that it is now uncommon for DEC to sponsor a liming job without some degree of volunteer involvement. This support has come from many sportsman's clubs, organized by local county Federations, as well as from individuals representing national organizations such as Trout Unlimited and the Boy Scouts of America.

VI. MITIGATION MEASURES TO MINIMIZE ADVERSE ENVIRONMENTAL IMPACTS

A. Pre-liming Actions

1. Lake Selection Criteria

Not all acidic lakes and ponds are suitable candidates for liming projects. Specific criteria will be used to select a limited number of waters which show (1) high potential for development of an important fisheries resource; (2) need to be protected to preserve rare, threatened or endangered species or strains of fish; or (3) represent a degraded aquatic ecosystem where restoration of the ecosystem would be the main objective of the liming. The criteria used will insure that liming projects are conducted on the most suitable candidates. These criteria will minimize the adverse impacts associated with the liming of acidic waters.

The lake selection criteria are a major part of the proposed revision of the Division of Fish and Wildlife Liming Policy (Section I). They were discussed in detail in Section II.D.4. - Factors Important in Selecting Liming Candidate Waters. In summary, waters which enter the DEC liming program must (1) have a summer surface water pH less than 5.7 or an ANC less than 20 μeq/l; (2) not be naturally acidic; (3) have a flushing rate less than 2 times per year; (4) have acceptable temperature and dissolved oxygen levels; and (5) have a record of historically supporting a viable fishery or be a broodstock water which contains an important population of a valuable fish species or be a degraded ecosystem which would benefit from an ecosystem restoration project. These criteria severely limit the number of waters which could be included in the DEC liming program and will insure that only suitable waters are limed.

2. Standardization of Lake Neutralizing Material

Many different materials have been used to neutralize acidic waters, and these were discussed in Section II.C.2. and have also been reviewed by Fraser et al. (1985a). These materials have various impacts on the aquatic environment depending primarily on how rapidly they change the pH of the water. Hydrated lime was used in the early DEC liming projects and although effective, was discontinued because of its rapid dissolution rate and very fine texture, which made it difficult to handle (Kretser and Colquhoun 1984). Agricultural limestone has become the material of choice in the vast majority of lake neutralization projects, and will be the primary material used in New York State.

The particle size of the limestone used for lake neutralization is of great importance in determining how much of the material dissolves and how much sinks to the lake bottom. The finer the material the more quickly it will dissolve. Boyd (1982) rated limestone particles 0-.25mm in diameter and smaller as 100% efficient, and it is recommended that for liming projects the particle size should be between 0.25 mm and 0.75 mm. Large particles which do not dissolve before settling to the bottom may provide some reservoir or neutralizing capacity as long as the particles remain in contact with the water. If they are covered with silt and bottom sediments however, this additional neutralizing capacity is lost. Insuring that the particle size of the limestone is in the 0.25 to 0.75 mm range will reduce the possibility of an ineffective treatment.

The chemical composition of the agricultural limestone used in the DEC liming program is another variable which will be standardized. The composition of the lime should meet the acceptable limits set for the U.S. Fish and Wildlife Service liming projects (Fraser et al. 1985). These limits include maximum allowable levels for aluminum, phosphorus, and other chemicals of concern and are presented in Table 10. Agricultural limestone used by the DEC will have to have been assayed prior to use to insure that the chemical composition is acceptable.

3. Calculation of Treatment Levels

The target pH level for most DEC liming projects will be 6.5 or above. Fish species other than brook trout may require a higher pH level because of their greater sensitivity to acidic conditions. The amount of agricultural limestone necessary to achieve this level of neutralization will be calculated on an individual lake basis. Previous liming programs have used treatment levels of a ton per acre (2245 Kg/ha) for all waters, and in general this has resulted in satisfactory results. However, every lake is different, and incorporating a number of lake variables to calculate the dosage rate will be an improvement in the DEC program. Variables which affect the amount of lime used include: pre-neutralization water chemistry, the volume of the candidate water, chemical and physical characteristics of the lime, and the target level pH of the treatment.

Several computer programs and models have been developed to calculate the proper amount of neutralizing material needed, and a program such as Deacid (Fraser et al. 1985) will be used for DEC liming projects. Retreatment dosages will also be calculated using the computer software and will be based on the water chemistry prior to retreatment. The particle size of the agricultural limestone is included as a variable in this program and is important in determining how quickly the lime dissolves. Large particles sink to the bottom more quickly and are not as effective. Limestone also dissolves faster in very acidic water (pH4.5) than in moderately acidic water (pH5.5). This factor may necessitate the use of a finer particle size aglime in retreatment projects than was used in the initial treatment. If the finer particle size lime is not used in these retreatments, then a greater amount of lime would be needed to reach the same target pH level.

Table 10. Acceptable limits for chemical constituents of candidate materials (table taken from Sverdrup 1985 and Fraser et al. 1985)

Parameter/Element	Upper Limit	Lower Limit	Percentage By Weight/Concentration
$CaCO_3$		X	70%
$MgCO_3$	X		5%
Organic material	X		5%
Phosphorus	X		0.1%
Aluminum[a]	X		1%
Manganese	X		1000 mg/kg
Chromium	X		100 mg/kg
Vanadium	X		100 mg/kg
Cadmium	X		1 mg/kg
Nickel	X		100 mg/kg
Copper	X		100 mg/kg
Lead	X		100 mg/kg
Mercury	X		0.5 mg/kg
Zinc	X		100 mg/kg
Cobalt	X		50 mg/kg
Thallium	X		50 mg/kg

[a]Most often found in the fairly inert form Al_2O_3.

4. Timing of Liming Projects

Lake neutralization treatment will be scheduled during the fall, winter, or spring, between the months of September and May. No treatments will occur while a lake is thermally stratified in the summer months. Such treatments could result in neutralization of the epilimnion but not the hypolimnion, and by scheduling treatments only during the fall, winter or spring, this problem will not occur.

The timing of liming projects will also be adjusted to occur during periods of low public use. This action will help to reduce the unavoidable impacts of using motorized vehicles for certain projects. Helicopter flight patterns, use of trails or roads, and staging areas will all be selected to cause a minimum of potential impact.

B. Post-Liming Actions

1. Post-liming Water Quality Monitoring Program

Water quality trends in neutralized lakes must be monitored on a long-term basis to protect against whole-lake reacidification. Routinely performed lake liming also is no guarantee against damages caused by acid episodes (see Unavoidable Adverse Effects). With this in mind, the monitoring program proposed will attempt to address the problem of when to retreat a lake by monitoring the long-term variability of specific parameters determined to be sensitive to acidification. The intent, therefore, is to propose a monitoring program that is simple, verifiable, and inexpensive to conduct.

Lake flushing rate should be determined prior to neutralization. It is assumed that most of a lakes buffering potential, following neutralization, is in solution. Therefore, lake flushing rate should serve as a preliminary estimate of when reacidification would occur. The bottom sediments will obviously contribute to overall lake buffering, however, their affect is not easily determined by simple empirical calculation.

Each lake in the liming program will be sampled once annually during the summer stratified period and more frequently if warranted. This sample will be collected from the center of the pond or if necessary at a representative location such as the pond outlet. Wherever feasible and practical a sample should also be collected during spring overturn. A fall overturn sample also should be collected if the summer sample indicates the water is near the reliming threshold. Water samples should be stored at $4^{\circ}C$ in polyethylene bottles and analyzed within one week of collection. This time schedule necessitates coordination of field personnel with the laboratory conducting the analyses.

Analysis of all samples will be carried out according to standard laboratory procedures for the analysis of dilute waters (Schofield 1978; ALSC 1985). Parameters which will be measured include air equilibrated pH (using a pH meter with glass electrodes), alkalinity (using Gran's plot titration methods), conductivity (using a conductivity bridge), and color (using a Hach or comparable color comparator). Additional parameters of interest which may be measured periodically include sulfate, calcium, and monomeric aluminum. For all chemical analyses a quality assurance/quality control program will insure that the data are accurate and reliable. This program will include periodic analysis of sample standards, duplicate samples, and inter-laboratory comparisons.

2. Strategies to Reduce Impact of Public Use

If the assumption is made that limed waters will be subject to increased use, then it may follow that a corresponding increase in resource degradation could occur. This of course will depend on the amount of increased use and whether a certain critical threshold is reached. For example an increase from 10 to 20 people using a remote pond in a year would not be expected to degrade the resource. Some specific types of resource degradation that might result from increased user pressure are:

- Increased littering
- Accelerated deterioration of facilities such as trails, lean-tos and designated camping areas
- Shoreline deterioration
- Diminuation of the so-called "wilderness atmosphere" on remote waters

Should these or other symptoms of overuse appear, several strategies are potentially available to ameliorate unsatisfactory conditions. Use of these strategies will depend on the designated land classification of the area if the water is located in the Adirondack or Catskill Forest Preserve. Waters in Wilderness, Primitive or Canoe Areas will receive the greatest protection from overuse. The following management strategies are possible and would be discussed in detail in the appropriate Unit Management Plans.

- Limit or prohibit use of problem areas by regulation and permit
- Limit users length of stay in problem areas by regulation and permit
- Encourage use of other less sensitive areas
- Make access to problem areas more difficult
- Improve access to less sensitive alternative areas
- Eliminate facilities in problem areas
- Improve facilities in alternative areas
- Discourage camping
- Prohibit camping by regulation
- Locate facilities in durable sites
- Discourage or prohibit use by regulation during times when impact potential is high
- Prohibit the use of damaging equipment by regulation
- Maintain impacted facilities
- Remove litter
- Rehabilitate damaged facilities or natural resources