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June 22, 2009

Guy Scaife, Town Administrator
Town Hall
1 Union Square
Milford, NH 03055-4240

Re: McLane Dam, Pre-Feasibility Evaluation for Hydropower Development

Dear Mr. Scaife:

Please find enclosed the pre-feasibility study letter report for the McLane Dam project. The report includes following sections as summarized below:

1.0 Background
2.0 Federal Energy Regulatory Commission (FERC) Licensing Process
3.0 Fundamentals of Hydropower Generation
4.0 Northeast Hydrodevelopment LLC- Conceptual Plans
5.0 Energy Analysis of Northeast Hydrodevelopment's Conceptual Plans
6.0 Costs of Hydropower Development
7.0 Flooding

The report is written for the layperson to understand the content. However, if you feel further modifications are needed before it is dispersed to the Selectboard and others, please let me know. Please note that although I am sending this via email, one hard copy will be sent to the Town of Milford. I hope this letter report addresses your needs. If you have any questions regarding the enclosed, please feel free to give me a call at 603-529-4400.

Sincerely,

Mark Wamser, PE
Water Resource Engineer

1.0 Background

The McLane Dam (see Figure 1) is located on the Souhegan River and is owned by the Town of Milford. It was constructed in the early 1920s by the Milford Power and Light Company for hydroelectric generation purposes. It was used from the time of construction until the late 1940s by Public Service Company of New Hampshire (PSNH). During that time, the downstream powerhouse contained two turbines totaling 260 horsepower (194 kW). In the 1950s, PSNH signed the facility over to the town.

Figure 1: McLane Dam

From the 1950s to the late 1980s the dam deteriorated and required renovation. In 1988, the town entered into a comprehensive lease agreement with the Northeast Hydrodevelopment Corporation[1] (NHC). Provisions of the lease included the construction and operation of a small hydropower facility at the dam and rehabilitation of the existing dam structure. NHC (the "Licensee") received a license from the Federal Energy Regulatory Commission (FERC, FERC No. 8924) in August 1988 to construct and operate a hydropower facility at McLane Dam. Once the Licensee obtained a license from FERC they initiated construction of the hydropower project. The developer completed Phase I of the project, which included construction of the dam and intake in 1992.

According NHC's preliminary permit application, PSNH who was the purchaser of the power from the site under Rate Order from the New Hampshire Public Utilities Commission went bankrupt. The Federal Bankruptcy Court voided the Power Purchase Contract held by NHC. NHC could not find another buyer for the power, which resulted in the site becoming financially unviable to develop.

In 1994, FERC found the Licensee in violation of the terms and conditions of the license. FERC corresponded with the Licensee on several occasions in 1994, detailing noncompliance with the terms and conditions of the license, including the schedule for project completion. FERC directed the Licensee to

[1] Note that Northeast Hydrodevelopment Corporation was the original Licensee for the project in the late 1980's and early 1990's. The current preliminary permit application was filed by Northeast Hydrodevelopment, LLC. Although the company structure may be different the same person, Norm Herbert, pursued the development of the project previously and today.

request an extension of time to complete the project. On August 5, 1997, the Licensee filed a request to surrender[2] the license for the McLane Dam Project because it was unable to complete the project, which was uneconomical. On November 22, 1999, the license was surrendered. FERC currently has no oversight over the dam; rather oversight has defaulted to the State (NHDES Dam Bureau).

On March 4, 2009, Northeast Hydrodevelopment, LLC (NHLLC) filed a preliminary permit application, pursuant to section 4(f) of the Federal Power Act, proposing to once again study the feasibility of hydropower development at the McLane Dam. On March 23, 2009, NHLLC first met with the town, after the permit application was filed, to discuss a lease agreement for the dam. On May 4, 2009, the FERC issued its Notice of Preliminary Permit Application Accepted for Filing and Soliciting Comments, Motions to Intervene, and Competing Applications and set a deadline of July 3, 2009 for comments and motions to intervene. The town of Milford filed for intervener status on June 10, 2009 given that the town owns the dam and NHLLC must either own the dam or have a lease agreement to operate the facility. FERC will likely grant the town intervener status. An intervener is an official party to a proceeding and has distinct advantages over those who only file comments on a given project. Interveners have the right to:

- Participate in hearings before FERC's administrative law judges;
- File briefs;
- File for rehearing of a FERC decision;
- Have legal standing in a Court of Appeals if they challenge the FERC's final decisioin; and
- Be placed on a service list to receive copies of case-related Commission documents and filings by other interveners.

Souhegan River- Designated River

The New Hampshire River Management and Protection Program (RMPP) was established in 1988 with the passage of RSA 483 to protect certain rivers, called designated rivers, for their outstanding natural and cultural resources. The program is administered by the New Hampshire Department of Environmental Services (NHDES). The RMPP provides certain instream protection measures for designated rivers and a river classification system to match general river characteristics with the specific protection measures. Rivers can be classified as natural, rural, rural-community or community. One of the designated rivers includes the Souhegan River. It is classified as "community" for the river reach that includes McLane Dam.

Per RSA 483:9-b it states the following:

II. The department may approve permits and certificates for the construction, operation, or maintenance of new hydroelectric power facilities at existing or breached dams provided that:

(a) The operational mode of any proposed facility shall be run-of-the-river, with project outflow equal to project inflow on an instantaneous basis and the project does not significantly alter the natural flow characteristics of the river; and

(b) The proposed facility does not provide for diversion of the river or segment above or below the existing dam for a significant distance; and

[2] To surrender the license, the Licensee must undergo a formal process with the FERC and regulatory agencies. Surrending the license means that the Licensee will forego developing the site further.

(c) The height of the impoundment is constant and, for existing or breached dams, is not raised above the maximum historic level of impoundment at that site.

What is unclear at this juncture is the interpretation of (c) above for McLane Dam-- specifically what is considered the maximum historic level at McLane Dam? Over the past few decades the "historic" level was the spillway crest. Previously, there may have been flashboards. The answer to this question may impact a hydropower developer's ability to affix flashboards to the spillway crest as it could raise the maximum "historic" level of the impoundment.

2.0 Federal Energy Regulatory Commission (FERC) Licensing Process

If FERC issues a preliminary permit to NHLLC they will have three years in which to conduct a detailed feasibility study and complete studies requested by state and federal agencies, and other interested parties. The following section is provided to give the town a sense of the next steps in the process and their level of participation in the process. Generally the process includes the following major milestones[3]:

- The Licensee must develop what is called a Pre-Application Document (PAD) that summarizes the proposed operation, existing environmental resources, cultural resources, recreation resources, streamflow data and include a list of proposed studies. The Licensee is required to list those studies they feel are necessary to evaluate the impact of hydropower construction and operation on various resources. Licensees address the proposed studies section of the PAD differently. Some Licensees who have been working with regulatory agencies for years and understand the FERC process are proactive and list studies that are rightfully needed. Other Licensees will take a minimal approach and list few, if any, studies--- this is commonly done because the Licensee is striving to reduce the overall cost of the project. As noted in the next bullet, listing few studies does not mean that the Licensee will only conduct the studies proposed. The Licensee is required to consult with agencies to resolve the proposed studies and level of effort required.

  In summary, the PAD is a summary of readily available data of the project. The PAD will be provided to state and federal agencies, the town, and any other interested party.

- Following issuance of the PAD, the Licensee is required to hold a site inspection and public meeting. The site visit is held to familiarize parties with the project. Typically, there is a day-time meeting for agency personnel, and an evening meeting with the public. The meetings provide parties an opportunity to voice their issues and concerns with the proposed project, and to ask questions of the Licensee.

- After the site visit/public meeting, FERC will establish a deadline in which parties can submit letters to the FERC identifying their issues, concerns and identify what studies they feel should be conducted. Typically, agencies and other interested parties will request the Licensee to conduct various studies aimed at evaluating the impact of project construction and operation on various resources. Interested parties will file a letter with FERC identifying what studies they feel are necessary. This will be an opportunity for the town to request studies. For example, the town could request the Licensee to conduct a study that demonstrates how the installation of flashboards could contribute to increased inundation under normal and flood flows above the dam.

- The next step in the process is the Licensee must develop proposed study plans (PSP) that either address the stakeholder study requests, or provide rationale why a given study is not warranted. The PSP's generally summarize the methods, procedures and level of effort to complete any field studies. The Licensee's PSP's are provided to FERC, agencies, and other interested parties for review and comment. A meeting is then required whereby the Licensee summarizes their various PSP's and stakeholders provide further comment. After this study plan meeting, FERC, agencies and other interested parties can again provide written comments on the PSP's. The Licensee again reviews the comment letters and develops final study plans (FSP's). Absent further comments from any interested party on the FSP's, FERC will formally approve the study plans. If a conflict remains relative to a given study, FERC has a procedure called Dispute Resolution—typically

[3] Note that the bulleted list is not meant to be a detailed, but generally summarized only the major milestones in the licensing process.

projects do not require Dispute Resolution. Assuming the study plans are approved, the Licensee is required to conduct the studies according to the approved study plans. Typically, the studies are conducted over the summer and reports are prepared in the fall/winter.

- After studies are completed, reports are developed and must be shared with interested parties. Another meeting is required to review the reports, and parties are provided an opportunity to file comments on the studies with the FERC. The Licensee must formally address any comments on the reports.

- The Licensee will develop a Draft License Application that summarizes the project, the study results, and includes a detailed description of the project with drawings. Again, the agencies, town and other interested parties will have the opportunity to provide comments on the Application.

- There are several other smaller milestones during this period, but eventually FERC will issue a license for the project. Generally, FERC allows the Licensee up to four years to construct and have the project producing power.

3.0 Fundamentals of Hydropower Generation

The following section provides basic background on how hydroelectric project produce power.

3.1 Hydropower Generation Potential

The amount of generation (in kilowatts, kW) at a given hydropower project is a directly related to three variables as explained in the formula below:

$$P=\frac{Q*H*E_s}{11.8}$$

Where:

- P=Power (units- kilowatt, kW)
- Q=Turbine Discharge (units- cubic feet per second, cfs). The higher the turbine flow the greater the generation.
- H=Net Head (units- feet). The higher the net head the greater the generation. There is a difference between gross head and net head. Gross head refers to the vertical distance between the impoundment water level and the tailrace[4] elevation as shown in the Figure 2 below. Net head is less than the gross head. Net head accounts for headlosses between the powerhouse intake and the tailrace. Headlosses are associated with the trashracks, elbows, contractions, expansions, friction losses in penstocks, etc.
- E_s=Turbine/Generator Efficiency (%). The higher the turbine efficiency the greater the generation. It should be noted that turbines have a range of efficiencies that vary with the magnitude of flow passing through the turbine as well as the net head. Typically, a hydropower turbine has an optimal setting where the efficiency is highest- this is commonly referred to as "best gate". Efficiencies above and below best gates will be less.
- 11.8=Constant for English/Metric conversion

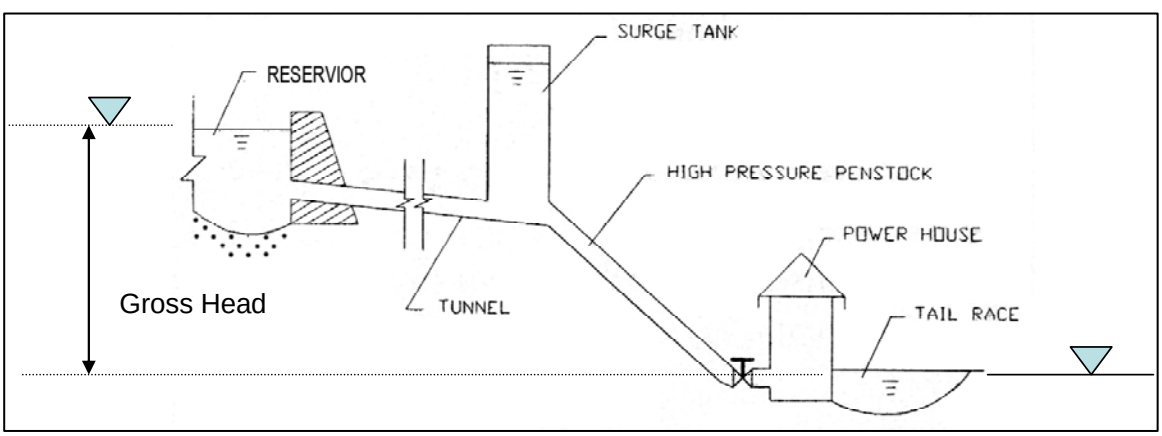

Figure 2: Schematic showing gross head at a hydropower station

[4] The tailrace is located immediately below where the turbines discharge back into the river.

3.2 Hydropower Operation

Most hydropower facilities typically operate as either "peaking" or "run-of-river" facilities. A peaking hydropower project normally has significant reservoir storage (more than available at McLane Dam); the storage is used along with inflow to the dam to generate at full turbine capacity during hours of the day when the price of power is high. Peaking operations typically result in lowering the reservoir water level through generation during periods of high energy prices. Water levels are lowered as the available inflow as well as reservoir storage is used to operate the turbine(s) at best gate. When the price of power is less, the turbine discharge is reduced allowing the inflow to refill the reservoir until the next peak cycle.

Alternatively, a run-of-river project does not utilize reservoir storage to supplement inflow for generation. Instead the hydropower facility relies solely on the available inflow to generate electricity. Under run-of-river operations the impoundment water level is not purposely fluctuated.

It is important to understand the distinction between peaking and run-of-river facilities as they are designed differently and have different environmental impacts. Peaking projects have greater environmental impacts due to the fluctuation of reservoir water levels and turbine discharges below the hydropower facility. In contrast, run-of-river facilities maintain relatively constant reservoir levels and the discharges below the hydropower facility generally match the inflow to the dam.

Based on NHLLC's preliminary permit application, they propose to operate the McLane Hydropower Project as a run-of-river facility.

3.2 Factors Impacting Hydropower Generation

As noted in the formula above, two factors that can influence generation is turbine flow and net head. Below is a description of flows that will not be available for generation and how the head can be increased.

Flow

Hydropower facilities operate over a range of flows; however, not all of the inflow into McLane Dam will be available for generation. When the inflow to McLane Dam exceeds the maximum hydraulic capacity of the turbine(s), or is less than the minimum hydraulic capacity of the smallest turbine, the water is spilled and is not available for generation. For example, say the maximum and minimum hydraulic range of a fictitious turbine were 100 and 20 cfs, respectively. If inflow was 300 cfs, then 200 cfs would be spilled, while 100 cfs would be passed through the turbine. Alternatively, if inflow was 10 cfs, then all 10 cfs would be spilled and no generation would occur.

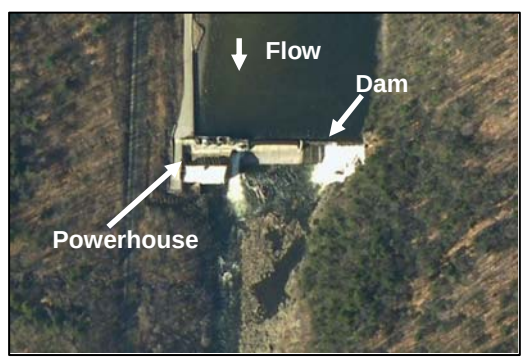

Figure 3: Example of Powerhouse Integral to the Dam

Other flows that would not be available for generation may include minimum flows below the dam for the protection of aquatic resources. The location of the powerhouse (which contains the turbines) will dictate whether a minimum flow is required. Shown in Figure 3 is a powerhouse that is integral to the dam. Thus, if the facility operates as run-of-river, whereby inflow to the dam equals outflow, the river below the dam will remain wetted.

Shown in Figure 4 is a powerhouse located further downstream of the dam. The purpose for locating the powerhouse further downstream is to increase the available head due to the natural drop in topographic relief---increasing the head will yield greater generation. This type of physical layout creates what is called a bypass reach. Unless a minimum flow is passed at the dam into the bypass reach, the riverbed would be dry when if all of the inflow is passed through the powerhouse. The state and federal agencies will require that a minimum flow be maintained in the bypass reach to protect aquatic resources. Some hydropower developers install a smaller turbine integral to the dam to generate with the minimum flow; absent a small turbine the minimum flow would be spilled (unavailable for generation). As described later, based on NHLLC's preliminary permit application, they may install a turbine integral to the dam to generate with any minimum flow requirement. Note that in the previous licensing proceeding, the agreed upon minimum flow below McLane Dam was 34 cubic feet per second (cfs) when the powerhouse was positioned further downstream of the dam. If the powerhouse is integral to the dam, then a minimum flow may not be required. Note that although 34 cfs was the agreed upon minimum flow in the previous licensing, the agencies will likely want to revisit this issue.

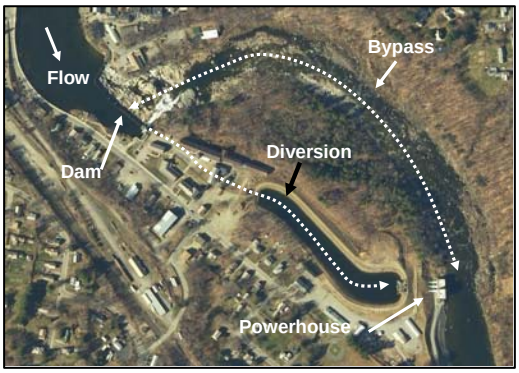

Figure 4: Example of Powerhouse Located Downstream of Dam

With the removal of the lowermost dam on the Souhegan River, the former Merrimack Village Dam, McLane Dam now represents the first barrier for upstream fish passage. Diadromous[5] fish can now move up the Souhegan River to McLane Dam. Fish passage is provided on the only two dams between McLane Dam and the Atlantic Ocean. These two dams are located on the Merrimack River. What is uncertain at this juncture is if the state and federal agencies will require upstream fish passage facilities as part of the hydropower development project. An upstream fish passage facility would be operated during the fish migration season, as described later. In order to pass fish through a fish ladder, flow is required to "attract" fish to the entrance and in the ladder to permit fish passage. The "attraction" flow would be unavailable for generation.

Head

As noted above, more head translates to greater generation. The options to increase head at the McLane site could include increasing the impoundment water level, and/or locating the powerhouse further downstream.

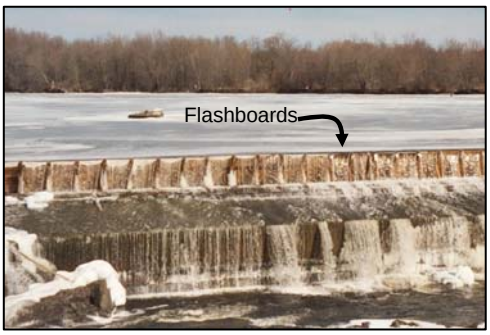

Figure 5: Example of Dam with Flashboards

To increase the water level of the impoundment, flashboards could be added to the dam as shown in Figure 5. Flashboards heights can vary, but are typically 2-3 feet in height and are added to the spillway crest elevation to increase the available head. As noted below, NHLLC is proposing to affix 3-foot flashboards, which will increase the water level upstream and thus inundate additional lands. What is unclear is whether the town of Milford currently has flowage rights to the additional lands that would be inundated with three

[5] Diadromous fish are those that migrate between freshwater and saltwater. The majority of diadromous fish (exception being American eel) migrate to freshwater to spawn in the spring and return to saltwater in the fall. Diadromous fish could include river herring, American shad, Atlantic salmon, sea Lamprey American eel and others.

feet of flashboards. To make this determination further research is needed relative to: a) property deeds and b) perhaps past historical documents on the dam may yield information on flowage rights.

4.0 Northeast Hydrodevelopment, LLC – Conceptual Layouts

In their preliminary permit application, NHLLC provided two conceptual layouts for the hydropower facilities as summarized below.

Alternative A- In NHLLC's first preliminary conceptual design (Development Scheme "A"), either a power canal or penstocks would be used to channel water from the outlet facilities to a powerhouse located approximately 80 feet downstream. Two or three submersible or tubular type turbine-generator sets (with an aggregate capacity of approximately 425 cfs at a gross head of 13.5 feet) would produce approximately 325 kilowatts (KW) of power. Three feet of flashboards would be added to the spillway crest of the dam. Approximately 150 feet of tailrace below the powerhouse would be excavated to develop the maximum hydraulic capacity for the site. Overhead conductors, approximately 500 ft long, would be installed to facilitate a single electrical interconnection to an existing PSNH 13.2 KV distribution line adjacent to the site.

NHLLC estimates that Alternative A can produce up to 1,400,000 KWH (kilowatt hours) of power per year.

Alternative B- In NHLLC's second preliminary conceptual design (Development Scheme "B"), generating facilities would be installed in a newly constructed powerhouse situated at the end of an 1000-ft long penstock to be laid from a point below the existing outlet works at the East abutment to the powerhouse terminus in the channel of the river near the most southeasterly part of the uninhabited "Souhegan Island". Two or three submersible or tubular type turbine-generator sets (with an aggregate capacity of approximately 425 cfs at a gross head of 18 feet) would produce approximately 450 KW at nameplate capacity. Three feet of flashboards would still be added to the spillway and approximately 150 feet of tailrace below the powerhouse would be excavated to develop the maximum possible hydraulic head. Approximately 500 ft of overhead conductors would be installed to facilitate a single electrical interconnection the PSNH "Milford Switchyard" adjacent to the site.

NHLLC estimates that Alternative B can produce up to 1,900,000 KWH of power per year.

Under Alternative A and B, a minimum flow turbine (referred to as an environmental turbine in NHLLC's permit application) would be located at the dam to pass the minimum flow in the bypass reach. What is unclear at this juncture is whether the hydraulic capacity of the turbines- cited by NHC as 425 cfs for Alternatives A and B- includes the flow through the minimum flow turbine. For purposes of our energy analysis, described below, it was assumed that the minimum flow would be included within the 425 cfs.

5.0 Energy Analysis Northeast Hydrodevelopment's LLC Conceptual Plans

The purpose of this section is to conduct an independent analysis of the energy potential of the site and compare it to NHLLC's estimates.

Souhegan River Hydrology

The drainage area at McLane Dam is reported to be 138 square miles. Located further downstream of the dam is a United States Geological Survey (USGS) gage that records streamflow on the Souhegan River in Merrimack, NH. The gage has a drainage area of 171 square miles. To estimate flows at the McLane Dam, flows at the USGS gage were adjusted by a ratio of drainage areas (138/171 or 0.81). For example, if the flow recorded at the USGS gage was 100 cfs, the estimated flow at McLane Dam would be 81 cfs (0.81 x 100 cfs). The USGS gage has been active since Jul 1909-Sep 1976 and Oct 2002-Sep 2008.

Using the estimated daily flows at the McLane Dam, a flow duration analysis was conducted using the full period of available record. Note that the flow duration analysis was necessary to conduct the energy analysis. A flow duration analysis provides the percentage of time a given flow is equaled or exceeded for the period of available streamflow. A flow duration curve is developed by ranking all the mean daily flow data for the period of record according to discharge. The percentage of the daily flow equal to or greater than a measured flow, termed the "percent exceedence", is calculated. Shown in Figure 6 is the annual flow duration curve at the McLane Dam. For example, a flow of 100 cfs is equaled or exceeded 57% of the time in the Souhegan River at McLane Dam.

Sizing of Facility Capacity

As a general rule of thumb, hydropower facilities are designed close to the 20% exceedence flow, which in this case is approximately 343 cfs (see Figure 6). Sizing turbines to cover flows higher than the 20% exceedence flow will result in greater expenditures for equipment and overall development. The capital cost of a hydropower facility increases as the size of the facility increases. NHLLC is proposing to size the total turbine capacity at 425 cfs, which is equivalent to approximately the 15% exceedence flow. Sizing the facility to the 15% exceedence flow is not unrealistic; however it is yet to be determined if this size project will be economically feasible. Note that NHLLC will conduct an energy and economic analysis to determine:

- The estimated cost to construct a 425 cfs hydropower facility;
- The estimated revenue that would be produced by a 425 cfs hydropower facility;
- The payback period— in general this represents the number of years before the hydropower facility turns a profit.

Note that investors have different payback periods. Generally, larger utilities will invest more upfront to construct a larger facility, which has a longer payback period. Alternatively, independent power producers may not have as much upfront money and will invest in a smaller project, which the goal of having a faster payback period. If the economic analysis shows that it will take several years to payback the development of a 425 cfs hydropower facility, then NHLLC may evaluate a smaller size hydropower station—with the goal of having a faster payback. The bottom line is that the size of the facility is very preliminary at this juncture, and presumable NHLLC will be conducting detailed economic analyses as the project proceeds.

Note it was assumed that the minimum flow turbine, which would be located integral to the dam, is included within the total turbine capacity of 425 cfs. For purposes of this analysis, we have assumed that the minimum flow unit would be sized to operate at 34 cfs, the minimum flow noted in the previous

license. For energy analysis purposes, we assumed that the minimum flow turbine could operate as low as 40% of the design flow of 34 cfs (or 14 cfs).

In summary, all inflows between 14 cfs (the lowest flow to operate the minimum turbine flow) and 425 (maximum turbine flow) would be used for generation. Inflows to the dam less than 14 cfs or greater than 425 cfs would be unavailable for generation—these flows would be spilled at the dam.

Fish Passage Flows

As noted above, if fish passage facilities are ever required at McLane Dam, an "attraction" flow is required to encourage fish to seek the entrance of the fish ladder. Although site specific requirements vary, typical attraction flows are 2 to 3% of the station hydraulic capacity for an upstream fishway and 2% for a downstream fishway. In this case, the attraction flow for upstream passage could range from 9 cfs (2% of 425 cfs) to 13 cfs (3% of 425 cfs). Note that the attraction flow is not available for generation. Generally, a fish ladder would operate in the spring when the majority of diadromous fish are moving upstream. Also, downstream fish passage typically occurs in the fall when juvenile diadromous fish are moving downstream to the ocean. The agencies will be concerned with the potential of entraining (sucking into the turbine) or impinging (fish getting caught again the trashracks) fish. Downstream fish passage must be provided and upwards of 9 cfs will be necessary to pass fish downstream.

Because it is unknown if fish passage facilities will be required at McLane Dam, for purposes of this study, we have not accounted for the attraction flow, and passage flows in the energy analysis.

Available Head

NHLLC indicated that the estimated gross head for Alternatives A and B were 13.5 feet and 18 feet respectively. The gross head estimates are based on 3 feet of flashboards being added to the spillway crest. As noted above, gross head does not account for headlosses. Headlosses occur between the trashrack[6] intake and the discharge location of the turbines. Headlosses could be attributable to trashracks, penstock friction, elbows, bends, constrictions, expansions, etc. Absent any drawings, headloss estimates can not be estimated and thus, we assumed a reduction in the gross head of 1 foot. Thus, for purposes of our preliminary energy analysis, we assumed a constant net head for Alternative A and B as 12.5 and 17.0 feet, respectively.

Note that the spillway crest elevation at McLane Dam, as reported in FERC's previous Environmental Assessment for the project, is 230 feet. The addition of 3-foot flashboards will raise the water level behind the dam to 233 feet. The net head at a given project will change with flow. As noted above, head is a function of the headpond elevation and the tailrace elevation. When flows are higher, the water level behind the dam will rise to some value greater than 233 feet. Similarly, the tailrace elevation will also rise. In summary, the net head will vary with flow; however, for purposes of estimating generation at the site, a constant net head was used.

Turbine Efficiency

Turbine efficiencies vary with head and flow. Typically, turbines are designed for a "best gate" setting, which yields the optimal turbine efficiency. Turbine discharges above and below the optimal turbine efficiency will have lower efficiencies. For purposes of estimating generation, a constant turbine efficiency of 85% was used over the range of head and flow conditions.

[6] Trashracks are located at the entrance to the hydropower facility to prevent debris from entering the turbine(s).

Average Annual Energy Generation

Based on the estimated constant net head, available flow, and constant turbine efficiency, the average annual generation was computed using the average annual flow duration curve data for Alternatives A and B. Shown in Figure 7 is the average annual flow duration curve at McLane Dam showing the volume of water available for generation. Figure 7 also shows the maximum and minimum turbine capacities.

We evaluated Alternatives A and B assuming a net head of 12.5 ft and 17.0 ft, respectively. Both of these alternatives assume that 3 feet of flashboards would be added to the dam. We also evaluated Alternatives A and B assuming no flashboards are added to the dam. Thus, we have included Alternative A2 and B2 assuming net heads of 9.5 ft and 13.0 ft, respectively.

Hydropower facilities do not operate 24 hours/day, 7 days/week. Even when there is sufficient flow available, the turbine may be inoperable due to scheduled or unscheduled outages. Scheduled outages occur when repair work is required. It is common to assume that 5% of the time the turbine would be unavailable for generation. Shown in Table 1 is the estimated average annual generation from our independent analysis assuming no downtime and 5% downtime. In the far right-hand column of Table 1 is NHLLC's estimate of average annual generation.

Table 1: Estimated Average Annual Generation for Alternatives A and B

Alternative	Net Head (ft)	Estimated Average Annual Generation (KWH/yr)- Assumes No Downtime	Estimated Average Annual Generation (KWH/yr)- Assumes 5% Downtime	NHC Estimate of Average Annual Generation (KWH/yr)- Unknown if Downtime was included
A	12.5 ft (with 3 ft flashboards)	1,401,000 KWH/year	1,331,000 KWH/year	1,400,000 KWH/year
B	17.0 ft (with 3 ft flashboards)	1,906,000 KWH/year	1,811,000 KWH/year	1,900,000 KWH/year
A2	9.5 ft (assumes no flashboards)	1,065,000 KWH/year	1,012,000 KWH/year	----
B2	14.0 ft (assumes no flashboards)	1,570,000 KWH/year	1,491,000 KWH/year	----

In general, our independent analysis is the same order of magnitude of NHLLC's average annual generation.

Note that these estimates are based on the NHLLC's sizing of the hydropower facility as 425 cfs. As more detailed feasibility analyses are conducted, they will evaluate the overall cost of a 425 cfs facility relative to the energy production of the site. It is possible that the cost of a 425 cfs can not be economically justified relative to the energy produced. If this is the case, NHLLC would likely consider reducing the size of the facility to determine if the project is still feasible. At some juncture, the cost to construct the project outweighs the projected revenues and the hydropower facility becomes infeasible.

Average Annual Revenue

Using the average annual generation values above, a range of energy pricing (cents /KWH) was used to estimate the revenue from the hydropower facility. Typically, hydropower generators sell electricity at wholesale prices. Information on wholesale pricing in New Hampshire is available from ISO-New England (weblink: http://www.iso-ne.com/markets/index.html) or from the Federal Energy Regulatory Commission (weblink: http://www.ferc.gov/market-oversight/mkt-electric/new-england.asp#prices).

Predicting future energy pricing is well beyond the scope of this study. The price of power can vary yearly, monthly, daily and hourly. However, for purposes of this study we looked at past average annual wholesale pricing from the ISO-New England website. It should be clearly noted that the revenue projections are based only order-of-magnitude estimates of the price of power and should not be construed as absolute—hence we have provided a wide range. Shown in Table 2 are order-of-magnitude revenue projections based on the price of power varying from $0.05/KWH to $0.10/KWH, in $0.01/MWH increments.

Table 2: Estimated Revenue for Alternatives A and B

Alt.	Estimated Average Annual Generation (KWH/yr)- Assumes 5% Downtime	Average Annual Revenue based on $0.05/KWH	Average Annual Revenue based on $0.06/KWH	Average Annual Revenue based on $0.07/KWH	Average Annual Revenue based on $0.08/MWH	Average Annual Revenue based on $0.09/MWH	Average Annual Revenue based on $0.10/MWH
A	1,331,000 KWH/year	$66,550	$79,860	$93,170	$106,480	$119,790	$133,100
B	1,811,000 KWH/year	$90,550	$108,660	$126,770	$144,880	$162,990	$181,100
A2	1,012,000 KWH/year	$50,600	$60,720	$70,840	$80,960	$91,080	$101,200
B2	1,491,000 KWH/year	$74,550	$89,460	$104,370	$119,280	$134,190	$149,100

The values above are considered gross revenues. Other costs that have not been accounted for once the project becomes operational include: annual operation and maintenance costs, administration, FERC reporting and compliance, and others.

As a frame of reference, the average wholesale electricity costs in 2007 and 2008 were $0.08149/KWH and $0.09689/KWH, respectively (Source: ISO New England- 2008 Annual Markets Report).

6.0 Cost of Hydropower Development

As noted in our scope, in lieu of a site-specific cost estimate for developing hydropower at McLane Dam, cost estimates from similarly sized hydropower sites in the general geographic region are provided. These order of magnitude costs of other hydropower developments, while not specific to this site, will provide perspective on the costs that could be expected should hydropower development at the McLane Dam proceed. This approach is appropriate at this early juncture given that this particular study is preliminary in nature. If FERC grants NHLLC a preliminary permit, they will presumably conduct a more detailed feasibility study, which would include site-specific cost estimates for developing the site.

As shown in Table 3, the estimated costs for hydropower development from previously conducted feasibility studies at other projects averaged approximately $3.3 million. It should be noted that these costs are based on receiving quotes from turbine vendors for new equipment and estimating civil, mechanical and electrical works. As a side note, the cost of turbines has increased considerably over the past few years as the price of steel has increased. The projects listed in Table 3 are located in the Northeast and New York and the cost estimates were developed within the past 4 years. The proposed generation capacity and available head at each site is similar to the McLane site.

Although the specific engineering configuration at each project described in Table 3 varied depending on existing site conditions, each project required construction and installation of typical major hydropower components (e.g., powerhouse, turbine/generator, intake, and penstock) at an existing dam, and would likely be representative of the order of magnitude costs expected to be incurred at the McLane Dam site. It should be noted that the other projects listed below did not include upstream fish passage facilities. If upstream fish passage facilities were required at McLane Dam, the costs would increase further.

Table 3: Recent Cost Estimates for Hydropower Development at Select Sites in the Northeast

Project	Available Head (ft)	Capacity (kW)	Estimated Cost
Project in MA	15	362	$3,000,000
Project in NY	9	500	$3,900,000
Project in VT	21	400	$2,960,000
McLane Dam	13.8-18.0 (gross head with flashboards)	380 KW (Alt A) 520 KW (Alt B)	

It should be noted that the estimates in Table 3 do not include other fees such as:

- Construction of upstream and downstream fish passage structures
- Evaluation of water rights and property ownership
- Direct communication with regulatory agencies to determine project constraints
- Determination of any known threatened or endangered species at the site
- Determination of any known hazardous materials at the site
- Historic/Archeological investigations
- Electrical interconnection requirements- connection to the grid via transmission lines
- Detailed design or architectural drawings
- Detailed field survey
- Administration and Legal
- FERC licensing
- Annual Operation and Maintenance costs

To bring a hydropower project on-line, several regulatory reviews and permits are required as well. The primary permitting agency that needs to be consulted to obtain a federal hydropower license is the FERC.

In addition, the NH Fish and Game Department (NHFGD), NH Department of Environmental Services (NHDES), and the US Fish and Wildlife Service (USFWS) are key agencies the Licensee would consult with.

Costs associated with the FERC licensing of a new or existing hydropower facility can be significant-these costs are borne by the developer. The costs are driven by the level of study required primarily by the state and federal agencies listed above. In addition, the level of mitigation required can increase the cost of the project.

For projects with smaller generation capacities, licensing costs and schedule can be reduced by applying for a FERC exemption from licensing. To qualify for exemption status, a conventional hydropower project must have a capacity of 5 megawatts (MW) or less (which would be the case for McLane), and be built at an existing dam. However, for a FERC exemption the project would still be subject to any terms and conditions that federal and state fish and wildlife agencies determine are appropriate to protect environmental resources. The typical timeframe to complete a FERC exemption process for a conventional hydropower project is approximately 1-2 years, depending on the environmental issues and the complexity of any necessary construction/rehabilitation work associated with the project.

As part of a FERC license, a State 401 Water Quality Certificate is required from the NHDES. Although licensing a project is a FERC process, the NHDES has a great deal of control in the process as the conditions they place on the 401 Water Quality Certificate have to be included in the FERC license. In addition, the USFWS has what is called Section 18 fishway prescriptive authority. This means that the USFWS can require upstream and downstream fish passage facilities at a given dam, if it can be justified.

Based on our experience with FERC relicensings and exemptions for similar projects in New England, we estimate that the cost for licensing could range from $150,000 to $450,000, and $100,000 to $200,000 for an exemption. The low estimate assumes there is little controversy associated with the project, while the higher estimate reflects a more controversial project with larger issues. It should be noted that the cost of a FERC regulatory process is not directly related to the size of the facility; each project has its own sets of environmental issues and complexities.

7.0 Flooding

It is our understanding that the Selectboard would like to understand:

- the impacts on flooding along the Souhegan River if the water level of the dam were raised by three feet with the addition of flashboards and,

- the impacts on flooding along the Souhegan River if the McLane Dam were removed.

This inquiry is driven by the relatively recent flooding that occurred along the Souhegan River in April 2007. To truly answer this question a detailed hydraulic model would be necessary to simulate water levels upstream of McLane Dam under flood flows for dam-in and dam-out conditions; however, this is beyond the scope of services. The analysis herein is based on available data.

Note that if FERC grants NHLLC the preliminary permit, the town of Milford will have the opportunity to request studies to determine the impacts of the proposed project. Our recommendation is for the town to request NHLLC to conduct a hydraulic study to demonstrate the expected increase in water levels upstream of McLane Dam during normal and flood flow conditions. The request would include not only the expected increase in water level, but also maps showing the incremental area of inundation under normal and flood flows due to the 3-foot flashboards.

Before evaluating the potential flood impacts of adding flashboards to the dam, it is important to quantify flood flows in the basin. Specifically, it is important to quantify if the magnitude of flood flows has changed over time. To provide some sense of the magnitude of flood flows, we obtained the Federal Emergency Management Agency (FEMA) flood insurance studies (FIS) for the Souhegan River. Note that estimates of the flood flows (10-, 50-, 100- and 500-year) reported in the FIS's along the Souhegan River were conducted in the late 1970's. We now have an additional 30+ years of flow information in which to update the previous 10-, 50-, 100- and 500-year flood flows. To determine if the flood flows have changed since the late 1970's an independent flood-frequency analysis was conducted.

Flood frequency estimates were provided in the original FIS at the Souhegan River near the USGS gage location in Merrimack, NH. Because instantaneous peak flow data is recorded at the USGS gage for the period 1910-1976 and 1981-2008, these data were used to update the flood frequency analysis. Shown in Table 4 (and Figure 8) are the 10-, 50-, 100-, and 500-year flood from the original FIS and based on our updated analysis. Also shown in Figure 9 is a scatter plot showing the instantaneous peak flows at the USGS gage for the period 1910-1976 and 1981-2008.

Table 4: Comparison of Flood-Frequency Estimates at the Souhegan River USGS Gage in Merrimack, NH based on the Original FIS, and an Independent Analysis

Method	10-year	50-year	100-year	500-year
Original Flood Insurance Study	6,920 cfs	11,900 cfs	12,500 cfs	22,000 cfs
Independent Flood Frequency Analysis	6,365 cfs	10,430 cfs	12,560 cfs	18,850 cfs

As the results show, the magnitude of flood flows has not changed considerably over time since the original FIS was conducted. Because flood flows have not changed appreciably, water surface profile provided (the water surface elevation along the Souhegan River above McLane Dam under the 10-, 50-, 100- and 500-year floods) in the FIS can be used.

The most recent flood event in the Souhegan River was the April 16, 2007 flood. This flood was the third highest flood recorded at the USGS gage on the Souhegan River in Merrimack, NH (see Figure 9). Note

that the instantaneous peak flow recorded at the USGS gage on that day was 10,500 cfs. This flow is equivalent to approximately the 50-year flood (see Table 4 above and Figure 8). The flows recorded at the USGS gage for the first and second floods of record were 16,900 cfs (on March 19, 1936) and 10,800 cfs (on September 21, 1938).

Note that the flood frequency estimates are based on the USGS gage in Merrimack, NH and the April 2007 flood was considered a 50-year flood at the USGS Gage. It is conceivable that in Milford, NH the April 2007 flood was equivalent to the 100-year flood or some other value. However, because no flow data on the Souhegan River is available in Milford, it was not possible to determine the flood frequency (10-, 50-, 100-, etc) at this specific location. Factors that can influence the magnitude of flooding include:

- The location of major precipitation in the basin. For example, if more precipitation occurred in the upper Souhegan River watershed than in the lower watershed, flows (per square mile of drainage area) would be expected to be higher in the upper basin.

- The location of flood control facilities in the basin. The Souhegan River Basin has several small flood control facilities in the basin that are designed to store water during major floods. The proximity of the flood control facilities relative to the location of the USGS gage will influence the flood frequency analysis.

- The location of bridges, dams and other hydraulic controls, can directly impact the area of inundation. Bridges and dams will cause water to "back-up" which subsequently causes flooding to occur.

The next step in the analysis is to review the water surface elevations above McLane Dam that were provided in the original FIS. Shown in Figure 10 is the water surface profile showing the predicted water levels attributable to the 10-, 50-, 100- and 500-yr flood flows. The estimated water surface elevations are based on the previous hydraulic modeling study conducted by FEMA in the 1970's.

The McLane Dam, Goldman Dam, and the Rte 13 Bridge (immediately above Goldman Dam) impact water levels upstream of the structures. The structures act as "hydraulic controls" as they cause water to back up behind the controls. Shown in the photographs on the following page are pictures taken around April 16, 2007 and on May 18, 2009 (no flood). The "flood" photographs were obtained from unknown sources on the World Wide Web. Shown in the photographs are reference locations.

Figure 10 includes the following elevations:

- As noted earlier, the spillway crest elevation of McLane Dam is 230 ft.
- With the additional of 3-foot flashboards, the normal water elevation behind the dam would rise to 233 ft.
- Flashboards are designed to fail once the depth of water on top of the flashboards reaches a certain depth. When the certain depth is reached the pins that hold the flashboards in place purposely fail to increase the overall discharge capacity of the dam. It is unknown at this juncture at what depth NHLLC would design the flashboards to fail. However, the rule of thumb in the industry is to have the flashboards fail with roughly 2 feet of water. Thus, the water elevation behind the dam could be as high as 235 feet before the flashboards fail.

The length of McLane Dam spillway is approximately 193 feet. The estimated flow over this length of spillway with two feet of water over the top of the flashboards was estimated to be 1,750 cfs (estimated to be between the 1 and 2-year flood). As flows surpass 1,750 cfs, the flashboards would fail and the discharge capacity of the dam would increase. Absent a detailed hydraulic model, the water surface elevations upstream of McLane Dam under the 10-, 50-, 100-, and 500-year floods would be similar to those shown in the original FEMA study- see Figure 10.

In summary, the addition of 3-foot flashboards would raise the water level above the dam and inundate lands. As Figure 10 shows, the water surface elevation of 233 feet would create a pool that backs up to the Goldman Dam. The backwater created with 3 feet of flashboards and 2 feet of spill (equivalent to elevation 235 feet) would create a water surface elevation that is greater than the height of Goldman Dam. Thus, adding flashboards will cause water levels to rise above McLane Dam and Goldman Dam. However, what is unclear is whether infrastructure would be impacted when the water level rises to 235 feet.

Once inflow to McLane Dam reaches approximately 1,750 cfs, it is assumed the flashboards fail, and the water surface elevation above the dam would be similar to those shown in FEMA's original study.

Removal of the McLane Dam would directly reduce flooding between the dam and Goldman Dam. In addition, based on the water surface profiles in Figure 10, removal of the McLane Dam would also reduce the water surface profile above Goldman Dam. For example, in looking at the water surface profile for the 50-year flood, the backwater created by McLane Dam creates a water surface elevation of

approximately 237 feet immediately below Goldman Dam. Water surface elevation 237 feet is above the Goldman Dam spillway crest elevation (estimated at around 234.5 feet). Because the water level is greater than the spillway crest elevation, the water surface profile above Goldman Dam is directly impacted by McLane Dam.

What is unclear at this juncture is how much the water surface elevations above Goldman Dam would decrease with the removal of McLane Dam. More specifically, would key infrastructure be spared from flooding if McLane Dam were removed? To answer this question a hydraulic model extending from just below McLane Dam to well upstream of Goldman Dam is needed. There is an existing hydraulic model that was developed for the original flood insurance study. The model would have to be obtained and updated to reflect existing conditions. The model would then be used to simulate the removal of McLane Dam and the resulting water surface profiles for the 10-, 50-, 100- and 500-year floods could be estimated. It is envisioned that the hydraulic model would be operated to determine the incremental contribution of flooding upstream of the Rte 13 Bridge by simulating the following in sequential order:

- Operate the existing hydraulic model under existing conditions (all structures in place) to determine the water surface elevation and area of inundation above the Rte 13 Bridge. This model run would reflect "existing conditions" and all other hydraulic modeling runs would be compared to the existing model.

- Remove McLane Dam (leave Goldman Dam and Rte 13 Bridge in place) to determine the reduction in the water surface elevation and area of inundation above the Rte 13 Bridge compared to existing conditions.

- Remove McLane Dam and Goldman Dam (leave Rte 13 Bridge in place) to determine the reduction in the water surface elevation and area of inundation above the Rte 13 Bridge compared to existing conditions.

- Remove McLane Dam, Goldman Dam and Rte 13 Bridge to determine the reduction in the water surface elevation and area of inundation above the Rte 13 Bridge compared to existing conditions. It is recognized that the Rte 13 Bridge would not be removed; however, by making this run the contribution of the bridge to flooding can be estimated.

- Note the hydraulic model could simulate McLane Dam with 3-foot flashboards; however the flashboards would be designed to fail when the water depth atop the flashboards exceeds a certain elevation.

The cost and complexity of developing a hydraulic model for this portion of the river system is somewhat dependent on the level of detail contained in FEMA's original hydraulic model. For example, additional field survey may be needed. An order of magnitude estimate to develop a detailed hydraulic model for this portion of the river is between $8,000 and $15,000.

As you know, the NHDES has an active dam removal program. They were heavily involved with the removal of the Merrimack Village Dam. In addition, grant monies are available to conduct both feasibility studies and removal of dams similar to McLane Dam. Before a decision on dam removal is made, a feasibility study is typically conducted that examines the following (this is not intended to be a complete list):

- Impacts of dam removal on flooding (hydraulic model is needed as described above);

- Impact of dam removal on wetlands, wildlife, fisheries, and rare, threatened and endangered species.

- Testing of sediments behind the dam is conducted to determine what, if any, contaminants are present.

- A sediment transport analysis is conducted to determine if sediments are likely to be transported downstream if the dam were removed. Depending on the sediment transport analysis and sediment testing, a sediment management plan is developed.

- Impact of dam removal on infrastructure is conducted—for example, removal of the Goldman Dam could cause scour of the Rte 13 Bridge pier and abutments.

- Impact of dam removal on archeological and historic resources.

Grant monies can be secured to complete the feasibility work described above. In fact, a few years ago the town of Henniker, NH removed a dam on the Contoocook River at no cost to the town; all of the funding was obtained from outside sources.

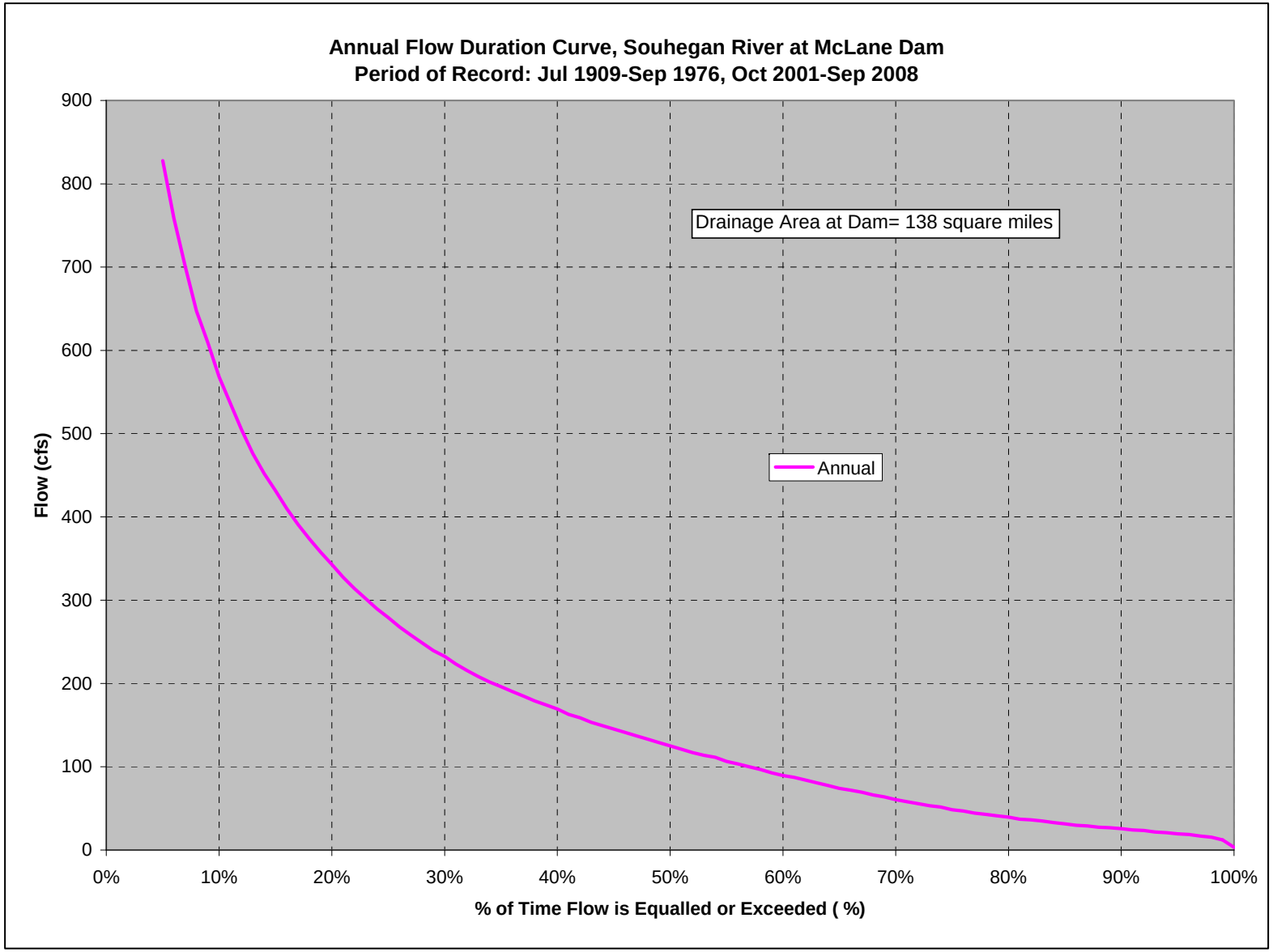

Figure 6: Annual Flow Duration at McLane Dam

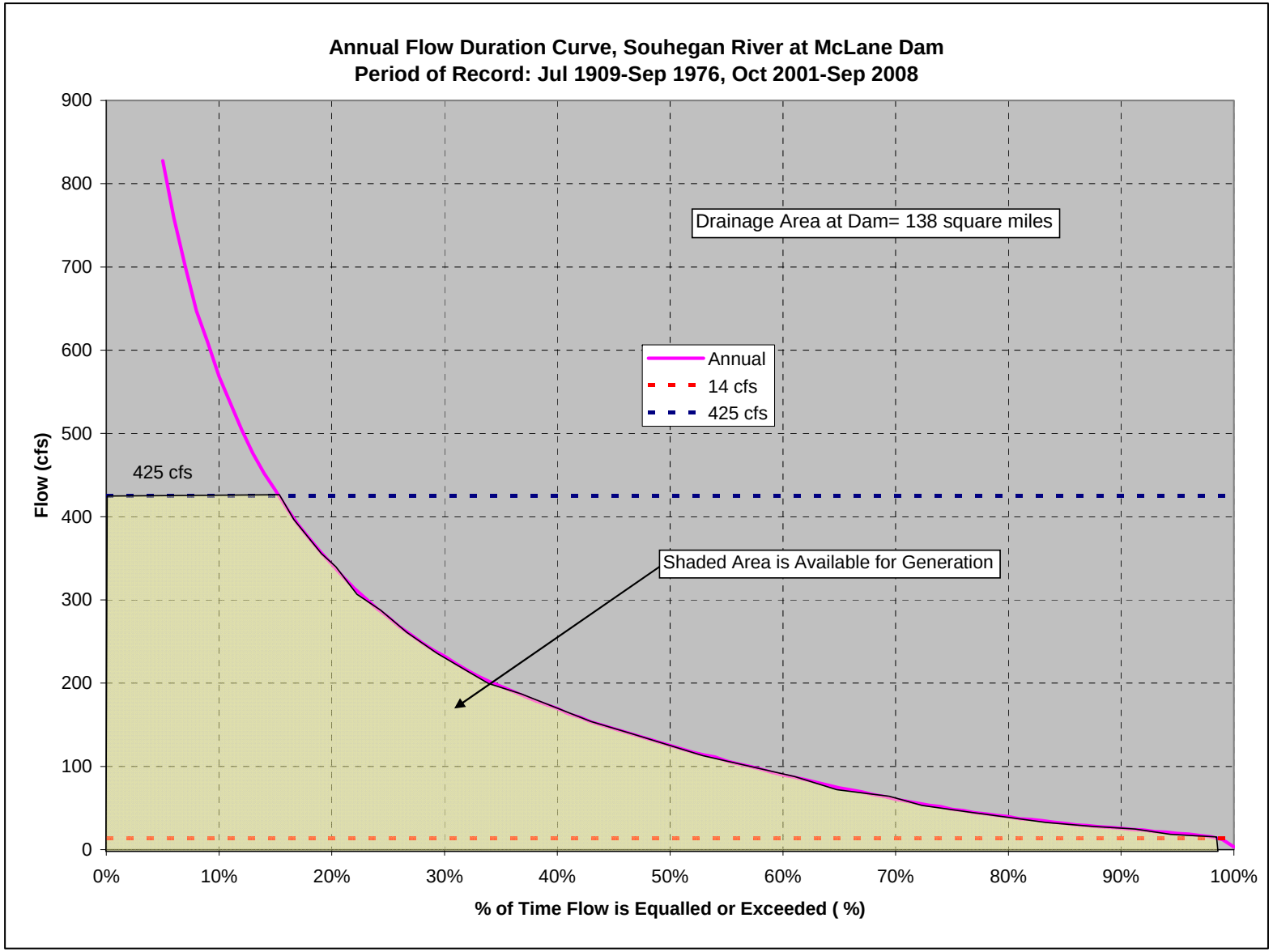

Figure 7: Annual Flow Duration at McLane Dam showing Shaded Area available for Generation

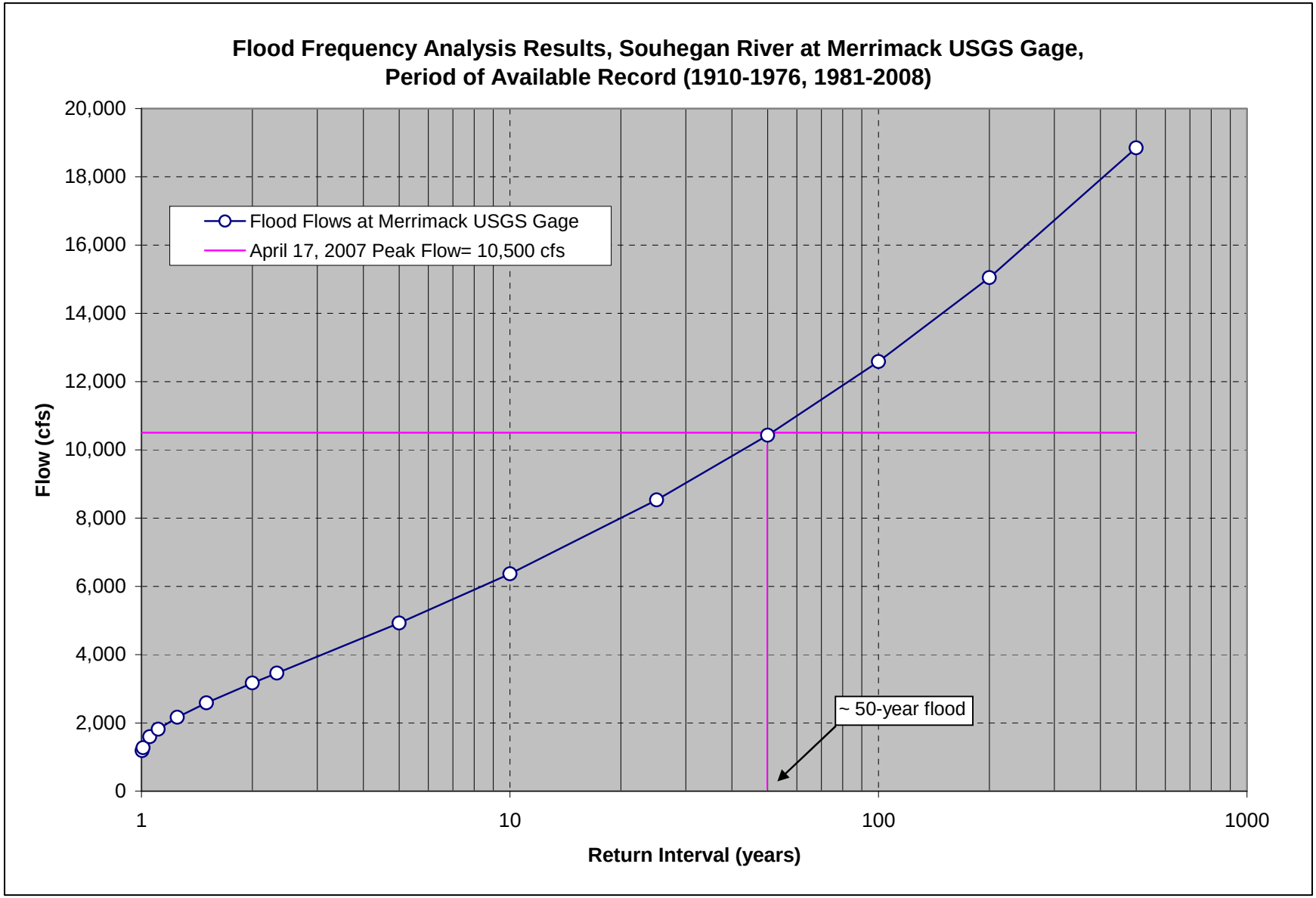

Figure 8: Flood Frequency Analysis at USGS Gage No. 01094000, Souhegan River near Merrimack, NH

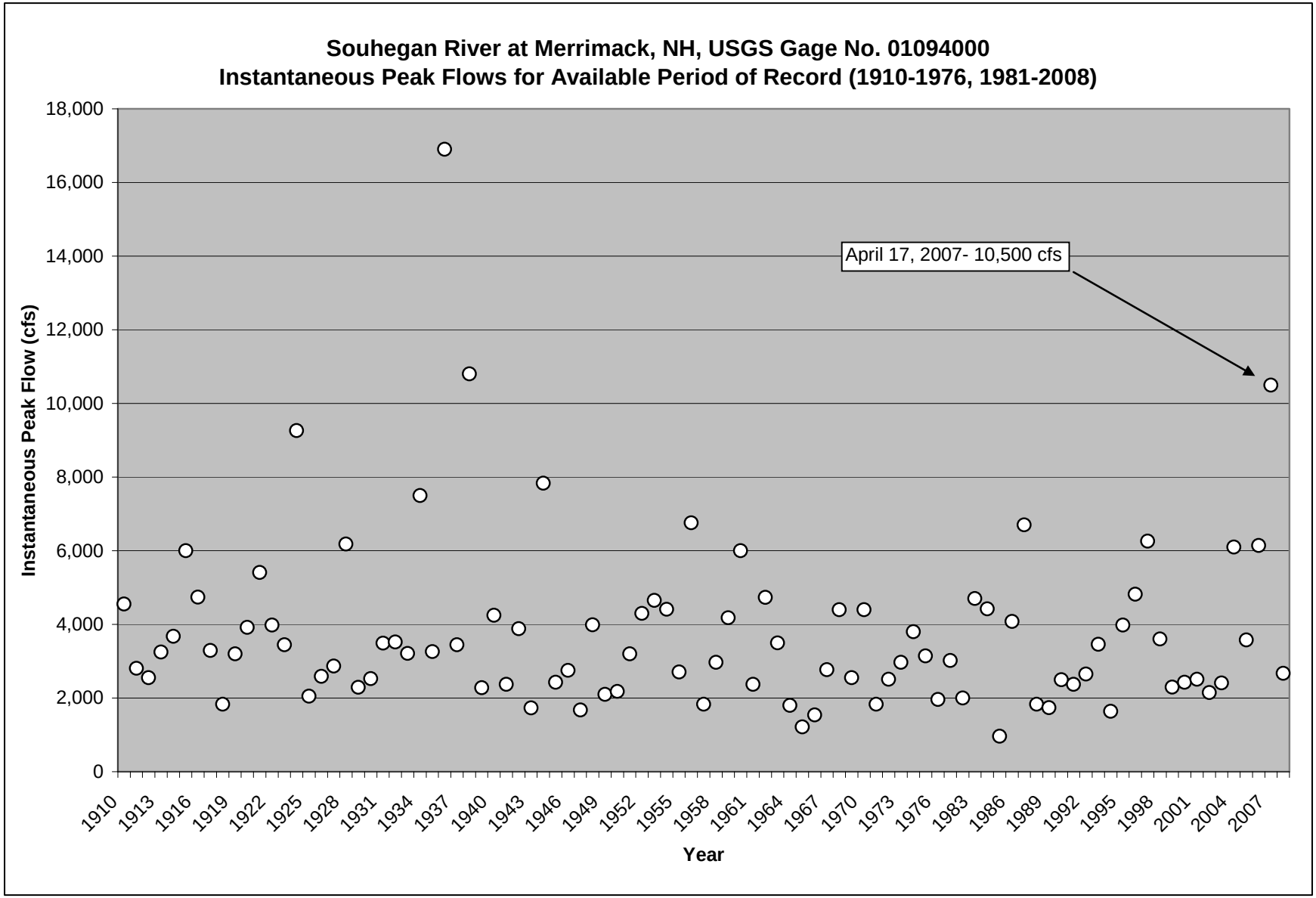

Figure 9: Souhegan River USGS Gage No. 01194000- Instantaneous Peak Flow for Period of Record

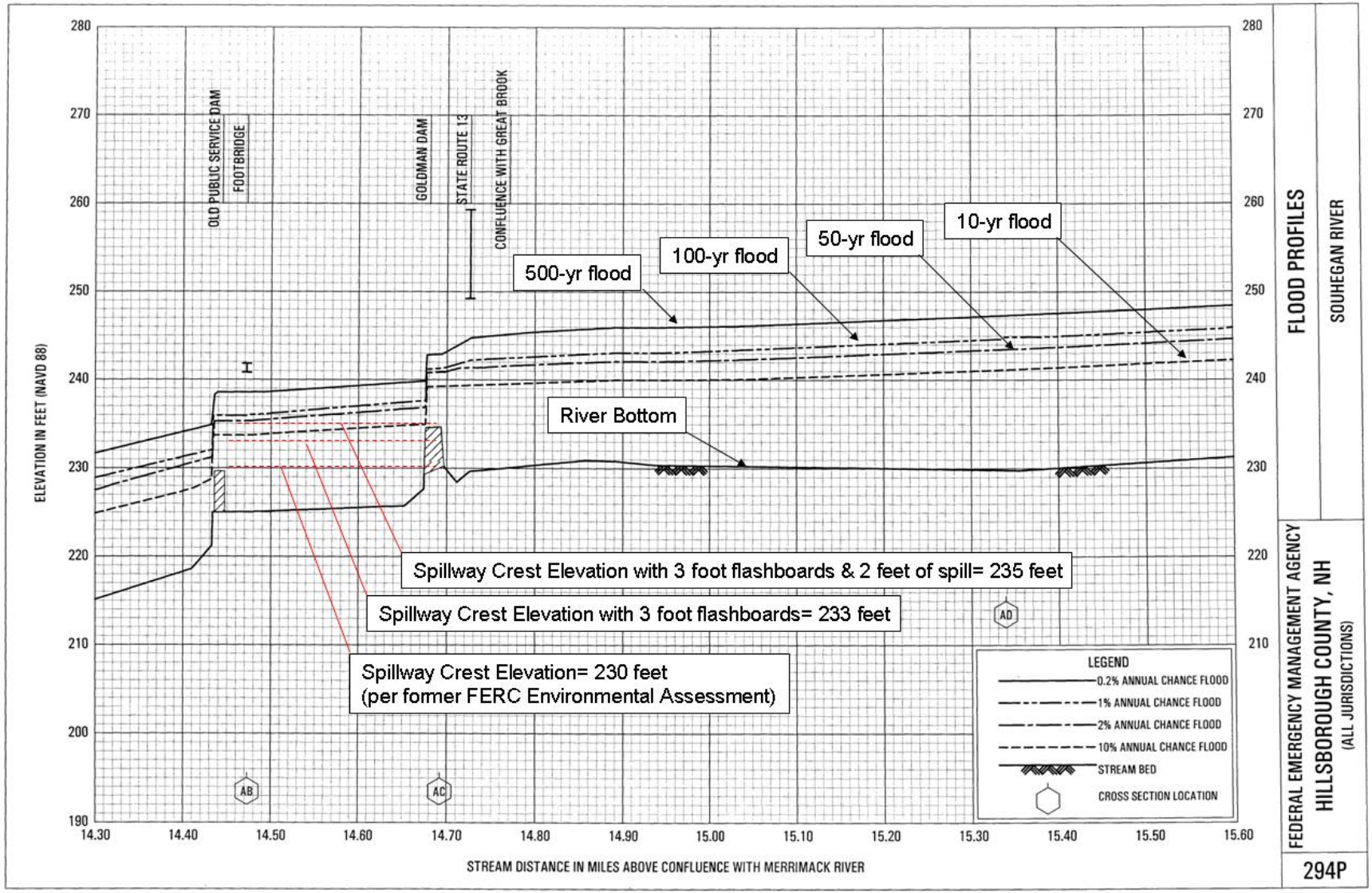

Figure 10: Water Surface Profile of Souhegan River above McLane Dam