In both allocation methods, the loads for all three mills are also water quality limited and could not be increased from the amounts in Table 8. As noted in Table 8, the weekly CBODu TMDL could also be implemented as a summer daily maximum permitted BOD5 load with the following factors applied as a product to the summer weekly average permitted BOD5 loads Fraser 1.4; MWV 1.5; and IP 1.25. These ratios were derived from four summers of discharge monitoring reports except for Fraser where two years were used due to the mill shutdown before that time period.

When the 30-day average dissolved oxygen criterion is tested, the model predicts that the 30-day average DO criterion of 6.5 ppm is met everywhere when point sources are at loads required in the TMDL (Figure 11). However since the criterion is just barely met at Livermore Falls, it can similarly be concluded that the monthly average loads required in the TMDL are water quality limited. The following table is a summary of the CBODu 30-day average TMDL at the entrance to Gulf Island Pond along with the same default and alternate allocations of BOD5 to point sources. The TMDL is expressed as a 30-day average to be consistent with the averaging period of 30 days for the load inputs, flow, temperature, and the DO criteria addressing growth of salmonid fish species.

Table 9 Gulf Island Pond 30-Day Average TMDL CBODU with Default and Alternate Allocations - Apply June to September

	Allocations at Outfall			Assimilation	Allocations Twin Bridges*	
Source	**Default** BOD5 4/15/03 Adjusted	**Alternate** BOD5 Allocate by = Impact	CBODu / BOD5	% BOD Remaining Twin Bridges*	**Default** Ultimate CBOD	**Alternate** Ultimate CBOD
NPS					10440	10440
Fraser	10180	10180	3.6	24.7%	9052	9052
Mead	8330	9270	3.6	45.8%	13735	15285
IP	7400	6719	3.5	65.0%	16835	15285
Berlin	660		Municipal Discharges are grouped in the TMDL due to their de-mimimus impact upon dissolved oxygen levels within Gulf Island Pond .			
Gorham	188					
Bethel	75					
Rum.-Mex	663					
Liv. Falls	500					
Munic Tot.	2086		3	41.3%	2585	2585
Total TMDL WLA (Point Sources) with clustering factor					**42206**	**42206**
WLA =Point Sources reduced by clustering factor					**39817**	**39817**
LA = Non-point Sources + Natural					**10440**	**10440**
Explicit Margin of Safety (10%)					**5584**	**5584**
TMDL Total					**55841**	**55841**

Oxygen Injection Load- Full attainment of DO criteria cannot occur without some amount of oxygen injection due to sediment oxygen demand.

*Twin Bridges or Rte 219 in Turner is the upstream boundary to Gulf Island Pond

Oxygen Load Requirements	Upper Narrows	Lower Narrows	Near Deep Hole	Efficiency
Default	30,000	150,000		0.333
Alternate #1	105,000	105,000		0.333
Alternate #2	50,000	65,000	42,000	0.333
Alternate #3	Other options are possible but must be approved by MDEP.			

Implementation of TMDL in Licensing

Point Source	Licensing Recommendation	Comment
Berlin Gorham Bethel Rumford-Mexico Livermore Falls	License as technology-based limits (BPT) year round.	Municipal discharges have a de-minimus impact to dissolved oxygen levels in Gulf Island Pond
Fraser Paper MeadWestvaco International Paper	Implement TMDL as limits that apply from June to Sept as a monthly average BOD5 load. . Require participation in oxygen injection system and ambient monitoring.	The paper mills have significant impact to dissolved oxygen levels in Gulf Island Pond.

Summary of Allocation Method.

1. Use paper mill loads based upon 4/15/03 paper mill modeling request or impact to Gulf Island Pond as initial basis.
2. Municipal allocations are technology based loads (design flow @ 30 ppm).
3. Fraser Paper load limited by meeting weekly average CBODu TMDL sample allocation = 11500 ppd.
4. Point source allocations inflated by clustering factor of 1.06 which accounts for simultaneous loads to the pond. Clustering factor derived from DMR's.*
5. Explicit margin of safety of 10% applied to TMDL.
6. Instream Aeration needed as TMDL load due to the model prediction of non-attainment with all point sources removed.

* The clustering factor eliminates the assumption used in implicit margins of safety by MDEP, which assumes that all point sources discharge their maximum loads simultaneously.

The model runs made by Qual2EU simulate water quality conditions in the river from Berlin to Turner. The terminal conditions at the end of the last modeled reach (Twin Bridges sampling location) become the boundary conditions for the WASP model, which simulates water quality of Gulf Island Pond. Each prediction run is a two step process involving both models.

In Gulf Island Pond, the river is classified as C requiring the daily minimum dissolved oxygen not be less than 5 ppm and 60% of saturation. New legislation states that dissolved oxygen readings below a point 0.5 meters from the bottom of the pond and below the point of thermal stratification[10] (bold face line in Figures 12 - 21) should not be considered in a compliance evaluation for dissolved oxygen. The DEP is applying the 30-day average dissolved oxygen of 6.5 ppm only at temperatures less than or equal to 24 ^{o}C on the Androscoggin River in order to meet the present narrative standards in class C water quality criteria listed at 38 MRSA &465 4 (b).

Model prediction runs in Gulf Island Pond were made for five different cases. The model prediction run results are presented in schematics of the pond similar to the format followed in the 2002 modeling report (Figures 12-21). The following is a summary of model prediction run results.

1. Current licensed loading of point sources and current oxygen injection requirements at one injection location at Upper Narrows.
    - Non-attainment of DO criteria occurs from a depth of 10 to 60 feet for periods of time during the summer at some locations (Figures 12 and 13).

2. TMDL loads implemented, but with only current oxygen injection requirements at one injection location at Upper Narrows.
    - Non-attainment of DO criteria occurs from a depth of 20 to 60 feet for periods of time during the summer at some locations (Figures 14 and 15).

3. TMDL loads implemented with additional oxygen injection involving two injection points; one at Upper Narrows and the other at Lower Narrows.
    - DO criteria can be met everywhere above the thermocline with oxygen injection rates of 30,000 ppd at Upper Narrows and 150,000 ppd at Lower Narrows assuming an oxygen transfer efficiency of 1/3 (Figures 16 and 18). This is the default oxygen injection strategy.
    - DO criteria can also be met everywhere above the thermocline with oxygen injection rates of 105,000 ppd at Upper Narrows and 105,000 ppd at Lower Narrows assuming an oxygen transfer efficiency of 1/3 (Figures 17 and 19). This is an alternate oxygen injection strategy.

[10] The point of thermal stratification (thermocline) is defined as the depth where a change in water temperature of greater than 1^{o}C per meter of depth occurs.

4. TMDL loads implemented with additional oxygen injection involving three injection points - Upper Narrow, Lower Narrows, and just above the Deep Hole.
   - DO criteria can be met everywhere above the thermocline with oxygen injection rates of 50,000 ppd at Upper Narrows, 65,000 ppd at Lower Narrows and 42,000 ppd above the Deep Hole assuming an oxygen transfer efficiency of 1/3 (Figures 20 and 21). This is an alternate oxygen injection strategy.

5. Point Sources at Zero-Discharge with and without oxygen injection
   - With no oxygen injection, DO criteria can only be maintained to a depth of 30 feet for periods of time during the summer at some locations (Figures 22, 23).
   - DO criteria can be met everywhere above the thermocline if oxygen is injected at 65,000 ppd at Lower Narrows assuming an oxygen transfer efficiency. of 1/3 (Figures 24, 25).
   - DO criteria can also be met everywhere above the thermocline if oxygen is injected at 105,000 ppd at Upper Narrows assuming an oxygen transfer efficiency. of 1/3 (Figures 26, 27).

In the 7-day and 30-day model simulations, one default and two alternate aeration strategies needed to meet the TMDL are presented. Many other designs are also possible. The strategies presented assume an oxygen transfer efficiency of 1/3 to the water column which is the estimated efficiency of the current oxygen injection system. The efficiency of the current system could be greatly improved so that lesser amounts of oxygen injection are possible. A third alternate aeration strategy is included indicating that many other systems are possible, but must have DEP approval to assure that dissolved oxygen criteria within Gulf Island Pond will still be maintained and no localized problems within the river will occur. DEP plans to include language in the licensing of waste discharges that allows flexibility provided that other designs are DEP approved.

In any of the prediction runs, the model predicts some non-attainment of DO criteria in the deeper segments directly above the oxygen diffuser located at Upper Narrows as indicated in an excerpt of the pond schematic shown below.

Model Schematic of Segments 8 - 16

[shaded box] Segments with predicted DO non-attainment

Turner Bridge		Upper Narrows
8	11	14
9	12 (shaded)	15
10	13 (shaded)	16

The non-attainment predicted in these two segments is believed to be not representative of actual conditions. The model calibration points were at Turner Bridge (model segments 8, 9, 10) and Upper Narrows (model segments 14, 15, 16). The DO non-attainment is predicted in segments in-between these two points (model segments 12, 13). The predictions for low DO on many other deep locations closer to the dam has been verified by actual data. The sampling location in 2004 was set up above the oxygen diffuser or an area represented in the model by segments 11, 12, and 13. DO readings here attained class C minimum and 30-day average DO criteria all summer. It is recommended that monitoring continue here in the future to confirm that this would also be the case during a summer low-flow and high temperature conditions.

TSS TMDL

Total suspended solids (TSS) are relevant to the TMDL to Gulf Island Pond due to its contribution to the sediment oxygen demand of Gulf Island Pond. TSS is also the pollutant of concern to water quality in the Livermore Falls impoundment where it contributes to aquatic life non-attainment. Two separate TMDL's will be set for TSS based upon both of these factors.

The TSS TMDL for Gulf Island Pond is needed to assure sediment oxygen demand will not significantly increase. The phosphorus TMDL is also important for controlling sediment oxygen demand. A calculation process for determining the various components of sediment oxygen demand in Gulf Island Pond is explained in detail in the Androscoggin River Modeling Report (June 2002). The TSS loads that originate from the April 15, 2003 modeling are used as a basis for determining the TMDL. The mill loads are then proportionally reduced to allow for a 10% explicit margin of safety. The oxygen injection requirements outlined in the proceeding section are a necessary component of the TMDL for both TSS and CBODu. A summary of the TSS TMDL and a sample allocation method is outlined below (Table 10). This TMDL addresses the accumulation of solids over a long time period and their contribution to sediment oxygen demand. Such analyses are typically undertaken over an annual time scale and hence the TMDL is expressed as an annual average.

Table 10 Gulf Island Pond TSS TMDL as Annual Average ppd with Default and Alternate Allocations							
Source	Allocations at Outfall			Assimilation	Allocations at Twin Bridges		
	Default = Impact	**Alternate #1** 4/15/2003	**Alternate #2** = ppd	% Remaining Twin Bridges	**Default** = Impact	**Alternate #1** 4/15/2003	**Alternate #2** = ppd
NPS					47907	47907	47907
Fraser	18959	16170	16283	71.0%	13461	11481	11561
Mead	15836	12170	16283	85.0%	13461	10345	13841
IP	14630	20170	16283	92.0%	13460	18556	14980
Berlin	660			Municipal Discharges are grouped in the TMDL due to their de-mimimus impact upon dissolved oxygen levels within Gulf Island Pond .			
Gorham	188						
Bethel	75						
Rumford-Mexico	663						
Livermore Falls	500						
Total Municipal	2086			82.0%	1711	1711	1711
WLA = Point Sources				**42093**	**42093**	**42093**	**42093**
LA = Non-point Sources				**47907**	**47907**	**47907**	**47907**
Explicit Margin of Safety 10%				**10000**	**10000**	**10000**	**10000**
TMDL Total				**100000**	**100000**	**100000**	**100000**

Implementation of TMDL in Licensing

Point Source	Licensing Recommendation	Comment
Berlin Gorham Bethel Rumford-Mexico Livermore Falls	License as technology-based limits (BPT) year round.	Municipal discharges have a de-minimus impact to sediment oxygen demand and dissolved oxygen levels in Gulf Island Pond
Fraser Paper MeadWestvaco International Paper	Implement TMDL as an annual average TSS limit. This will limit mill discharges to current levels to assure that sediment oxygen demand within Gulf Island Pond does not increase.	The paper mills have significant impact to sediment oxygen demand and dissolved oxygen levels in Gulf Island Pond.

Summary of Allocation Method.

1. The annual TSS TMDL is needed to assure that sediment oxygen demand levels in Gulf Island Pond do not increase.
2. Use paper mill loads based upon 4/15/03 paper mill modeling request or impact to Gulf Island Pond as initial basis.
3. Municipal allocations are technology based loads (design flow @ 30 ppm).
4. Paper Mill loads are reduced from 4/15/03 basis to preserve explicit MOS.

The TMDL for TSS in the Livermore Falls impoundment uses macro-invertebrate sampling and a linear discriminate model to determine attainment / non-attainment status. The TSS loads discharged to the Androscoggin River during the time that rock basket samplers for macro-invertebrates were placed in the river are compared to attainment / non-attainment status of aquatic life criteria. Model runs were made by Qual2EU to determine actual TSS loads to the Livermore Falls impoundment. The Qual2EU model accounts for TSS lost in the river through settling from the point of discharge to the Livermore Falls impoundment. A TSS settling rate of 0.10 per day was used in the model runs. This rate was calibrated with actual data (see Androscoggin River Modeling Report, June 2002). A summary of conditions and results during aquatic life sampling are as follows:

Table 11 - Conditions During Aquatic Life Sampling							Aquatic Life Criteria Status Class			
	Flow Rumford cfs	Temp Jay ^{o}C	Intermittant Drainage CFSM*	Int Paper TSS PPD	Mead WV TSS PPD	Fraser TSS PPD	Liv Falls Imp	Lower Otis Imp	Upper Otis Imp.	Upper Middle Jay Imp.
June- Aug 95	1920	23.5	0.48	19804	10607	8133	N/A	N/A	N/A	B
Aug Sept 96	2715	20.6	0.62	5750	6398	10100		C	B	B
June-Aug 00	2432	20.7	0.97	9300	4920	10012	C	C	B	B
July Aug 02	2040	24.0	0.58	9100	4000	2062	N/A	C	C	B
June Aug 03	2370	22.4	0.90	10700	5120	7304	C	C	B	B
July-Aug 04	2440	23.1	0.88	7650	3800	10227	B			

*CFSM = Cubic feet per second per square mile of drainage. N/A = Non-attainment of Class C

It can be observed that class C aquatic life criteria were not met in the summers of 1995 and 2002, the two years of lowest mean flow during the sample period. A summary of actual loads to the Livermore Falls impoundment during each of these years is as follows:

Table 12 - TSS Loads in ppd to Livermore Falls Impoundment - Class C						
	Fraser	Mead WV	Int. Paper	Non-Point	Total	Aquatic Life Status
June- Aug 95	4659	8295	19804	7200	40258	Non-attainment
June-Aug 00	5735	3773	9300	11400	30508	C
July Aug 02	965	3014	9100	7900	21279	Non-attainment
June Aug 03	4118	3976	10700	10200	29294	C
July-Aug 04	6305	2852	7650	7700	24807	B

In the total loads estimated to the Livermore Falls impoundment, the municipal contribution is assumed to be about 300 ppd. Data collected in 1999 are used to assign the boundary TSS concentration in Berlin of 1 ppm. Non-point TSS concentrations are assumed to be consistent in any given summer that was analyzed. The differences in non-point source TSS loads from year to year are due to differences in river flow. When river and tributary flows are higher, non-point TSS loads are higher.

When total TSS loads are compared to the evaluations of aquatic life criteria, the 2002 assessment appears inconsistent with assessments in 2000, 2003, and 2004. The lowest TSS load to the Livermore Falls impoundment occurred in 2002, yet non-attainment of class C aquatic life criteria occurred in that summer. The TSS loads that occurred in 2000 and 2003 are about 40% higher but class C aquatic life criteria were met in those years. In the summer of 2004, the TSS load to the Livermore Falls impoundment was 16% higher than 2002, but class B aquatic life criteria was met in 2004. River flow was about 16% to 19% lower in 2002 compared to the other three years, but this difference is probably not large enough to explain the apparent inconsistency in the 2002 results of macro-invertebrate sampling. Another factor DEP has considered to explain the aquatic life non-attainment in 2002 is the lack of a large runoff event that could help to flush the river bottom of solids that have settled onto benthic organisms (Figure 28). The summers of 2003 and 2004 contained a number of runoff events that could have potentially flushed the river and cleansed the bottom of settled solids. The rock baskets used for macro-invertebrate sampling were typically placed in the Androscoggin River in the months of July and August. It is possible that very large flushing events that occurred in June prior to the placement of samplers could also have flushed the river bottom.

The summer of 2000 contained only one large runoff event in July to August. It is unlikely that the moderately elevated flow from this one event would be enough to flush the river bottom. The summer of 2002 started with very high flows in June up to mid-July and an extended period of virtually no run-off from mid July to the end of August. A similar summer lacking runoff occurred in 2001, although no macro-invertebrate sampling occurred that year. Without additional macroinvertebrate data collected under low flow and low runoff, it is difficult to explain the apparent contradiction of the 2000 and 2002 aquatic life evaluations, and the relationship of TSS and flow to aquatic life attainment.

For this TMDL calculation, a phased implementation will be used in which the 2002 data will not be used to set an initial TMDL until more data can be collected at summer low flow conditions to confirm whether or not the lack of flushing also contributes to aquatic life non-attainment. After the collection of an additional aquatic life data set and evaluation of attainment status at extended low flow conditions, the TMDL should be re-evaluated. It is suggested that if extended low flow conditions look likely in any given summer, that hydrologic flushing of the impoundment also be investigated as a possible implementation strategy.

Another possible explanation for the apparent inconsistency in the data is that shorter term peaks of TSS from the mills results in non-attainment of aquatic life criteria through an acute event rather than a chronic event such as sixty days that is being used as the averaging time period of the TMDL. It is suggested that this possibility be further explored in the phased implementation of the TMDL when causes to aquatic life non-attainment status are being investigated in the future.

The TMDL uses a clustering factor of 1.06 to account for the unlikelihood of all point sources discharging their maximum 60-day average TSS simultaneously in any given summer. This clustering concept is similarly used in the phosphorus and CBODu TMDL's and the reader should refer to these sections for a more detailed explanation. An explicit margin of safety of 10% is applied to the total TMDL. The following TMDL for TSS in the summer (June to September) results using the other four years. One default allocation based upon impact to the Livermore Falls impoundment and two possible alternate allocation methods are presented. A 60-day averaging period is used due to the time period required for the samplers used to evaluate aquatic life attainment status.

Table 13 Livermore Falls Impoundment TSS TMDL as a 60-Day Average ppd (June-Sept) with Default and Alternate Allocations

	TSS Allocations at Outfall in ppd			Assimilation	TSS Allocations at Livermore Falls ppd		
Source	**Default** = Impact	**Alternate #1**	**Alternate #2** = PPD	% Remaining Twin Bridges	**Default** = Impact	**Alternate #1**	**Alternate #2** = PPD
NPS					7800	7800	7800
Fraser	16600	14800	11060	50.0%	8628	8385	5530
Mead	11000	10000	11060	75.0%	8628	7500	8295
IP	8300	10000	11060	100.0%	8628	10000	11060
Berlin	660			Municipal Discharges are grouped in the TMDL due to their de-mimimus impact upon dissolved oxygen levels within Gulf Island Pond .			
Gorham	188						
Bethel	75						
Rumford-Mexico	663						
Municipal*	1587	1587	1587				
Total TMDL WLA (Point Sources) with clustering factor					25885	25885	25885
WLA =Point Sources reduced by clustering factor					**24420**	**24420**	**24420**
LA = Non-point Sources + Natural					**7800**	**7800**	**7800**
Explicit Margin of Safety (10%)					**3580**	**3580**	**3580**
TMDL Total					**35800**	**35800**	**35800**

Implementation of TMDL in Licensing

Point Source	Licensing Recommendation	Comment
Berlin Gorham Bethel Rumford-Mexico Livermore Falls	License as technology-based limits (BPT) year round.	Municipal discharges have a de-minimus impact to aquatic life in the Livermore Falls impoundment.
Fraser Paper MeadWestvaco International Paper	Implement TMDL as 60-day average TSS limit from June - Sept. Require ambient monitoring of aquatic life. Require the investigation of hydrologic flushing in the Livermore Falls impoundment.	The paper mills affect aquatic life criteria attainment in the Livermore Falls impoundment.

Summary of Allocation Method.

1. The 60-day average TSS TMDL is needed to meet aquatic life criteria in the Livermore Falls impoundment.
2. Paper mill loads discharged during aquatic life sampling used as basis to set paper mill limits.
3. Municipal allocations are technology based loads (design flow @ 30 ppm).
4. A clustering factor of 1.06 is applied to the TMDL to account for the unlikelihood of all point sources discharging their summer 60-day average maximums simultaneously. Clustering factor is derived from the mill discharge monitoring reports.
5. An explicit margin of safety of 10% is applied to the total TMDL.

The TMDL splits the difference of TSS loads known to cause aquatic life non-attainment (40258 ppd) and loads that did not cause non-attainment (30508 ppd). Summer macroinvertebrate sampling will be a yearly requirement until more data can be collected during extended low flow conditions.

Table 13 provides a default TSS allocation for the three paper mills based upon equal impact to the Livermore Falls impoundment and two other alternate allocation methods. Other allocation methods are also possible. Pollution trading between the paper mills or municipal point sources is also a possibility. The trading ratio for International Paper, MeadWestvaco, and Fraser Paper are presented in Table 14. Note that regulatory agencies can also use the trading ratios to consider different allocations in the licensing process that would still provide an equal amount of protection in the licensing process.

Table 14 - Trading Ratios for TSS as a 60-Day Average

Trading Rules
U=Upstream Point Source
D= Downstream Point Source
T= Ratio stated in table for U vs D.
D gains 1 ppd for T ppd that U gives up.
U gains T ppd for 1 ppd that D gives up.

TSS	Fraser	Mead	IP
Fraser		1.5	2
Mead	1.5		1.33
International Paper	2.0	1.3	

Note:Trading ratios are derived from the ratios of % TSS remaining at Liv. Falls.

Water Quality Model Sensitivity Analysis

In a model sensitivity analysis, parameter rates, or inputs are varied and the model output prediction for variables of interest such as dissolved oxygen or chlorophyll-a are observed and compared with one another. It can then be determined which parameters or inputs are most important for influencing the model's prediction.

The 2002 Modeling Report investigated the importance of sediment oxygen demand, oxygen injection, and paper mill BOD input levels upon the model prediction of dissolved oxygen. Sediment oxygen demand (SOD) was found to be the most important since the model prediction of DO changed the most within given percentages of change for SOD. Varying oxygen injection rates resulted in the second largest response to model prediction of DO and the amounts input for the paper mill BOD inputs resulted in the lowest response of the model DO. This is a useful exercise in showing that reducing pollutants that contribute to SOD (algae, TSS) and oxygen injection are more efficient cleanup actions than reducing paper mill BOD.

The sensitivity analysis undertaken for this report will investigate model responses for predicted chlorophyll-a by varying the following; the OP mineralization rate, light saturated intensity, fraction of dead algae recycled to organic-P, and the boundary ortho-P concentration. The model was run with the OP mineralization rate at 0.02, 0.03, 0.04, and 0.05 per day; the saturated light intensity at 175, 200, 250, and 300 langleys ; the fraction for recycling to organic-P at 0.5, 0.6, 0.7; and boundary ortho-p at 5.5, 6, 7, and 8 ppb. The results show that the model is equally sensitive to changes in the OP mineralization rate and the fraction of dead algae recycled to OP rate, but insensitive to changes in the saturated light intensity (Figures 23 and 24). Within the ranges investigated, the model showed moderate sensitivity to changes in the boundary ortho-P.

Discussion of the Dead River

The Dead River was sampled weekly during the summer of 2004 at two locations, usually on the day after the sampling of the Androscoggin River and Gulf Island Pond. Class B DO criteria were met in the Route 106 sampling location all summer. Non-attainment of class B dissolved oxygen criteria occurred on at least three occasions at the lower sampling station below the dam in Leeds. Algae blooms has also been a water quality issue on the Dead River. During the aerial monitoring of algae blooms by DEP in the summer of 2004, mild algae blooms were observed on the Dead River from the plane on two occasions. In addition algae blooms have been reported on the Dead River in summers subsequent to 2004 by local residents. As will be explained below, the Dead River is a very complex and unique system and much more data collection is needed to fully determine how the system functions.

The temperature data taken at one-meter depth increments in 2004 at both Dead River locations indicates that a high amount of thermal stratification occurs. The thermal stratification appears to be much stronger at the sampling location below the dam. The temperature gradient here from the water surface to the bottom depth of three meters of $5^{o}C$ or more occurred from late July to the end of August. The lack of water movement of the Dead River flow below the dam to the confluence of the Androscoggin River (about one mile in length) is the reason for the strong thermal stratification.

The Dead River is unique from many tributaries in that flow reverses direction during higher flow events.[11] The flow is actually the Androscoggin River backing up the Dead River up to the dam. With the information collected to date, it is still unclear if the Androscoggin River backs up to the Dead River dam at low flow events approaching 7Q10. The dam also impedes flow movement up the Dead River. In this situation, flow released from the Dead River dam is trapped and becomes stagnant. The lack of water movement and stagnation that results is a large contributing factor to the non-attainment of class B minimum DO criteria.

At Androscoggin River flow events exceeding 16,000 cfs, back flow overtops the dam and pollutants from the Androscoggin River may reach Androscoggin Lake. The dam and its three-foot flashboards are part of a DEP and stakeholder management strategy to minimize pollutant loads from the Androscoggin River to Androscoggin Lake. An important part of this strategy is the maintenance of the flashboards to assure that failure of the three foot boards does not occur during a high flow event.

[11] A similar back flow situation occurs in the Little Androscoggin River drainage for Hogan and Whitney Ponds.

The Androscoggin River water temperature is usually warmer than the Dead River water temperature in the latter part of the summer when thermal stratification occurs. When the Androscoggin River is backing up the Dead River during this time, it flows over the surface of the Dead River water released from the dam. The Dead River water is trapped below the Androscoggin River back flow.

Some stakeholders have suggested that point source discharges on the Androscoggin River may be contributing to the dissolved oxygen non-attainment measured below the Dead River Dam. Since larger rivers do not ordinarily influence water quality of their tributaries, with the data collected to date on the Dead River, DEP does not yet support this conclusion. The relationship between the Androscoggin River stage as related to the Dead River stage at low flow conditions is not fully understood. It is critical to obtain the information before any conclusions can be made about the pollutant sources that are likely responsible for the dissolved oxygen depletion on the Dead River.

Point source phosphorus contributions to Androscoggin Lake during backflow events that overtop the dam have been calculated by the DEP lakes assessment section[12] to be only 0.4% of the annual phosphorus load to the lake. Hence regulation of point source phosphorus discharges to improve Androscoggin Lake water quality would not prove to be very effective, since point sources are such a small proportion of the phosphorus load to the lake. In this assessment, the phosphorus loads within the Androscoggin Lake watershed were calculated to be the major source of phosphorus accounting for about 78% of the annual phosphorus load to Androscoggin Lake. Non-point sources originating from the Androscoggin River watershed were calculated to be slightly fewer than 8% of the annual phosphorus load to Androscoggin Lake. Internal loading within the lake is estimated to be about 14% of the annual phosphorus load.

Additional data collection on the Dead River in the future could include the following:

- Stage readings at the Dead River and Androscoggin River confluence and below the Dead River dam to better establish if back flow events occur at low flow conditions.
- DO and temperature profiles, chlorophyll-a, secchi depth, total-P, and ortho-P at additional locations in the Dead River above and below the dam.
- Conductivity profile readings in the Dead River at locations directly above dam and below dam at many locations. Also in Androscoggin River above the Dead River confluence. Conductivity of the Dead River and the Androscoggin River water should be much different and this could help establish what is occurring hydraulically.
- Ultimate BOD on the Androscoggin River above the Dead River confluence and in some locations on the Dead River below the dam.

[12] Androscoggin Lake – Dead River Phosphorus and Hydrologic Loading Analysis, MDEP, August 2003. Estimated provided as percentages of annual phosphorus loads are for the current dam in place with three foot flashboards with the assumption that the flashboards will be maintained to prevent failure.