GUIDANCE DOCUMENT: ALTERNATIVES ANALYSIS

<u>SUPPLEMENT TO RULES WATER WITHDRAWAL FOR SNOWMAKING</u>

INTRODUCTION

This document provides guidelines for conducting an alternatives analysis, as provided for under the Agency rules *Water Withdrawals for Snowmaking*, Section 16-05. An alternatives analysis quantifies the demand for water through the snowmaking season; provides an evaluation of all feasible and reasonable source and storage alternatives that would avoid or lessen the impact to the natural condition of the source stream; and identifies the alternative that best conserves the natural condition of the source stream while supporting snowmaking needs. The Agency will consider the results of the analysis, as well as Vermont Water Quality Standards and other statutory requirements, in determining the conservation flow conditions or recommendations.

The Agency shall consider both natural resource and economic constraints in determining whether an alternative is "feasible and reasonable", the terminology used in the rules. An alternative shall be considered to be feasible and reasonable if it is available and capable of being implemented after taking into consideration cost, existing technology, logistics in light of the overall project purpose, permitability, and the environmental impacts of the alternative. The scope should include non-resort lands that can be obtained for project use and are logistically close enough to serve the purposes of the project.

Section 16-05(3) of the rules requires a study plan to be submitted to the Agency for review and concurrence before beginning an alternatives analysis. The study plan should describe the process and methods to be used in the analysis, the schedule to be followed, and the points at which Agency involvement will be sought. If the project is likely to be subject to federal review due to the involvement of federal lands or permitting under Clean Water Act Section 404, the applicant should also coordinate the study plan development with the affected federal agency.

The alternatives analysis itself should cover six basic topics: (1) a project description and statement of need; (2) a needs or demand analysis; (3) an evaluation of water sources investigated; (4) an evaluation of storage options investigated; (5) a system model; and (6) a summary of results. The summary of results should include a discussion of the preferred alternative and the schedule for implementation of the alternative, enhanced conservation flows, and other elements of the project (eg. added snowmaking trail coverage). Each of the six topics is discussed in separate sections of this guidance document.

The recommended system model for the alternatives analysis integrates water demand with source and storage options to determine how effective a specific alternative would be in achieving the snowmaking goals of the ski area and conserving stream flow. To conduct an alternatives analysis the following steps are recommended:

1. collect data on terrain and coverage requirements to construct a daily demand curve for the snowmaking season (see Section II of this document for more details);
2. conduct an evaluation of source options, as outlined in Section III, and construct seasonal hydrographs (flow over time) for each source;
3. compile a list and preliminary review of storage options following the guidelines in Section III;
4. review the source and storage options in consultation with the Agency to develop a list of combined alternatives for further analysis as specified in Section III;
5. combine the information in a series of mass hydrograph system models[1] (see Section IV), and present the results for each alternative as a function of that alternative's ability to minimize the impact to the natural condition of the stream and provide sufficient water to support snowmaking operations; and
6. for each alternative, evaluate its economic and environmental feasibility.

An applicant may choose to complete an analysis that differs from the recommended approach in this document; however, the Agency asks that concurrence with the intended study design be sought before proceeding.

In addition to satisfying the requirements of the Agency rules, the alternatives analysis can serve as the foundation for sound snowmaking planning by identifying specific opportunities, limitations and capabilities. For example, the analysis can be used to identify periods during the snowmaking season when water shortfalls are most likely to occur, and a portion of reservoir storage can be set aside specifically for use during these periods. To increase the utility of the analysis and to insure that it does not become outdated, the Agency strongly recommends that the applicant conduct the alternatives analysis in conjunction with the ski area master planning process.

The data compiled for this analysis and any computer models developed should be retained for future use. Section 16-03 of the rules provides for periodic review of approved systems at no greater than 20-year intervals in order to determine whether it would be feasible and reasonable to revise the conservation flow requirements. Subsequent reviews will be facilitated if the data and models continue to be available.

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[1] A mass hydrograph integrates water demand (use) and available supply from streams and storage on a time scale from the beginning of the season, showing where shortfalls or excesses in water availability and storage occur and quantifying these shortfalls and excesses. Such analyses are standard for safe yield analyses for drinking water supplies and are now commonly used in designing snowmaking systems as well. The analysis is usually done for several seasons using historic U.S.G.S. gage records so that the variability in system performance can be examined. Seasonal climate data (temperature and snowfall) can also be included in the modeling of the demand.

I. GENERAL PROJECT DESCRIPTION AND STATEMENT OF NEED

A description of the ski area and historical and projected snowmaking and water use should be furnished to provide the Agency with the background needed to evaluate the proposal for increased water use for snowmaking. This description should include information on existing source and storage system design; minimum stream flow standards including permit references; historic water use and pumping rates, discussed in the context of the trail coverage and expansion history; and details of the snowmaking system and management practices.

The description of the proposed changes to the ski area and/or snowmaking system should include projected changes in trail acreage and classifications, percent of trails covered, and other changes that may affect water use on a seasonal or interval basis[2]. The results of the full analysis should also be briefly summarized in this section. This should include the projected volume of water and/or storage needed and a description of the preferred alternative for meeting this need.

II. NEEDS ANALYSIS

The information provided in this section is used to create a model of demand describing daily, interval and total water demand through the snowmaking season and to establish the basis for the need for additional water. The purpose of gathering this information is not to specifically prescribe snowmaking management conditions, but rather to support an estimate of the volume of water needed to carry out snowmaking operations.

The following information, along with any additional information that the applicant believes may be relevant, is used to create a generalized seasonal model of snowmaking water demand:

1. length of snowmaking season and target trail opening dates;
2. total acreage and break down of acreage by trail classification;
3. target snow depths for each class;
4. approximate snow density for machine-made snow in gallons of water/acre-foot;
5. distribution of water use through the season;
6. recovery and maintenance needs;
7. estimation and sources of water loss during snowmaking (eg. charging pipes, evaporative loss, etc.); and
8. snowmaking equipment water-use characteristics.

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[2] The season is generally divided into intervals that reflect different snowmaking management strategies and, therefore, different water demand rates. Division of the season into intervals allows the mass hydrograph analysis to be used to project how well the system performs in each interval.

The applicant should examine historical use characteristics in developing a projected demand model. The extent to which historical demand information is weighed into the final demand model should be fully explained; if historical information is not used, the reason for not using it should be explained.

Figure 1 depicts a generalized demand curve with discrete intervals.[3]

The generalized demand curve can be further refined by adjusting for actual temperature and natural snowfall conditions in order to increase the precision of the demand estimates. Temperature decision variables that are considered in system operation can be used to redistribute snowmaking water demand in a manner that more realistically represents timing and quantity of water use. Figures 2 and 3 show temperature conditions and the resulting adjusted water demand curve for 1986-87.[4] (Note: in the example; the estimate of total seasonal demand does not change, but is redistributed accounting for days of no snowmaking due to high temperatures).

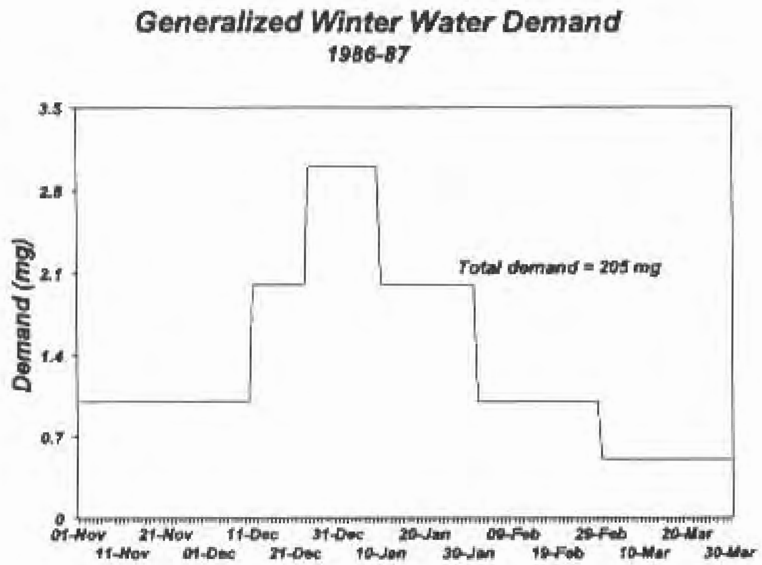

Figure 1. Generalized demand curve for daily water use for example snowmaking season. (Units are in millions of gallons per day.)

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[3] The generalized demand curve was created based on a composite of water use at existing ski areas and does not represent any one ski area in particular.

[4] Based on 1986-87 NOAA air temperature data from South Lincoln, Vermont.

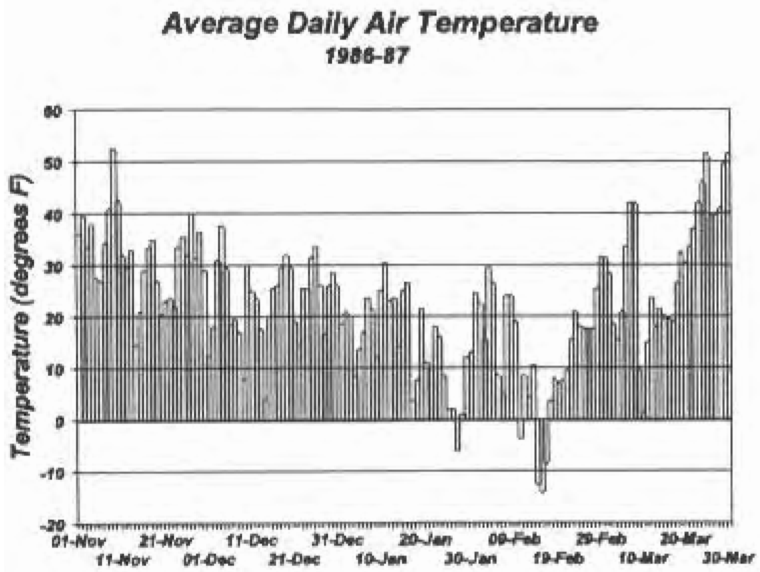

Figure 2. Average daily air temperature conditions for example snowmaking season.

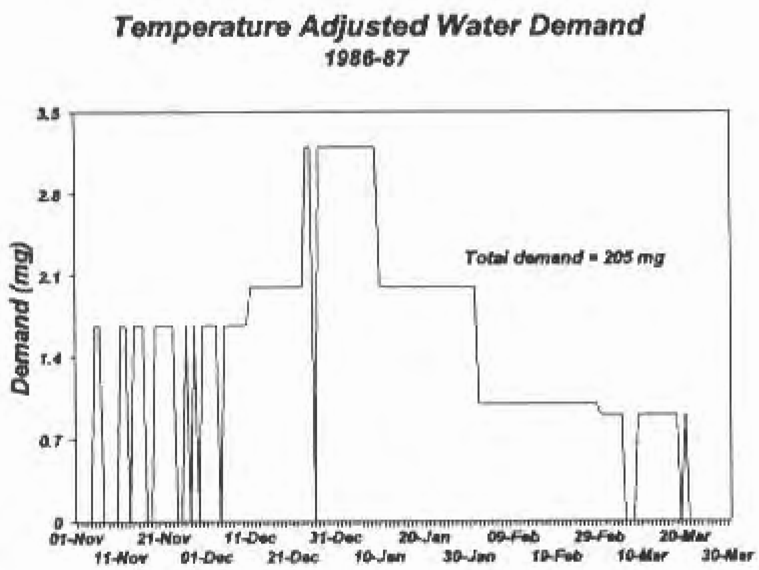

Figure 3. Air temperature adjusted generalized demand curve for daily water use for example snowmaking season. (Units are in millions of gallons per day.)

In some years, natural snow contributes significantly to the snowpack and may reduce the need to make snow. Historic snowfall data should be included in the form of its snow water equivalent (SWE)[5] to estimate how much additional machine-made snow is needed to meet demand. The weather station(s) to be used in estimating natural snow for modeling purposes should be discussed with the Agency, as well as the method for transferring the data to the ski area (eg. adjustments for elevational effects). Figures 4 and 5 show snow water equivalent through the season and the SWE and temperature adjusted demand curve.[6] SWE is deducted from the demand on the days that water demand is greater than zero.[7] The model can be refined using climatological data for each of the model years or for only those years in which there is a shortfall of available water.

An evaluation of demand side management must be included in the needs analysis. Demand side management is the use of conservation and efficiency measures to provide the same level of service with less water. The Agency encourages water conservation as a method of reducing the impact to the natural condition of the stream.

Information on the extent of demand-side management currently in place should be provided, including information on existing water conservation and efficiency measures utilized in the snowmaking and in any associated domestic water supply system. Plans for future water conservation and estimates of potential water savings should be discussed and reflected in the demand model.

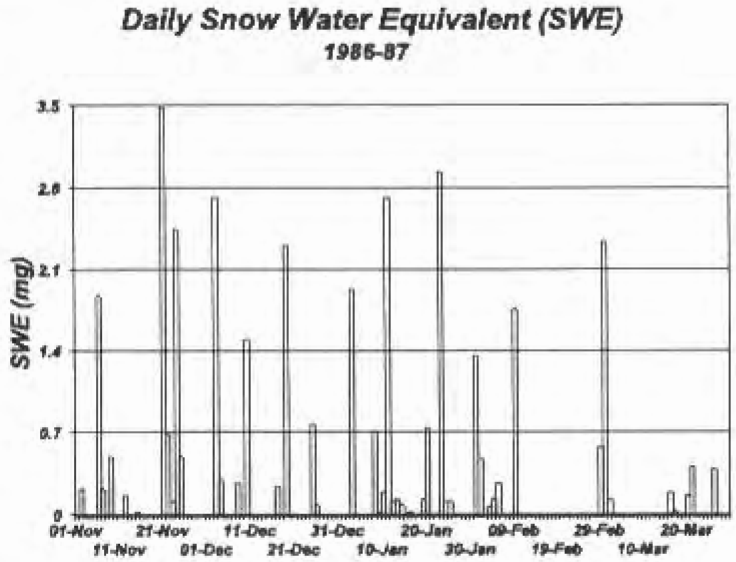

Figure 4. Natural snowfall water equivalent for example snowmaking season.

[5] The NOAA data is recorded as inches of precipitation for both snowfall and rainfall. In the case of snowfall, this unit of measurement is the same as the SWE.

[6] Based on 1986-87 NOAA snow water equivalent data at Northfield, Vermont.

[7] Another variable that can be considered to adjust the demand curve for specific modelled seasons is the snow on ground database. It can be assumed that the demand for water to make machine-made snow will be low during periods when the actual natural snowpack is substantial.

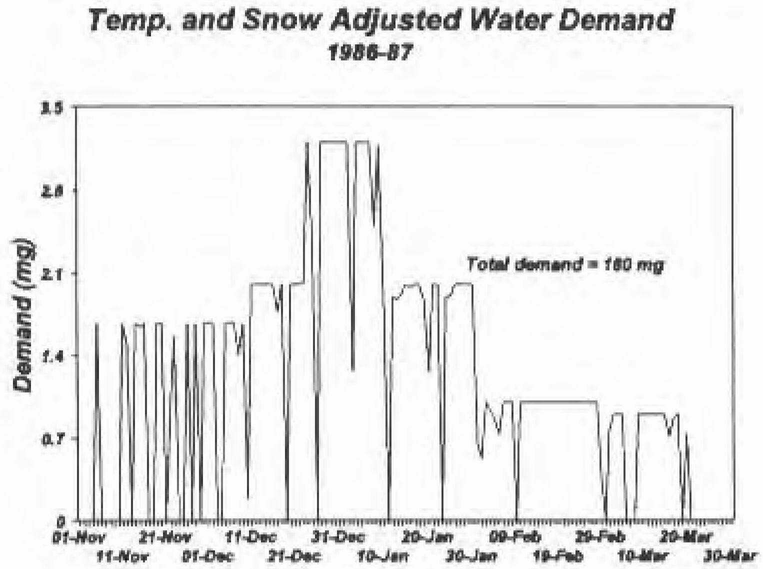

Figure 5. Snow and temperature adjusted demand curve for daily water use for example snowmaking season. (Units are in millions of gallons per day.)

III. SOURCE AND STORAGE OPTIONS

In evaluating supply-side options, combinations of source and storage options are assessed to determine which alternative best meets snowmaking needs while minimizing the impact on the natural condition of the stream and surrounding natural resources. In cases where source and storage opportunities are limited on ski area lands, this evaluation should include source and storage options on lands not currently under the applicants ownership or control. The rationale for the defined study area should be included in the proposed plan of study.

The Agency suggests following an iterative process in investigating source and storage options. In order to maximize study efficiency, it is helpful to narrow the field of alternatives as the study progresses so that detailed studies of poor candidate source and storage options are avoided. Before the source and storage options are initially selected, the applicant should have a rough idea of its source and storage needs, based on a preliminary needs analysis. The first array of options should be reviewed with the Agency to determine if other options bear investigation and to screen out options that clearly would have significant environmental impacts or other insurmountable problems that cannot be mitigated. After this initial screening, there should be continuing dialogue between the applicant and the Agency as the study goes forward with the detailed assessment of individual sites.

SOURCES

Candidate sources should include both surface water and groundwater. Any existing stream flow or pump test data should be considered to estimate quantity and timing of water availability. The stream flow hydrograph shown in Figure 6 is an example of flow data which can then be used to quantify available water under various conservation flow standards and source and storage options.[8] Potential new sources should be evaluated to determine their suitability for water withdrawal by considering hydrology, biology, physical characteristics, wildlife habitat, proximity to infrastructure, elevation difference from base area, land ownership, and applicable federal, state and local regulations. The method to be used to estimate the hydrologic characteristics of the sources should be discussed with the Agency during study plan development.

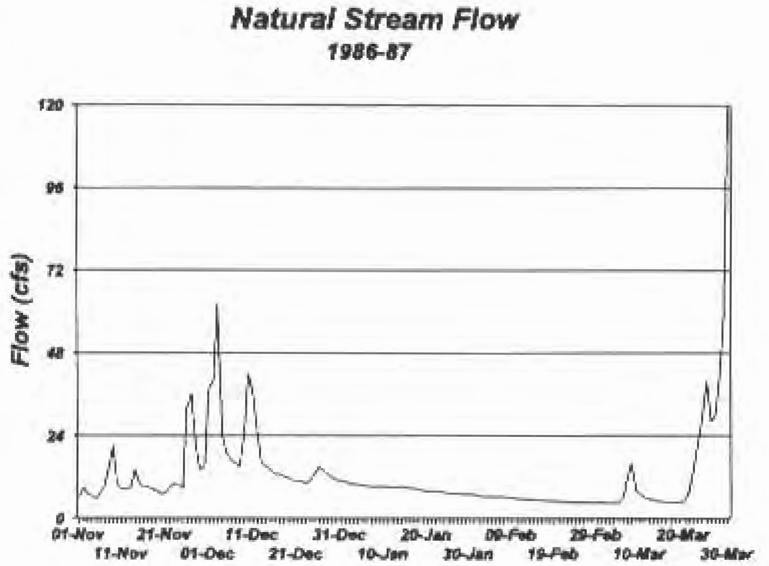

Figure 6. Natural stream flow hydrograph for source stream for example snowmaking season.

STORAGE

The use of reservoirs to capture water and store excess water at times of flow higher than the conservation flow standard is critical to most snowmaking systems. Off-stream storage systems provide snowmaking water at times of low stream flow. In addition, the use of storage can help enhance instream flows, and reduce or eliminate the need to draw water from streams at times of low flow.

[8] Based on 1986-87 USGS stream flow data from East Orange Branch at East Orange, Vermont. The watershed area at this site is 8.95 square miles. Approximately half the winter data at this gage are estimated and have an associated error of up to 15%.

Describe existing and potential storage options that could be used to help meet demand by providing the following information:

1. a map depicting the potential storage site locations;
2. a storage comparison chart with size, volume, physical, biological and hydrologic characteristics; and
3. estimates of construction cost per unit area of storage for existing and potential storage (including above or below ground storage tanks).

For selected alternatives, the above information should be accompanied by a more detailed site analysis, including:

1. physical characteristics, including geology, volume of material excavated, and design dimensions for dam embankment;
2. biological considerations, including fish and wildlife habitat impacts and/or benefits;
3. wetland impacts;
4. hydrologic information, including connection to adjacent streams and to groundwater;
5. aesthetic considerations such as surface area, dam/embankment height, adjacent land use, surrounding vegetation and visibility;
6. land use and zoning restrictions; and
7. historic, archeological and cultural resources.

In addition to the ecological and hydrologic analyses, a cost estimate for each alternative should be included for a smaller number of storage options arrived at through a screening process with the Agency. This information will be used to determine the feasibility and reasonableness of each storage option. The economic analysis should be based on up-to-date cost estimates and should include: cost estimates per unit volume of storage for construction; cost estimates for construction of the delivery system to transport water from storage to base facilities or existing hook-ups; and expected annual cost for operation and maintenance of the supply system, including energy costs. Cost estimates should include a breakdown of all assumptions used in the calculations, such as earthwork volumes, spoil/barrow costs, and equipment and labor. The underlying assumptions for estimating the energy costs should be provided.

IV. SYSTEM ANALYSIS

In this part of the study process, the demand, source and storage information for a range of alternatives is combined to compare demand over time with available water in a mass hydrograph system analysis. First, a set of alternative scenarios for meeting demand and complying with the Agency procedure are defined. Next, the demand curve, a management regime, climatic conditions, and the source/storage combinations are defined for each alternative. Finally, these data are combined in a mass hydrograph analysis to compare supply with demand on an interval-by-interval basis for at least a 25-year period.

The needs, source, and storage data collected for the example case have been combined in a mass hydrograph analysis to illustrate the recommended modeling approach. Figure 7 shows the gross water volumes available from the source stream; Figure 8 shows the changes in reservoir volume during periods of storage depletion (reservoir drawn to supply water to meet snowmaking demand that cannot be supported by the source stream) or storage recovery (source stream has adequate flow to both meet snowmaking demand and refill the reservoir). This case assumes that there is 250 acres of snowmaking terrain, a 50 million gallon storage pond and a pump capacity from the stream of 3,000 gallons per minute.

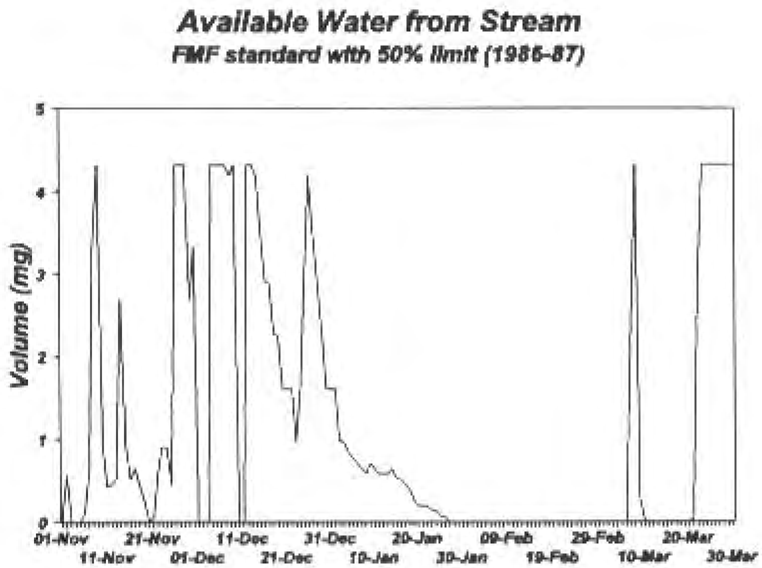

Figure 7. Water available from source stream with full flow standard in place for example snowmaking season, millions of gallons per day.

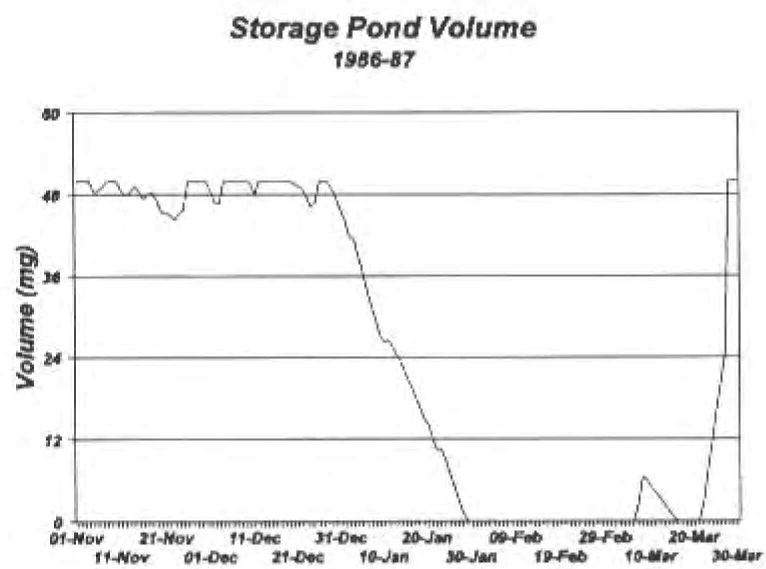

Figure 8. Reservoir net storage volume available through example snowmaking season, millions of gallons.

Based on the estimates of natural snow and machine-made snow from a specific alternative, a percent completion relative to total demand is calculated for each year modeled.

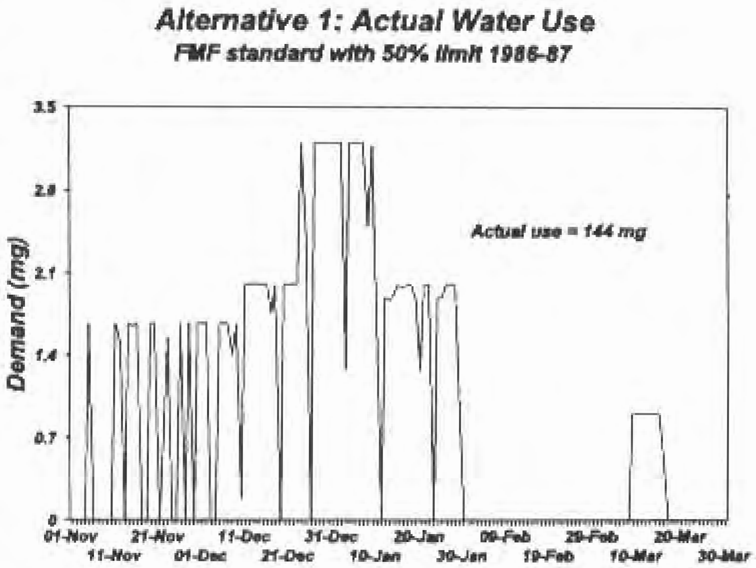

Figure 9. Actual water use under Alternative 1 for example snowmaking season. (Units are in millions of gallons per day.)

Figure 9 shows how much water would be used for snowmaking under the prescribed conditions in 1986-87. The results should then be compared to the target completion rates to determine whether or not the alternative satisfies snowmaking needs. In the example used here, approximately 80% of the total demand was satisfied in 1986-87. A design criterion or goal for the system must be established in order to determine if an alternative is acceptable. The suggested design criterion that has been used in some cases is the target of 80% completion in 80% of the years. With an 80/80 target, the source and storage system provides 80 to 100% of water demand in 8 out of 10 years. If shortfalls exist, each interval can be assessed to identify the periods in which the shortfall commonly occurs.

The results of the modeling effort should be summarized, including the following information for each alternative:

1. volume of water used and percent completion by season and interval within a season;
2. percentage of years in which the percent completion is equal to or greater than the target completion rate;
3. an estimate of the additional volume of storage needed to reach the target;
4. total cost with a breakdown including cost per unit of storage volume; and
5. other issues that may be relevant.

V. RECOMMENDATIONS

Based on the results of the system model, describe the preferred alternative, with the conservation flow level to be supported and the extent to which it meets system needs. In addition, explain why the other modeled alternatives were ruled out.

In the case of a system that is categorized as expanded existing, a schedule of compliance must be proposed. In certain cases, the full implementation of an alternative may be feasible at the time of the initial expansion, obviating the need for a longer term schedule. If the preferred alternative for an expanded existing system will not ultimately support attainment of the conservation flow general standard, then the applicant should address the feasibility of changing the scale of snowmaking buildout in order to achieve compliance with the general standard. For example, instead of working towards serving 85% of its trails with snowmaking, the applicant could settle for 70%, if the result would be support of the FMF instead of a lower minimum flow.

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