspectives and has developed the first steps for an SB3 type of the flow reservation, which provides the critical flow components for the natural flow regime. Unfortunately the water availability analysis tools and implementation options that will be needed to convert the flow components of the regime into a reservation or set aside have not yet been well developed by TCEQ. Thus, this Project will need to develop the options and tools needed in the Cypress basin.

Monthly WAM: One important disconnect between the traditional analysis of availability in Texas and current understanding of instream flow requirements is the use of a monthly Water Availability Model (WAM). The WAM is a FORTRAN based computer model that implements the prior appropriation doctrine for the Cypress basin. Calculations are preformed by overlaying current water rights on historical hydrology to predict available diversions and resulting river flows on a monthly time step. A monthly timestep is not suitable for determining impacts on environmental flows which have much shorter response times. This is particularly true for the short duration high flow pulse and flood flows. For example a 6,000 cubic feet per second (cfs) pulse event is indistinguishable in the WAM from a constant average flow of 200 cfs for 30 days, however these regimes result in very different biological responses. An analogous situation occurs at the low flow end where a month of extremely low flows can be masked by a short duration high flow events.

One option for addressing this problem is to develop a daily time step WAM. Some effort has been made towards this objective, however the daily datasets necessary to drive a daily model have not yet been developed. A second option is to scale the daily targets up to monthly, while recognizing the inherent problem described above, in order to make a gross evaluation of how well the system meets the instream flow needs and conversely what impact meeting these instream targets would have on future water rights. This is essentially the approach taken by the TCEQ in evaluating water availability for the San Marcos River Foundations instream flow water right application.

Applying this second option to the current flow regimes for the Cypress Basin, the first step is to convert the instantaneous flow rates in cfs into a monthly volume of acre feet (ACFT). Recall that the building blocks developed in this project included targets for dry, average and wet conditions, thus three sets of monthly volumes were developed for each creek. The WAM includes the years 1948-1998 (51 years or 612 months).

Table 1 shows the frequency of meeting these flow proposed in the building blocks on a monthly volumetric, basis. Table 1 and subsequent figure display results for three scenarios. The first column “Naturalized” represents the flows that would have occurred in the absence of man’s activities. Typically naturalized flows are developed from USGS gauges by making adjustments based on upstream diversions and returns. The “Current Conditions” simulation as the name implies is intended to represent the flow

that would occur assuming current levels of withdrawals and returns. This alternative could be useful in helping to identify water that has been permitted but is not currently being fully utilized. The “Full Authorization” simulation includes maximum permitted withdrawals and assumes 100% reuse; no return flows. This very conservative approach ensures that TCEQ does not grant permits which would overappropriate the basin but does not represent a very realistic portrayal of current or even future conditions. TCEQ uses the fully appropriated simulation to consider water availability for new water applications.

Table 1 Annual frequency of meeting initial building blocks targets for base flows

Site	Dry			Average			Wet		
	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization
Big Cypress Creek	78%	50%	23%	67%	41%	19%	60%	37%	17%
Little Cypress Creek	82%	83%	81%	71%	71%	69%	53%	53%	52%
Black Cypress Bayou	79%	79%	79%	66%	66%	66%	52%	52%	52%

These results show that for Black and Little Cypress the dry condition targets are met or exceeded around 80% of the time, the average targets 70% of the time and wet targets 50% of the time under natural and regulated conditions. Given the relatively small quantities of water diversions from these two creeks this is not surprising. The difference between 83% and 81% for Little Cypress means that there were just 12 months out of 612 during which natural monthly flows would have met the base dry target while flows resulting from the full authorization simulation would not. The shortfalls during these months ranged from 51 ACFT/Month (about 0.8 cfs) to 1,720 ACFT/Month (about 30 cfs). Ten of the 12 months had shortfalls less than 1,000 ACFT/Month (about 15 cfs).

The analysis of flows for Big Cypress shows the impact of Lake O’ the Pines (LOP). While naturalized flows show a pattern similar to the other two tributaries, regulated flows, assuming full authorization and zero return flows, indicate a substantial decrease, over 50%, in the frequency of meeting the targets under the fully authorization simulation. Since the WAM is based on the prior appropriation doctrine, whenever LOP (priority date 1959) is not full or spilling, no water is released except for water rights with a senior date. Zero flow months predicted by the WAM are not that uncommon –about 11% of the months – and there are many months (~75%) in which flows are predicted to average less than 6 cfs (the lowest value in the initial recommendations). There are a number of reasons for these results including

1. the rather conservative assumptions used in water right rights permitting, e.g. full authorization and zero return flows,
2. the fact that the model does not show releases for downstream contracts; therefore entire LOP permitted withdrawals are assumed to occur lake side (Currently NETMWD has a contract for 9,000 ACFT to supply water to Marshall which diverts from Big Cypress below LOP however since this is a contact, this diversion is assumed to occur lakeside and thus is not reflected in the WAM at the Big Cypress gauge location), and
3. the WAM does not include any conditions not explicitly included in state water rights permit thus does not include the minimum 5 cfs flow release required for LOP (This 5 cfs flow requirement is mandated by federal law and could not be violated even if the Cypress Flows Project were to recommend lower flows).

While the initial building blocks were derived from low flow percentiles, the frequency at which these targets should be achieved was not explicitly defined. There are a number of reasonable options that could be proposed. For example, every period could be designated as either dry, average or wet; dry

implying the driest third of the time, average the middle third and wet the wettest third, which translates to dry should be met 100% of the time, average at least 66% of the time, and wet at least 33% of the time. A second option could be that the targets should be met at their natural frequency (or perhaps some acceptable level below that frequency in acknowledgement the impact of development). From Table 1, this would mean that dry should be met or exceeded about 80% of the time, average about 70% of the time, and wet about 50% of the time. (Note that these percentiles differ from the 75th, 50th and 25th low flow statistics used in the building blocks. The discrepancies are due to two factors. First, the percentiles were based on flow separated, low flow conditions and thus do not include the percent of the time when the flows were high. (See IHA flow separation algorithm) Second, the results in Table 1 represent frequencies based on the WAM simulated flows for the period from 1948-1998 while the base flow recommendations were derived for gauged pre-LOP flows from 1924-1959.) One should also note that this second option for desired frequencies would imply that there would be times that flows would fall below the dry target levels, as they have naturally. That might suggest the need for subsistence targets or an absolute minimum that flows should never violate. Finally these issues might be viewed differently for regulated versus unregulated systems. For example while it is possible to ensure an absolute minimum flow (base-dry or subsistence) on Big Cypress via reservoir releases, that option is not available on the unregulated streams.

A more sophisticated analysis (presented in Table 2 – Big Cypress only, statistics for Little and Black are included in the appendices) evaluates the frequency of meeting the various targets for each month.

Table 2 Monthly frequency of meeting initial building blocks targets for base flows in Big Cypress

	Base Flow Targets Percent Excedence								
	Dry			Average			Wet		
	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization
Jan	92%	65%	29%	75%	49%	29%	61%	41%	27%
Feb	98%	75%	37%	80%	63%	33%	75%	57%	31%
Mar	94%	75%	45%	80%	67%	43%	73%	63%	31%
Apr	88%	71%	35%	76%	63%	33%	71%	57%	25%
May	86%	71%	33%	78%	71%	33%	75%	65%	29%
Jun	80%	51%	24%	78%	47%	22%	71%	45%	20%
Jul	73%	22%	8%	59%	16%	4%	45%	10%	4%
Aug	57%	31%	16%	31%	6%	0%	31%	6%	0%
Sep	61%	37%	20%	39%	12%	6%	39%	12%	6%
Oct	55%	18%	2%	55%	18%	2%	51%	16%	0%
Nov	71%	31%	10%	71%	31%	10%	71%	31%	10%
Dec	82%	49%	16%	75%	49%	16%	57%	47%	14%
All Months	78%	50%	23%	67%	41%	19%	60%	37%	17%

It is notable that some of the lowest frequencies occur in months for which initial building blocks were adjusted upward based on professional judgment and review of existing instream flow studies. Nonetheless this analysis supports the conclusion that based on existing water availability modeling, the building blocks targets would not be met if the desired frequencies under either of the options described above. The results also suggest that there is substantial unperfected water. This water which has been permitted but currently is not being diverted or is not being reused is reflected in the current conditions simulation. Significant increases in the frequencies of meeting the initial recommendations could be achieved by dedicating some of this water to meet instream flow needs.

Daily Water Availability Analysis: Although daily time step WAMs have not yet been developed for the Cypress basin, it is possible to convert the monthly outputs from the WAM into daily flow estimates. This is accomplished by applying a flow distribution pattern to the monthly values to distribute these monthly volumes to daily flow rates. For Little and Black Cypress, which have only been

moderately altered, this is a fairly straightforward exercise commonly applied in water planning. Daily gauge records for a given month are used to pro-rate the monthly flows from the WAM.

In the case of Big Cypress, whose flow was substantially altered, the issue is slightly more complicated. When distributing monthly naturalized flows to daily, it does not make sense to use the pattern produced at a regulated flow gauge. Likewise, for regulated flows, it does not make sense to apply a natural flow pattern to produce regulated daily flows. For this analysis, if the appropriate distribution pattern was not available, flows were distributed based on a pattern derived from another time period but for which the total monthly flows were roughly the same.

Once daily flows are produced for natural and regulated simulations, the frequencies and durations of meeting each of the flow component defined in the building blocks can be assessed including the sub-monthly high flow targets. Table 3 presents the results of this daily analysis.

Table 3 Daily frequency of meeting initial building blocks targets for base, pulse and flood flows in Big Cypress

	Base Flow Targets Percent Excedence								
	Dry			Average			Wet		
	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization
Jan	90%	57%	24%	66%	42%	19%	56%	38%	16%
Feb	98%	63%	29%	77%	54%	21%	68%	49%	16%
Mar	88%	61%	30%	76%	55%	22%	68%	51%	18%
Apr	79%	57%	24%	69%	53%	20%	62%	49%	16%
May	77%	59%	27%	72%	57%	24%	64%	54%	23%
Jun	75%	47%	15%	68%	37%	14%	56%	31%	11%
Jul	67%	22%	8%	50%	15%	7%	38%	10%	5%
Aug	49%	21%	15%	27%	4%	6%	27%	4%	6%
Sep	50%	29%	17%	27%	11%	8%	27%	11%	8%
Oct	44%	14%	6%	44%	14%	6%	41%	14%	5%
Nov	62%	25%	7%	62%	25%	7%	61%	25%	7%
Dec	76%	42%	13%	72%	42%	12%	56%	36%	9%
All Months	71%	41%	18%	59%	34%	14%	52%	31%	12%

High Pulse			Small Flood			Large Flood		
Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization
33%	37%	14%	33%	2%	0%	22%	0%	0%

For the base flow targets, these results suggest that the monthly analysis presented above slightly over estimate the frequency of meeting the targets. The monthly analysis over predicts the frequency meeting the targets by about 5 %, for example the June base average target is met 80% of the time according to the monthly analysis but only 75% of the time in the daily analysis. Figure 1 provides and illustrative example to explain this difference.

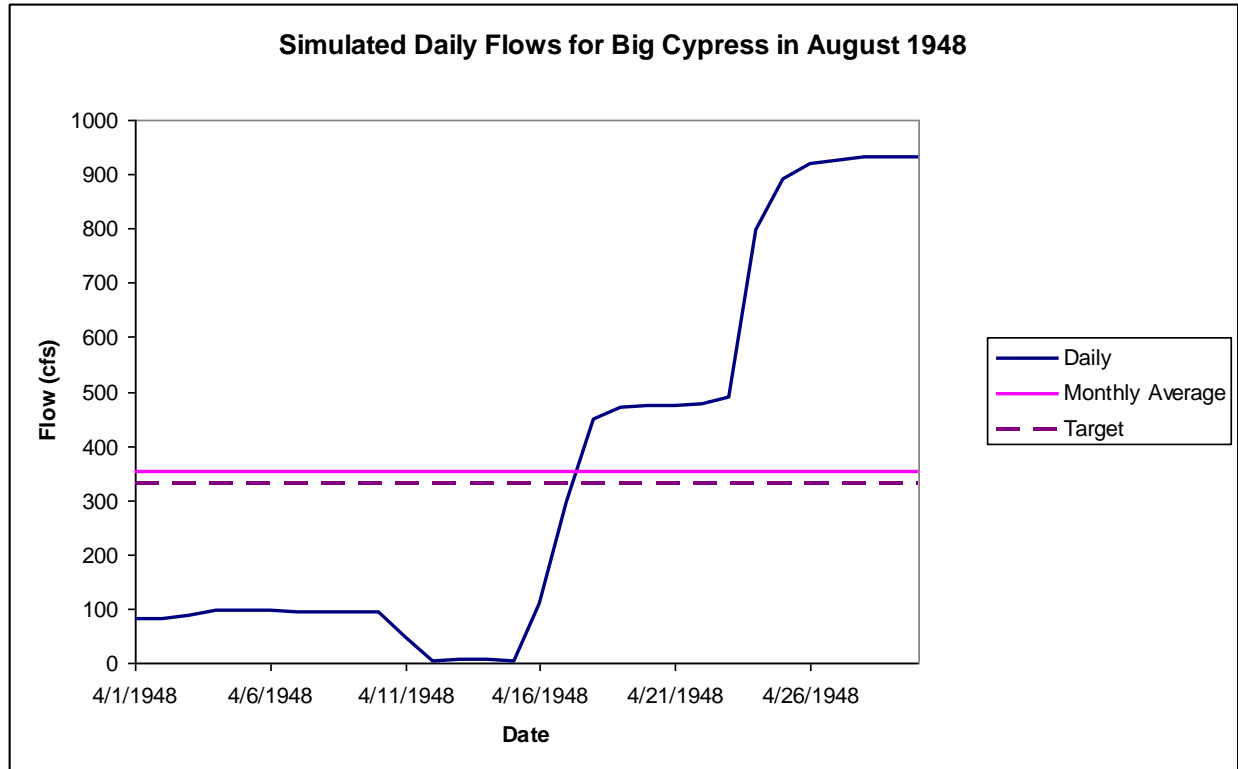


Figure 1 Simulated daily and monthly flows as compared to initial building blocks base flow – average target

In this example the WAM predicts a regulated monthly volume of 22,404 ACFT or approximately 377 cfs daily average flow. The base average target for August is 330 cfs, so according to the monthly WAM analysis this target would be met, however when an appropriate daily distribution is applied to this monthly flow (as described above) half of the days fail to meet the target flow.

Unlike the monthly WAM analysis, the daily analysis allows for some interpretation of the effect of the regulated flow on satisfying short duration high flow events. The results presented at the bottom of in Table 3 represent the annual frequency of meeting the various flow components as defined in the building blocks. Thus, for instance, the 33% for the high flow pulse target under naturalized flows means that in 33% of the years there were at least 4 events for which flows exceeded 1,500 cfs for at least 2 days. The regulated simulation predicts that the high flow pulse targets are only met in 14% of the years under the fully authorized simulation.

Conclusions: This analysis suggests three principle findings. First, the options for desired frequencies at which flow conditions (dry, average and wet) are applicable will need to be considered if not defined. Second, in general, it appears that base flow targets could be met a reasonable frequency at Little and Black Cypress even assuming the fully permitted conditions. Therefore, a reservation which limits future diversions to protect flows in the building blocks (assuming an appropriate trigger method to determine dry, average and wet conditions can be developed) might be adequate to meet the objectives of this project. Finally, in Big Cypress it appears that existing permits, as they are analyzed in the WAM, could result in lower frequencies of meeting the target conditions than might be desired. A more detailed daily reservoir operations model will likely be necessary to evaluate the potential of various alternatives that could be used to increase the frequency of meeting these targets.

Appendix 1

Monthly analysis for Naturalized Flows, Current Conditions (TCEQ-Run8), and Full Authorization (TCEQ-Run3) for Little and Black Cypress Creeks.

Table 4 Monthly frequency of meeting initial building blocks target flows in Little Cypress

	Base Flow Targets Percent Excedence								
	Dry			Average			Wet		
	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization
Jan	88%	88%	86%	75%	75%	71%	51%	51%	47%
Feb	86%	86%	86%	82%	82%	76%	67%	67%	65%
Mar	88%	88%	88%	75%	75%	75%	75%	75%	75%
Apr	90%	90%	90%	84%	84%	82%	63%	63%	63%
May	90%	90%	90%	86%	86%	84%	75%	75%	75%
Jun	86%	86%	84%	73%	71%	71%	51%	51%	51%
Jul	80%	80%	76%	69%	71%	67%	39%	37%	37%
Aug	65%	67%	59%	55%	57%	55%	41%	41%	41%
Sep	65%	67%	63%	57%	57%	57%	39%	39%	37%
Oct	75%	76%	75%	57%	57%	57%	43%	41%	41%
Nov	86%	86%	86%	65%	65%	65%	43%	41%	39%
Dec	88%	84%	84%	73%	73%	73%	55%	55%	53%
All Months	82%	83%	81%	71%	71%	69%	53%	53%	52%

Table 5 Monthly frequency of meeting initial building blocks target flows in Black Cypress

	Base Flow Targets Percent Excedence								
	Dry			Average			Wet		
	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization
Jan	84%	84%	84%	69%	69%	69%	57%	57%	57%
Feb	84%	84%	84%	78%	78%	78%	75%	75%	75%
Mar	76%	76%	76%	75%	75%	75%	71%	71%	71%
Apr	90%	90%	90%	78%	78%	78%	59%	59%	59%
May	90%	90%	90%	76%	76%	76%	76%	76%	76%
Jun	82%	82%	82%	63%	63%	63%	49%	49%	49%
Jul	75%	75%	75%	55%	55%	55%	37%	37%	37%
Aug	61%	61%	61%	59%	59%	59%	45%	45%	45%
Sep	67%	67%	67%	67%	67%	67%	35%	35%	35%
Oct	75%	75%	75%	59%	59%	59%	37%	37%	37%
Nov	82%	82%	82%	55%	55%	55%	35%	35%	35%
Dec	76%	76%	76%	57%	57%	57%	43%	43%	43%
All Months	79%	79%	79%	66%	66%	66%	52%	52%	52%

Appendix 2

Daily analysis for Naturalized Flows, Current Conditions (TCEQ-Run8), and Full Authorization (TCEQ-Run3) for Little and Black Cypress Creeks.

Table 6 Daily frequency of meeting initial building blocks target flows in Little Cypress

	Base Flow Targets Percent Excedence								
	Dry			Average			Wet		
	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization
Jan	84%	83%	83%	68%	68%	66%	49%	48%	47%
Feb	87%	86%	85%	73%	73%	71%	60%	60%	57%
Mar	88%	87%	86%	73%	73%	72%	64%	64%	63%
Apr	86%	85%	85%	70%	70%	69%	57%	57%	56%
May	87%	87%	86%	75%	75%	74%	61%	61%	60%
Jun	78%	77%	76%	60%	59%	58%	45%	44%	43%
Jul	69%	70%	68%	54%	54%	52%	34%	34%	33%
Aug	57%	61%	56%	48%	50%	47%	27%	27%	26%
Sep	56%	58%	56%	49%	50%	48%	29%	28%	28%
Oct	65%	67%	65%	48%	48%	46%	32%	32%	31%
Nov	79%	79%	78%	58%	58%	56%	41%	40%	39%
Dec	82%	81%	80%	68%	68%	66%	52%	52%	51%
All Months	76%	77%	75%	62%	62%	60%	46%	45%	44%
		High Pulse Current	Full		Sm Flood Current	Full		Lg Flood Current	Full
	Naturalized	Conditions	Authorization	Naturalized	Conditions	Authorization	Naturalized	Conditions	Authorization
		39%	37%	35%	35%	35%	16%	16%	16%

Table 7 Daily frequency of meeting initial building blocks target flows in Black Cypress

	Base Flow Targets Percent Excedence								
	Dry			Average			Wet		
	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization	Naturalized	Current Conditions	Full Authorization
Jan	79%	79%	79%	60%	60%	60%	51%	51%	51%
Feb	81%	81%	81%	69%	69%	69%	61%	61%	61%
Mar	76%	76%	76%	68%	68%	68%	57%	57%	57%
Apr	82%	82%	82%	71%	71%	71%	51%	51%	51%
May	82%	82%	82%	69%	69%	69%	60%	60%	60%
Jun	70%	70%	70%	53%	53%	53%	35%	35%	35%
Jul	65%	65%	64%	44%	44%	44%	30%	30%	30%
Aug	56%	56%	55%	52%	52%	52%	36%	36%	36%
Sep	52%	52%	52%	52%	52%	52%	30%	30%	30%
Oct	62%	62%	62%	49%	49%	49%	30%	30%	30%
Nov	73%	73%	73%	49%	49%	49%	34%	34%	34%
Dec	75%	75%	75%	51%	51%	51%	41%	41%	41%
All Months	71%	71%	71%	57%	57%	57%	43%	43%	43%
		High Pulse Current	Full		Sm Flood Current	Full		Lg Flood Current	Full
	Naturalized	Conditions	Authorization	Naturalized	Conditions	Authorization	Naturalized	Conditions	Authorization
		39%	39%	35%	35%	35%	8%	8%	8%

Appendix 3

Analysis of gauge flows for Big Cypress

Although gauge records are not directly used for water availability analysis, since they do not necessarily include existing water rights commitments, a review of pre- and post LOP gauge records and their comparison to the initial building blocks may be insightful. Pre-LOP has a period of record from 1924-1959 and post-LOP is from 1980-2005.

Table 8 Monthly frequency of meeting initial building blocks target flows on Big Cypress based on gauge data

	Base Flow		Targets		Percent Excedence	
	Dry		Average		Wet	
	Pre	Post	Pre	Post	Pre	Post
Jan	91%	78%	60%	59%	40%	37%
Feb	97%	81%	51%	59%	40%	52%
Mar	80%	78%	69%	59%	46%	52%
Apr	83%	59%	69%	44%	43%	37%
May	89%	52%	86%	52%	69%	44%
Jun	66%	63%	66%	56%	51%	44%
Jul	74%	89%	60%	52%	40%	37%
Aug	64%	100%	22%	8%	19%	8%
Sep	61%	96%	17%	27%	17%	27%
Oct	25%	52%	25%	52%	25%	52%
Nov	33%	48%	33%	48%	33%	48%
Dec	64%	67%	58%	67%	33%	56%
All Months	69%	79%	51%	61%	38%	56%

Table 9 Daily frequency of meeting initial building blocks target flows on Big Cypress based on gauge data

	Base Flow		Targets		Percent Excedence	
	Dry		Average		Wet	
	Pre	Post	Pre	Post	Pre	Post
Jan	93%	69%	71%	62%	60%	55%
Feb	99%	85%	77%	76%	62%	66%
Mar	86%	79%	75%	73%	65%	65%
Apr	85%	68%	76%	60%	69%	53%
May	91%	57%	84%	52%	69%	44%
Jun	82%	81%	67%	64%	50%	54%
Jul	80%	97%	55%	64%	41%	46%
Aug	70%	100%	28%	54%	28%	52%
Sep	53%	89%	24%	57%	23%	53%
Oct	28%	56%	28%	56%	25%	46%
Nov	44%	49%	43%	48%	35%	41%
Dec	74%	66%	60%	61%	44%	57%
All Months	74%	75%	57%	60%	47%	53%
	High Pulse		Small Flood		Large Flood	
	Pre	Post	Pre	Post	Pre	Post
	44%	35%	44%	0%	31%	0%