ACKNOWLEDGEMENTS

This report was prepared by consultants Jerry Jenkins and Peter Zika for the Fragile Areas Review Committee, the Department of Forests, Parks and Recreation and the Department of Water Resources and Environmental Engineering. The employees of the Agency of Environmental Conservation wish to express their gratitude to the consultants for the depth and thoroughness of their field work and of this report. This document has already been instrumental in aiding important decisions on the future of Vermont's river environment.

This project was conceived of originally by Thomas Willard, Environmental Engineer in the face of a renaissance in hydropower. The project was developed and overseen by Charles Johnson, State Naturalist and Stephan Syz, Water Resources Planner. Many people have contributed to the report including Alison DesMeules, Jeffrey Cueto and Jerry McArdle, all of the Agency of Environmental Conservation.

Stephan Syz
February 20, 1987

DISCLAIMER

This report was prepared by consultants and does not necessarily represent the views of the Department of Water Resources and Environmental Engineering (hereafter referred to as DWR&EE or "Department"). The descriptions of water quality are subjective evaluations by the authors and may not, in some cases, accurately describe the present water quality or the present fishery. The recommendations also may or may not represent the views of the Department. They do warrant careful consideration. The most current data can be obtained from the Department or the District Fisheries Biologist.

EDITING

Some sections of this report have been edited by the Department to prevent confusion and to make the report consistent with state policy.

HEALTH HAZARD

Swimming is not recommended in Class C waters due to the possibility of a health hazard in the event of the failure of disinfection systems.

PRIVATE PROPERTY

The property adjacent to many of the sites described is privately owned and permission from the land owner should be obtained before entering upon the land.

STUDY LIMITATIONS

There are many unknown, waterfalls, cascades and gorges. This report must be regarded as a sampling rather than as a complete inventory. No significance should be attached to the fact that a site has been omitted from this report. Prior to this survey, there had been no inventory of waterfalls, gorges, and cascades in Vermont. The consultant studied those sites which the Agency staff happened to know. Additional sites were uncovered during the study and others have been reported to the Department while this report has been in draft form.

ADDITIONAL SITES

The Department intends to eventually make this report a complete and accurate description of all the waterfalls, cascades and gorges in Vermont. You are invited to write the Department at 103 South Main Street, Waterbury, Vermont with the location, description and, if possible, photos of additional sites. These sites will be investigated further and included in the next printing.

PHOTOGRAPHS

Photographs, including numerous slides and color prints, of many sites are on file in the Agency of Environmental Conservation. Most of the photos were taken by Peter Zika and Agency personnel. However, certain prints were taken from slides provided by the Vermont Travel Division.

SITE IMPORTANCE

The evaluation of site importance contained in this document represents the opinion of the consultants. It is entirely possible that other sites in this report or sites as yet unreported will be considered to be important by the Agency either because of their intrinsic characteristics or as similar sites are harmed in the future making the remaining sites of a type more important.

PART I

ABOUT WATERFALLS, CASCADES AND GORGES

INTRODUCTION

This report contains the results of an inventory of waterfalls, cascades and gorges that was commissioned by the State of Vermont and took place in the spring, summer and fall of 1983 and 1984. The purpose of the study was to list the waterfalls and gorges of Vermont, help classify them by size and appearance, and help decide which were important recreational sites and natural areas.

There are several reasons for the study. The first is that waterfalls and gorges are beautiful places that deserve to be protected, and, as with any resource, to protect them you must first know how many exist and where they are and what is interesting and important about each one.

A second reason for surveying waterfalls, cascades and gorges is that many of them - perhaps one-third or more - are potential sites for hydroelectric development. There is currently much interest in hydroelectric projects, and in 1984 the Vermont Department of Water Resources and Environmental Engineering (DWR&EE) was considering over 100 applications for permits to build dams and powerplants. Many of the projects being planned would alter falls, cascades and gorges and the Agency wanted to know the uses and natural and recreational values of all known sites. This information is important when the Agency issues comments to the Federal Energy Regulatory Commission on a developer's license or exemption application. If an area is especially unique the Agency could oppose the project. In addition, the DWR&EE issues or denies Water Quality Certificates and the ability of a water to support important water uses is one of several criterion considered.

In the early summer of 1983, we were given a map of about 100 places that were believed to have waterfalls and/or gorges. We visited 92 of these sites and found about 70 waterfalls and gorges and about ten other wet places that were not big enough to include in the study*. An additional 13 sites were surveyed in 1984. At each site, we would try to explore as much of the area as we could, look for rare plants, make general biological and geological observations, and try to determine what the site was good for and how many people use it. The time we spent at each site varied with our schedules and the complexity of the site, but for the most part, our visits were brief and devoted to reconnaissance rather than to investigation.

This report contains descriptions of 89 individual sites, some general information about the methods used and the

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* For this report, a waterfall or a cascade had to be over three feet high, and a gorge had to have a pair of continuous rock walls over ten feet high.

limitations of the study, and eight chapters that compare the sites and summarize particular findings.

The report is organized as follows: PART I contains methods and general results, and includes sections on geology and geomorphology, types and sizes of sites, plant communities and rare plants, uses, comparative importance, water quality, and conservation and restoration. PART II contains a glossary of our technical and descriptive vocabulary, and brief reports on the 90 sites where we found waterfalls or gorges. The APPENDIX contains reports on nine sites where we did not find waterfalls or gorges, a list of sites for future investigation, and a summary of information on the sites studied.

The site reports in PART II are arranged by river basin, following the normal procedure for DWR&EE reports. Summary lists for each basin precede the site reports for that basin, and give an idea of the regional groupings of sites. Indices to sites, river, town, and DWR&EE number are provided at the end of the report.

Readers interested in a brief summary and evaluation of the sites are referred to the various tables in PART I, which compare the sites and give lists of the most exceptional sites in various categories.

We would particularly like to call attention to limitations of the survey. These are discussed more fully in Chapter 1; but we note here that this survey was at best a reconnaissance and not a thorough investigation. We neither investigated every known falls and gorge, nor searched out every unknown one, nor conducted thorough biological and geological investigations of the sites we visited. Hence, our comparative rankings of sites are only provisional. A deeper investigation is bound to discover important sites that we did not visit, and biological or geological virtues at sites which we thought were undistinguished.

We have tried to allow for the effects of future discoveries by not stressing distinctions between sites based on our estimates of the abundance of a certain type of site or a certain type of feature. (For example, we do not place great stock on our estimates of exactly how rare a certain plant or a certain type of gorge is, because experience has taught us that these estimates change quickly.) Hence, we stress that 60 out of the 80 sites we visited have importance as natural and recreational areas, but de-emphasize our more detailed estimate of the number of sites that are highly important at the state level.

We have included quantitative estimates of the latter sort because they are an intellectually convenient way of summarizing information, and because they are useful for the administrative classification of sites. But we stress that they are suspect: they are based on partial information, introduce a specious

quantification and very subjective estimates about naturalness, beauty, and wildness, and because they can only be made at all by pretending that the values of certain users - scientists and geographers for example - are representative of the values of all the rest of the users.

The last difficulty is especially significant. Places are not important in themselves, but only because someone values them. Thus, estimates of their value depend on whether the estimator can identify (and sympathize with!) the persons to whom they are valuable. In science and geography, it is customary to value the unusual: hence, we as scientists value a damaged, unswimmable, dangerous, and unloved gorge on the Clyde highly because it is the only limestone gorge in north central Vermont, and because limestone gorges are rare in the state as a whole. We expect, and rightly so, that rare places illustrate the farthest possibilities of our landscape and so contain information we can not get elsewhere. But for many activities - walking, fishing, swimming, resting, and so on - it is much more important that a place be beautiful and clean and satisfying and near you than that there be no other places like it. We would no more retire to the Clyde Gorge for recreation and pleasure than we would bother to hunt rare plants at our favorite swimming holes.

And so we are dealing not only with different grades of importance, but also with different kinds of importance, and this makes it difficult to decide whether a place that is of high importance because it is an unusual land form is more or less valuable than a place that is locally important because it is beautiful and pleases the people who go there.

Hence, rather than make too much of the differences between sites, we prefer to say that there are at least 60 waterfalls and gorges that have undeniable importance for science, scenery, beauty or recreation, and that all of them are important natural areas. If any one is destroyed, the state will lose something of value. In some cases, what is lost will be unique, and in some cases it will be duplicated elsewhere. As explorers and scientists, we are biased towards the unique, but as conservationists, we oppose any destruction of attractive landscapes, regardless of whether they are unusual or ordinary.

* * *

Finally, a few notes on style and authorship. This report is the result of collaboration between Peter Zika and Jerry Jenkins. Both of us are field biologists who specialize in botanical survey. Usually only one of us visited a given site. We used a standard survey method, but our abilities - hence, our emphasis - differed: Zika did very thorough vascular plant lists and concentrated on rare vascular plants. Jenkins did more extensive moss inventories and concentrated on rare moss species.

The site descriptions were prepared by each of us separately for the sites visited, using a standardized descriptive language which is explained in Section 9. After the individual reports were written we then spent several days discussing and comparing sites until we agreed on our comparisons and evaluations. Jenkins wrote the main text of the report, drafted the summaries and tables, and edited the site reports. Zika researched and prepared the historical information on rare plant records, edited the entire text, and surveyed the additional sites in 1984. Despite the individual responsibilities, we emphasize that the design and accomplishment of the survey was very much a collaboration, and that the conclusions and judgements are our joint product and responsibility.

The report makes very little use of numbers, except for our visual estimates of the size of the waterfalls and gorges. We have avoided creating a numerical rating system to evaluate the importance of the sites visited, and we avoid expressing either the relative importance or abundance of a particular group of sites as a percentage. This is done in the interests of precision. The senior author was trained in mathematics and the philosophy of science, and regards numerical ratings of landscapes and percentages derived by dividing one uncertain quantity by another as gross examples of haphazard thought and poor scientific taste, and eschews the pretense of quantification when the substance is unquantifiable.

* * *

There has already been much alteration and destruction of waterfalls and gorges. This, combined with the number of people who use and appreciate the ones that remain, seems to us argue for the defense of every important site we have left. We believe, with the psalmist, that waters restore the soul; and with an Irish poet that by climbing to the places where water moves over stones we find both calm and passion. We have ourselves experienced restoration and calm and passion in our walks and explorations, and treasure the experiences and the places that produced them. The places existed long before we did; it is our greatest hope that we can help to assure that they live long after we do.

1. METHODS OF LIMITATIONS

A map of about 100 sites believed to have waterfalls or gorges was prepared by the DWR&EE and edited by Charles Johnson, the state naturalist. It included sites from various natural areas surveys and published sources, sites that might possibly be used for hydropower projects, and sites known personally to state employees who happened to be available when the map was being made. We refer to this in the reports as the state waterfall map or the water resources map. It is not official and has not been published.

Because the map had more sites than there was time to survey, no attempt was made to locate additional sites.

Usually only one of us visited each site. We would explore the whole area, make notes on the landscape, setting, rocks, site condition, and water quality, and do some biological investigation. We would always note the general vegetation and look for rare vascular plants. At about two-thirds of the sites we made species lists, either of vascular plants, or of bryophytes, or of both. The object was to see as much of the site as possible in the time we had, and this usually did not allow us the time for very detailed scientific work.

We did not inventory animals. We noted the presence of aquatic insects because they are roughly indicative of the amount of oxygen in the water, but did not count or identify them. In a few site reports we included information on a rare animal or important fishery, but no effort was made to evaluate every site for its importance to fauna.

We did not do any detailed geological investigations. We would locate the site on the state geological map or on a USGS geological quadrangle and attempt to correlate what we saw with what the map said should be there, but because of the difficulties in recognizing individual strata and because of our own deficiencies as geological observers we often were uncertain about what we were really seeing.

While at each site we attempted to guess how much it was used, by looking for paths and trampling and litter and by asking neighbors and visitors. We also looked for fish and swimmable pools and noted old dams, mill foundations, and so on. These studies were of necessity catch-as-catch-can: in many cases we do not really know much about who uses the site or what they do there.

No attempt was made in our study to determine the history of the sites or their cultural value. This will require a separate investigation.

* * *

Since the survey was limited in completeness and intensity, the findings and conclusions are provisional, and we would ask that the reader keep in mind the following:

1. The survey was limited to published sites and sites personally known to us or to employees of the State Environmental Agency.

2. Most sites were seen only once, usually at low water, and hence, we do not know what the sites look like at full flow. Thus, we know a lot about what was under the waterfalls, and less about how spectacular the water itself was.

3. Surveys of vascular plants were done in late season and so some early species (particularly rare sedges and violets) would not have been found.

4. Full surveys of bryophytes were only done at about half the sites that looked like they had interesting bryophyte communities.

5. No information about birds, reptiles, amphibians or insects was systematically gathered. Most of such information found in this report is derived from the authors' study of white-water rivers in Vermont.

6. Geological information is incomplete, and in particular we are for the most part unsure about the relation between the structural geology of the sites and the land forms we observed.

7. Our estimates of the amount and kind of use a site receives are circumstantial and approximate.

8. We do not know the culture and the history of the sites.

* * *

Unknown Sites

We believe that there are likely to be twice as many waterfalls and gorges in Vermont as are reported here. The argument goes as follows:

This survey was limited to published sites and sites that were known to us or to government employees. A site was liable to get on the list if it was a major hydropower or recreation site, or if it had been included in the natural areas survey*, or if it were in one of the parts of the state that we or the state

* The natural areas survey, done in the early 1970's, concentrated on places known to the investigators, and omitted many places and many regions of the state entirely.

people knew well, or if it were a known site for rare plants. On the other hand, if it were a local swimming hole or a falls or gorge on a mountain brook some distance back in the woods, it was quite likely that it did not get on the list.

Thus, the survey was biased towards large and well-known sites, and was in no sense a systematic river-by-river inventory of everything that exists. A few examples may make the extent of this bias clear.

a. Out of 90 sites, only six were more than one-quarter mile from a general-use road, and three of these six were on woods roads or major hiking trails. Even admitting that nice waterfalls attract users and hence, tend to have trails or roads, this suggests strongly that backwoods sites had little chance of being listed and surveyed.

b. Falls and gorges seem to occur somewhat randomly as a result of local stratigraphic peculiarities (see page 8). Since we are unable to look at maps and predict that some streams will have sites and others would not, we have every reason to expect that the mountain streams that have not been surveyed will have their share of sites. This is particularly true of the formation we call a chain of pools and cascades, which is more frequent on mountain brooks than anywhere else.

c. There is no reason to assume that every large or spectacular site is widely known or has been included in published lists. A 50-foot-high falls on Baldin Brook in Wolcott, one of the five or so falls this high in the state, was officially unknown until its owner applied for a permit for a hydroelectric project. The beautiful cascades on the Rock River in Dover were almost unknown, even locally, but was on the natural areas survey because a local geologist had visited them.

d. It is also wrong to assume local swimming holes are always widely known; many times, while looking for one site, we were told that it was an indifferent place, and if we really wanted to see a nice swimming hole, we should go somewhere else.

e. This survey includes no high altitude falls. Such falls certainly exist: they are usually temporary falls that run mostly in the spring and are found on the headwalls of mountain ravines. They are often quite pretty and can be important botanical sites.

We have no way of estimating how many unlisted sites exist. With very little effort, we learned of 20-30 more sites while surveying the 90 on the list, and would suspect that, by asking in the garage or general store of each village in Vermont, we

would have no trouble finding out about 50 other local swimming holes. We would imagine that, with more difficulty, an equal number of mountain sites could be discovered by systematic exploration. Hence, we estimate - entirely by guess work - that this survey covers, at most, half of the extant small falls and gorges.

Note, however, that the coverage of large sites is likely to be much better than 50%. Large sites are often on large rivers, and even when they are not, they are often noticed and used, either recreationally or for power. In the course of our survey, we neither were told about nor discovered any large sites that had not been listed. Doubtless some exist (cf. paragraph c, above), but we believe that there are likely to be very few large sites that are not currently known*.

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* This has been partially confirmed since the above was written. While doing field work on other projects in 1984-5, we encountered approximately 20 small falls and gorges, confirming our expectation that they are really quite numerous in the state as a whole. In addition, basin planning studies by DWR&EE have revealed another ten to 15 new sites, including a number of important swimming holes and several large falls. These findings suggest that there are still many unknown falls and gorges, and make it essential that this report be regarded as a sampling rather than as a complete inventory.

2. GLOSSARY OF DESCRIPTIVE AND TECHNICAL TERMS

For the purposes of this study, we used the following conventions:

A site is called a **gorge** if it has continuous rock walls at least ten feet high on both sides.

A site is called a **waterfall** if water fell vertically or almost vertically for three feet or more.

A site is called a **cascade** if the water fell three feet or more over rocks that were not vertical or almost vertical.

A site is called a **chain of pools and cascades** if there were five or more pools and cascades along a stream and the total length of the chain was over 300 feet.

(Sites that did not fit into at least one of the categories above were not considered as a waterfall or gorge for the purposes of this report. In particular, wooded ravines (which are often locally called gorges) of whitewater streams without drops of over three feet were not studied.)

Large gorges: walls 40 feet or more high.

Small gorges: walls ten to 40 feet high.

New York type gorge: a gorge with vertical walls and a large falls at the head of the gorge, generally in limestone.

Large falls and cascades: vertical drop greater than 20 feet.

Small falls and cascades: vertical drop ten to 20 feet.

Urban sites: sites located within a heavily settled area.

Industrial sites: sites currently or formerly used for hydropower, with evident dams, penstocks, retaining walls, buildings, powerlines or other alterations.

Rural sites: sites in farm country, with or without buildings in view.

Woodland sites: sites largely surrounded by woods.

Mountain sites: woodland sites on steep slopes.

Wild sites: sites largely or completely in their natural condition.

Secluded sites: sites at least one-quarter mile from a maintained road, and not receiving heavy recreational use.

Degraded sites: a site that formerly was of at least moderate importance but which has been damaged by pollution or alteration.

Restorable sites: a site whose importance could be increased by pollution abatement, or by increasing the summer flow, or by removing derelict structures.

Mild pollution: pollution or fertilization sufficient to cause turbidity or substantial amounts of algal growth, or that gives the water a noticeable smell or taste.

Bad pollution: anything that you do not like to look at or smell or would not swim in.

Large stream: any stream with an average width of over 75 feet.

Medium-sized stream: a stream with an average width of 20-75 feet.

Small stream: a stream with an average width of 20 feet or less.

Mountain stream or **headwaters stream:** small steep gradient woodland stream on steep terrain near the top of its watershed.

Alluvial stream: a stream with a continuous flood plain more than three times its own width.

Rippled rocks: water-shaped rocks with rippled or fluted surfaces. Generally we did not note them unless the rippling was about 3cm deep or more.

Bedding: the layers of the rock.

Sculptured rocks: rocks with concave surfaces formed by erosion, usually associated with potholes.

Contact: a place where two different formations meet.

Uncommon plant or **scarce plant:** one currently known from less than 50 sites in Vermont.

Rare plant: one currently known from less than ten sites in Vermont.

Bryophytes: mosses and liverworts.

Vascular plant: one of the flowering plants, ferns, or fern allies.

Penstock: a pipe, often large, diverting water under pressure from a dam to feed a powerplant.

For purposes of comparison, in the summary section of each report we compare the construction, botany, privacy, tidiness, and swimmability of each site using the following ratings:

1. As to the overall visual interest of the rock formations at the site.

   poor rocks: hardly worth noticing.

   average rocks: similar to those at many other sites. (Please note that an average waterfall can be a very pretty place.)

   nice rocks: above average, hence, the site is memorable either for overall prettiness, or for details.

   fine rocks: exceptional visual interest, as good as any place like it in the state.

   spectacular rocks: formations of striking size and rockiness.

Spectacular rocks are by definition bigger than non-spectacular rocks, but they are not necessarily prettier or better-made. Thus, Quechee is spectacular, but we do not judge the cliffs to be outstandingly pretty and hence, do not rate the rocks as fine.

2. As to botany.

   poor botany: few plant species at the site.

   average botany: about what you would expect.

   exemplary botany: better than average in either the number of species or the general abundance of vegetation; judged to be an excellent example of the type of community that can develop in this habitat.

3. As to privacy and naturalness.

   not secluded or wild: roads or buildings adjacent and visible.

   somewhat secluded: isolated from the surroundings; roads and buildings may be nearby but you can not see them, and the site does not get large numbers of visitors.

wild: in its natural condition, with only forest or mountain land visible; at least 400 yards from a maintained road.

very secluded: over one-half mile from a road and not on a major trail.

private: isolated from its surroundings and receiving few visitors.

4. As to tidiness.

clean: no litter, junk or debris.

fairly clean (= some trash): <1 bottle/1,000 square feet.

a **mess:** lots of litter, junk or debris.

5. As to water quality.

very clean: used only for mountain streams with no farming or settlement in their watershed.

clean: no turbidity, only small amounts of green or blue-green algae (diatoms may be abundant), no special smell or taste.

mild pollution: some smell, foam, scum, discoloration, etc.

disgusting: exactly that.

6. As to swimmability.

good bathing: pools and clean water, not deep enough to swim.

fair swimming: pools to swim in.

good swimming: good water, deep pools, pretty site.

great swimming: very beautiful or very exciting or both.

3. CLASSIFICATION, GEOMORPHOLOGY, GEOLOGY

This report uses a very simple descriptive classification:

A **falls** is a vertical or near vertical drop, at least three feet high, at which the water shoots outward and falls without touching the rock. A **small falls** is under 20 feet high, a **large falls** over 20 feet high.

A **cascade** is a bedrock exposure, which may be low-angle or high-angle but is not vertical, over which a stream drops at least three feet, and at which the water remains in contact with the bedrock and does not shoot upward. A **small cascade** is under 20 feet high, a **large cascade** over 20 feet high.

A **gorge** is a section of stream channel with continuous rock walls at least ten feet high on both sides. A **small gorge** is under 40 feet high, a **large gorge** over 40 feet high.

This classification is straight-forward and easy to apply, but does not take into account the geomorphological processes that create and maintain the sites. We developed a more complicated classification based on geomorphology, but found it was not very useful in field studies.

The rest of the chapter is devoted to a geomorphological classification of falls and gorges: even if it is not directly applicable to the present field results, such a classification contains ideas that are interesting in themselves and might be applicable in more detailed field work in the future.

To develop a geomorphological classification, we begin by noting that in our part of the world, with old mountains and a humid temperate climate, exposed rock faces of any sort are unusual. Stream and hillslope processes, if left to themselves, create smooth hillslopes and stream beds; cliffs wear down and become vegetated and indistinguishable from other slopes; cascades and falls wear away at their lips and are obliterated. Thus, our falls and cliffs are transitory features; the ones we see are either recently created, or are self-renewing and so are able to counteract the normal action of erosion.

There are other landscapes for which this is not true. Such landscapes either lack substantial surface and stream erosion, or have features in their structure or history which interfere with the tendency of erosion to produce even slopes. Thus, in the Sierra Nevada range there has been recent tectonism and faulting; in the Hudson and Connecticut Valleys there has been recent fluvial erosion; and throughout the north temperate zone the

mountains have been exposed to recent glaciation, both by valley glaciers and large ice sheets.*

Falls and gorges have exposed rock faces, and since in our part of the world rock faces get obliterated fairly quickly, this either means that they are recently created, or that some process is re-steepening them and hence, keeping them free of talus or alluvium. Thus, a logical way to classify them is according to the processes that create them or keep them steep. Table 1 summarizes such a classification:

TABLE 1

CLASSIFICATION OF ROCK FACES ACCORDING TO THE PROCESSES THAT CREATE AND MAINTAIN THEM

1. Rock faces created by glaciation. These are found on the headwalls of cirques, and on the lee sides of mountains that were completely glaciated.

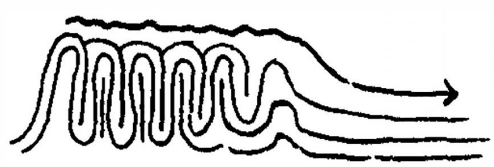
2. Faces created by thrust faults.

3. Faces resulting from differential erosion. A difference in the erosion of adjacent rocks can both either create or maintain a face. Several instances can be distinguished:

3a. Erosion rate varies downslope, resulting in cascades and falls.

less erodable rock more erodable rock

Differences in erodability are often associated with differences in bedding:



vertical bedding horizontal bedding

*Living in the postglacial northeast, we tend to believe that steep mountains are automatically ledgy and steep streams automatically have falls. But the unglaciated southern Appalachians - old, well-eroded mountains - are extremely steep and yet are almost entirely smooth and vegetated, with few large ledges or major falls.

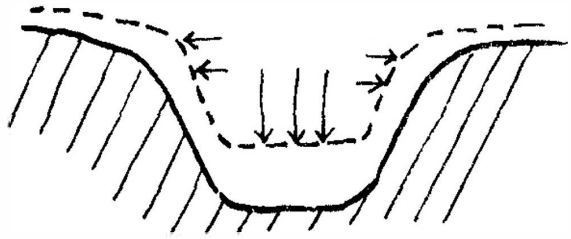
Table 1, continued.

3b. Erosion rate varies across the slope, resulting in gorges.

less erodable more erodable less erodable

3c. Erosion rate varies with direction, resulting in gorges.

horizontal erosion is slow

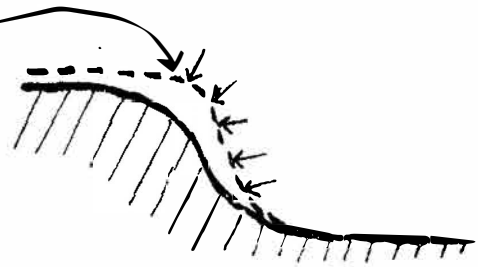


vertical erosion is fast

3d. Erosion augmented at the base of a drop, undercutting it and resulting in the "parallel retreat" of the face.

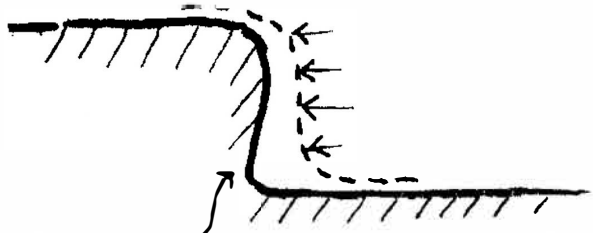
Normal situation resulting in obliteration of a face:

erosion greatest here



before after (cliff angle declines)

Augmented erosion producing the "retreat" of the whole face:



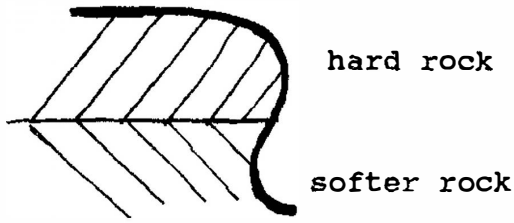
erosion augmented below and equal or greater than above

cliff angle remains the same or steepens

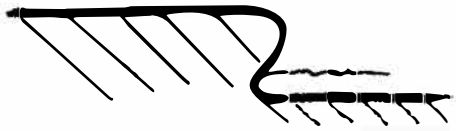
Table 1, Continued.

Parallel retreat is both common and important. It may take place in several ways:

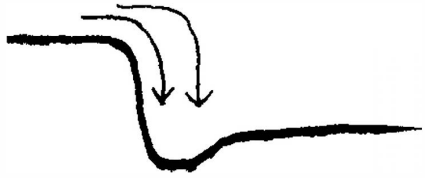
There may be a layer of soft rock underneath a harder rock.



Or a river may cut laterally at the cliff base.



Or a falls may develop sufficient energy to make a plunge pool and undercut its own lip.



The last case mentioned - the parallel retreat of a falls that undercuts itself - is important because the retreating falls may be creating a gorge as it grows, and because the retreating falls may actually grow in height.

Not all of the processes in Table 1 are equally common, and not all of them apply equally to falls and gorges. Thrust faulting seems unimportant in Vermont because most of the faults are very old, and erosion and glaciation have long since obliterated the faces created by the thrusting.* Glaciation has been important in the mountains, but not along the major lowland rivers. It creates cliffs and small falls but rarely large falls or gorges.

Eliminating glaciation and thrust faulting, we get the following geomorphological classification of waterfalls and gorges.

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*Some falls are found at thrust faults but this is usual because the rocks are of different hardness rather than because an ancient scarp still persists.

TABLE 2

GEOMORPHOLOGICAL CLASSIFICATION OF WATERFALLS AND GORGES

1. Gorges created by the lateral migration of streams.

2. Gorges created by the upstream migration of a falls.

3. Gorges created in other situations where the river is cutting down faster than the walls are receding.

4. Falls and cascades that originated by the steepening of mountain slopes by glaciers.

5. Falls and cascades located at the contact points between formations of different hardnesses.

6. Falls and cascades located at points within a single formation where the bedding is more resistant.

7. Falls (usually not cascades) that are undercut at the base and moving upstream.

The problem with the sort of classification outlined in Table 2 is that to use it you have to know something about the history of the site. Usually direct evidence on geological history is lacking, and the history has to be inferred - when it can be inferred at all - from fairly technical evidence. Often to use this classification at a site you would have to look carefully at all the rocks there, map their bedding and stratigraphy, try to determine how erodable they are, and look for evidence of former river channels. This is obviously not something that can be done in a few hours, and equally obviously not the sort of thing that a botanist is liable to be very good at doing, no matter how many hours are spent.

For these, we did not try to apply our geomorphological classification to every site, but instead confined ourselves to the following general remarks about the importance of each type in Vermont.

1. Rock faces caused by the lateral migration of streams are common. Most wooded ravines have some cliffs next to the stream that seem to have originated in this manner. These streamside cliffs are usually confined to the outside of bends, and do not occur opposite one another and so do not form gorges. They are usually less than 30 feet high. Their small size and restriction to the outside of bends seem to indicate that they are geologically short-lived forms, that can only exist as long as the stream continues to cut at their bases.

2. While for the most part sidewards migration of streams does not seem to have created major gorges it is possible that some wide, steep-walled gorges - the Clarendon Gorge for example - may be maintained by side-cutting rather than down-cutting and so be examples of Type 1 above. But this is just conjecture. In practice it may prove difficult to decide whether a given gorge owes its steep walls to side-cutting or to down-cutting or both, and so the distinction between Types 1 and 3 may be difficult to make.

3. The best examples of Type 2 gorges - gorges formed by the recession of falls - are the large limestone gorges of northern and western Vermont. These gorges typically have vertical walls and a sharp change in slope at the rim of the gorge. They all have large falls or steep cascades at the head of the gorge which are two-thirds to fully as high as the gorge is deep. We currently have five good examples (cf. Chapter 3) of this type of gorge. All are in soft limestone. Because similar gorges are much commoner west of Vermont we call these "New York" type gorges.

4. A number of falls on woodland streams are at the heads of small gorges and show the steep gorge walls and undercutting of the base of the falls we associate with the recession of falls. Many of these are undoubtedly Type 2 gorges with receding (Type 7) falls.

5. Most of the remaining gorges do not have a falls near the head of the gorge and so it is not obvious whether they are formed by down-cutting or the recession of a falls or a combination of the two. We can argue for down-cutting in many cases. This is clear for what we call sculptured gorges*, which are gorges which have concave vertical walls made by an eddy first cutting a pothole which then enlarges and cuts vertically down into the rock. Here the continuous vertical markings are proof that rapid down-cutting has

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*Sculptured gorges are very striking. Some sculpture occurs at about a dozen gorges, and large sculptured features at about six gorges. In two places - Texas Falls and the Huntington Gorge - the whole gorge is sculptured and the sculpture extends up to the rim of the gorge. It appears that these sites began as a chain of potholes that enlarged until they met each other and cut vertically down and formed the gorge. At Huntington Gorge, it is possible to see where individual potholes have bored down 30-40 feet vertically into the rock.

Potholes are interesting features because they can influence the eddies that create them, and hence, are potentially self-amplifying features - agents of erosion as much as products of it. It would be interesting to know why they occur at some sites and not others. Geologists have no general answer to this, (note continues on next page)

occurred. It is also probably true for long gorges like Quechee where the walls are much the same angle for one-half mile or more. If the gorge had been formed by the recession of a falls followed by the subsequent widening of the walls the angle of the walls would be less at the lower end than at the upper.

6. Besides these two types (the sculptured gorges and long gorges with walls at a constant slope) there are many smaller gorges which we cannot classify from our field studies, and which may have been created either by down-cutting or recession, or by some combination of the two.

7. Many high mountain cliffs, especially those at the heads of ravines or in a down-ice direction, are generally believed to have been made by glaciers. For the most part these cliffs have only small, intermittent streams. Thus, Type 4 sites - falls of glacial origin - do occur in the state but are mostly small and only flow in the spring and early summer. So far as we know none of the falls we surveyed is of glacial origin.

8. A number of our falls and cascades are mapped as occurring at or near the contact between different formations, and so are potentially Type 5 falls that have resulted from the differential erosion of the two rocks. In some cases, particularly where continuous dikes of a hard rock extend across the stream (Jelly Mill Falls, Clarendon Gorge) this was easy to determine in the field. In other cases we could not identify the formations at a site and could not prove that this was the case.

9. A large number - perhaps two-thirds - of the small cascades and falls we visited occurred in places where the bedding (layering and cracks) of the bedrock was vertical rather than horizontal. Such sites are examples of our Type 6 falls - falls created by structural inhomogeneities rather than by differences in the composition of the rock. Presumably vertical bedding, like the end grain of wood, is more resistant to wear than horizontal bedding. In any event it is very common at small falls, and, especially in

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but we might, from our observations this summer, suggest two things: first that they require a reasonably steep gradient, and second that the rock must be homogenous and without conspicuous joints, so that it will be disposed to wear away rather than break off in chunks. The type of rock seems less important. Potholes are found in both limestone and schist, but not, so far as we know, in shale, nor in quartzite, and probably not in gneiss. It appears from this that they can occur in rocks of a range of hardnesses, but neither in very hard nor in very soft rocks.

the central Green Mountains where the rocks are intricately folded and vertical bedding is common, is perhaps the commonest cause of irregular stream profiles in the state.*

10. Receding falls (recognizable by undercut bases and downstream gorges) are uncommon. As mentioned above there are a few receding falls associated with large limestone gorges. There are also a number of mountain falls that are undercut; some of these are clearly receding and others may recede someday. But such sites are far less common than ones at which the face of the falls is parallel to the bedding, without noticeable undercutting or a downstream gorge. Hence, it seems like that, while moving waterfalls occur, the majority of our falls, especially in schists and quartzites, are stationary.

Returning to our superficial classification of falls and gorges by size, it is logical to ask if certain types of falls or gorges tend to be associated with certain types of rocks. This can be determined from Table 3, which gives the number of sites where different types of rocks occurred, and the number of each sort of feature (small gorges, large gorges, etc.) at these sites.

TABLE 3

TYPES OF FEATURES ASSOCIATED WITH PARTICULAR ROCKS

Rock	# Sites*	Number of Features**			
		Small Falls & Cascades	Large Falls & Cascades	Small Gorges	Large Gorges
Schist & phyllite Schist	37	27	12	6	9
Quartz granulite & conglomerate	4	1	1	1	1
Phyllite	8	5	2	1	
Quartzite	9	6	2	3	
Limestone	12	5	2	5	1
Dolomite	9	3	3	3	3
Granite	4	2	2	1	
Slates	3		1	2	1
Gneisses	2	1		2	
Amphibolites	2		3		
Greywacke	2		2		

* Number of sites at which this rock type occurred.
** Number of features of this type at sites with a given rock type; note that a single site can have several kinds of features.

*Our subsequent work on whitewater rivers provided additional confirmation of this: in that study we looked at the small ledges and rock-lined chutes that create the turbulence in many whitewater rivers, and found that the vast majority of them are associated with vertical or high-angle bedding.

No strong patterns emerge from Table 3, but we can use it as the basis for several weak generalizations and negative results:

1. The number of sites of a particular rock type is roughly proportional to the abundance of that rock in the state. Thus, there is no evidence that falls and gorges are more common in some types of rock than others.

2. Every type of falls and gorge can occur in schist.

3. Gorges appear to be relatively more common in limestone and dolomite than in harder rocks, but the difference is not great.

4. Large features of any kind are quite uncommon in quartzite, gneiss or granite. They are relatively much more common in slate, phyllite and limestone.

5. Both of the sites where greywacke occurs had large falls or cascades, though with only two sites surveyed, this might be coincidence.

6. Rocks of all ages occurred at the sites, but precambrian rocks were rare at falls and gorges, despite the extensive occurrence of precambrian rocks in south central Vermont.

7. No obvious geographic patterns in the incidence of different sorts of sites were discernible.

Looking at these results, we might venture the following tentative generalization: the presence of a certain type of geomorphological structure may not depend so much on the particular type of rock present as on whether the appropriate contrasts of hardness and erodability occur within that rock, or between that rock and adjoining formations. In limestone terrain there are complicated patterns of joints and layers, and gorges and falls - especially receding falls and gorges formed by the recession - are common. In the terrain dominated by schists, lithologies are more homogenous but there has been much complicated folding and hence, much local variation in erodability, and falls and gorges of all types are common. Our schists may be comparatively less fractured and jointed than our limestones, and this may be why carved features seem somewhat more common than in the limestones, and receding falls rarer. Finally, quartzite and gneisses and granites are very homogenous hard rocks, often without much jointing, and perhaps more uniformly erodable than the softer rocks. They produce falls and gorges in places where they adjoin softer rocks, but many falls and gorges may be less common in regions where they are the dominant rocks (the precambrian highlands of the southern Green Mountains, for example) than elsewhere. They tend to chip off

rather than wear away and so rarely produce sculptured surfaces, at least in Vermont.*

* Since this was written we have examined a number of whitewater streams, and found that the streams on precambrian gneisses and quartzites tend to have large numbers of large, round, fairly mobile boulders in their beds. In addition their beds are very smooth, and lack the small ledges and cascades characteristic of many streams on cambrian and younger rocks. We now suspect that this is because the mobile boulders grind the stream beds smooth, but it is still possible that the lack of conspicuous joint systems and bedding planes in the older rocks may be involved.

4. THE TYPES OF SITES AND THEIR ABUNDANCE

Compiling the results of the surveys using a simplified classification we can get a rough picture of the abundance of various sorts of falls and gorges in Vermont.

Tiny falls or cascades from one to three feet high probably occur on almost every stream in the state, and are not worth noting individually.

Small falls or cascades from three to 20 feet high are common on mountain and headwaters streams, and also occur, though less frequently, on larger streams. We noted a total of 45 falls or cascades under 20 feet high in this survey, and assume that two to five times that many exist which are unknown to us. Table 4 (at the end of this section) lists the sites at which there are only small cascades and falls.*

These small cascades and gorges differ in importance. About half of them are either very pretty natural areas or are popular recreational areas or both, and are what we call either locally important or moderately important sites.

Since many small cascades and falls are currently unknown or unlisted it follows that there are a number of important sites not on our list. We do not advise that a systematic attempt be made to locate these sites and survey them, since at present there is not much pressure for the development and alteration of small sites. But since many small sites have local or statewide importance, we do advise that a careful field check be made when there is a proposal to develop or alter a small site that has not been surveyed here.

Large falls and large cascades are rarer. Only 22 were found. They are listed by size in Table 5 (at the end of this section). The highest site would be the steep falls and cascade at Benjamin Falls, about 320 feet high. If you agree to regard the two falls at Carver Falls as a single large falls, the second highest waterfall in the state is 120 feet high. (And this seems fair: if you rode a barrel down Carver Falls you would very quickly be 120 feet lower than when you started, though there would be a bump and a bit of cascading in the middle.)

Twenty of the 21 large falls and cascades were within one-quarter mile of a road. Nine are on large and medium streams in the lowlands and 12 on smaller streams in the mountains. Nine of the mountain sites are important recreation areas; the other three are on brooks used for hydropower or water supply and have dams above them and reduced summer flows. Six of the nine

* Since this table was compiled at least 20 more small falls have been encountered which are not included in this report.

lowland sites currently have major dams above them, and hence, much reduced flows. A permit has been issued for the construction of a dam at one of the three remaining undammed lowland sites.

Let us stress the last fact: so far as we know there are only two places in Vermont where a large waterfall on a medium-sized or large stream has natural flows, and where you can see a falls or cascade 20 feet high or more on a large river without seeing a dam as well.

In the course of our study we did not encounter any large falls or cascades that were not on the DWR&EE map.* We still suspect that unknown large falls and cascades exist, but think that they must be either quite rare or quite remote or both. The best chance for finding them is to look for high falls on very small brooks, somewhat like the 50 foot falls on Baldin Brook in Wolcott. At present we have no way of knowing how many such falls might exist.

Because an undisturbed high falls or cascade would automatically be a very valuable natural area, it might be worthwhile to survey mountain streams for unknown large falls. Such a survey is not a high-priority matter for the state, but would certainly be an interesting thing to do in the future.

Gorges are apparently less common than falls. This is partly because many gorges have a falls or cascade in them but many falls and cascades do not have a gorge. It is also because gorges are not as attractive as falls and cascades and may be under-reported.

We surveyed 18 small gorges and 16 large ones. Twelve of the 18 small gorges were associated with a falls or cascade. All the gorges had streams in them, and so far as we can tell all the gorges are the direct results of fluvial erosion. Table 6 summarizes the small gorges, and Table 7 the large ones. (Both tables are at the end of this section.)

Our definition of a gorge (any site with ten foot high, paired, rock walls) is broad, and hence, the small gorges described here are a small sample - perhaps only 10% - of the small gorges in the state. Most small gorges are modest places which differ only slightly in biology and attractiveness from the woods around them and do not merit special consideration as natural areas. But this is not universally true: some small gorges are very beautiful, and others have interesting plants, particularly mosses. Hence, it should not be assumed that because we have a lot of them we can mess up as many as we want, or that because they are smaller than the large gorges they are automatically less important. Some are very important natural

* Since this was written we have collected reports of several unsurveyed large falls and gorges.

features, and get just as much attention from conservationists as the large gorges.

The major gorges are all on medium-sized and large rivers, and we think it unlikely that a mountain brook could cut a gorge 40 feet deep. All of the large gorges are near roads, which would be expected since essentially every major river in the state has roads following the valley.

Because of the association of large gorges with major rivers and medium-sized rivers we do not think it likely that there are any unknown large gorges.

Five of the large gorges are what we have called "New York" type gorges: steep-walled gorges in soft rock formed by the recession of a large waterfall.

Ten of the 17 large gorges have dams; at seven of the dam sites the gorge is dammed at the top and the flow restricted. At the other three, the dam is below and the gorge is flooded.

Thus, only seven of the large gorges currently known in Vermont, have not been altered by a dam. Only one of these, the Big Falls of the Missisquoi, is on a big river. It is a treasure: originally there were five large falls and six large gorges on the major Vermont rivers. At present, the Big Falls is the only site where either a large falls or a large gorge can be seen in their unaltered condition. (It is also the only "New York" type gorge without a dam, and also an important botanical site.)

Brockway Mills, one of the four large gorges without a dam, is currently proposed as the site for a hydroelectric project. The project would not damage the gorge or the flora, but it would place some large structures within a large gorge and gorges such as this are rare in Vermont.

Potholes and sculptured rocks are found at a number of different kinds of sites. Table 8 (at the end of the section) lists 13 sites at which we found large sculptured features. Small potholes and minor sculpturing were found at several other sites.

Chains of pools and cascades seem to occur mostly on mountain streams, or, less commonly, on larger streams in upland valleys. None have been found on major rivers, and none in the Connecticut and Champlain lowlands. We believe that they are associated with high-gradient streams that carry fairly coarse bedload. They are frequently associated with gorges: we currently know 12 major chains of pools in the state, and eight of the 12 are either in or directly below a gorge. Table 9 (at the end of the section) lists the major pool chains found in the survey.

Almost all the chains of pools are valuable sites. Many afford excellent swimming, and by good fortune all of them are largely undisturbed and have in consequence much natural beauty. Several are one-half mile or more from a road, and are among the very few sites we surveyed to which there is not direct road access. Others, particularly Cavendish Gorge and Brockway Mills Gorge, are near roads but are in deep gorges and when you are in them you seem very isolated. Cavendish is a popular local swimming area, and there are trails and you can climb down into it at several places, but when you have been in it alone for an hour or two you come to believe you have at least a planet to yourself, and are surprised if you meet another person.

The pool chains are often very pretty places, modest and pleasing and fitting the scale of the countryside. In many ways it is far more satisfying to ascend a series of small falls than to come upon a single large falls in an otherwise ordinary stream. The single falls seems anomalous and accidental; you are there and see it and it is all done. Because it is anomalous it has not told you anything about the character and energy of that stream, or of the way the valley is put together. A chain of pools leads you on and shows you how the rock changes and how the stream has used its liveliness and imagination, and hence, is a more thorough expression of the structure and personality of the whole mountain.

We thus find pool chains fascinating places to visit, appropriate to our landscape and expressive of it. We have come to think of them as a distinctly New England feature, natural in our country just like high granite falls are in the Adirondacks, or deep "shut-in" gorges and falls in the Ohio Valley. Hence, we value them highly, and are pleased that a number of fine ones exist and are still wild, and even more pleased to think that there are likely a number in the mountains that are as yet undiscovered.

TABLE 4

SITES CONTAINING SMALL CASCADES OR FALLS BUT NO LARGE CASCADES OR FALLS AND NO POOL CHAINS*

Site	Features Present**	Comments
Allen Brook Cascade	SC	industrial site
Bellows Falls	SC, SG	industrial site, former site for *Astragalus alpinus*
Blake Falls	SF, SC	small falls in woods
Covered Bridge Falls	SC	a sign says you can walk your dog here
Devils Pothole	SF, SC	big potholes carved out of rock
Dogs Head Falls	SF	undisturbed site, fine view, nice rocks, good swimming
Duck Brook Cascades	SF, SC	on Long Trail, important because remote and popular with hikers
East Calais Cascade	SC	a lot of junk dumped here
Falls of Black River	SF	chunks of an old bridge around
Falls of Little Otter Creek	SC	wide but not high
Highgate Falls	SG, SF	fine rocks, former site for *Anemone multifida*, needs more summer flow, existing hydro site
Jelly Mill Falls	SC, SF	popular swimming site
Kelly River Falls	SC	several small cascades in a chain with small pools, nice rocks, good swimming
Lana Falls	SC	nice rocks, popular recreation site
Lower Falls of Union Village	SC	would be flooded by proposed hydro project
Lower Green River Falls	SC	proposed to be dammed

Table 4 (Continued).

Site	Features Present**	Comments
Lulls Brook Ravine	SC	pretty place, unusual in this part of the state, recently dammed for hydro (11/85)
Marshfield Falls	SC	low cascade 100 yards long; hydro plant has been approved for this site
Nelson Brook Gorge	SG, SF, SC	granite gorge with exemplary mosses, only site for Neckera pinnata in our study
New Haven River Cascades	SG, SF, SC	nice rocks, exemplary biology, pretty view, good swimming
North Branch Falls	SF, SC	good swimming, nice rocks
Northfield Falls	SC	more average than most
Pikes Falls	SC	popular swimming place
Roaring Brook Cascade	SC	very small site
Seven Falls of Huntington River	SC	rocks average to nice
Shelburne Falls	SC	one of the most northern sites for Platanus occidentalis
Sutton Brook Falls	SF, SC	small site altered by I-91
Tillotsons Mills	SC	
Twin Falls	SF, SC, SG	good swimming
Upper Falls of Union Village	SC	developed as a recreation area, nice rocks, popular place
Upper Green River Falls	SC	
West Branch Falls	SC	possibly a good site for mosses, locally popular site, fine rocks, moderate seclusion
Willoughby River Falls	SC	famous rainbow trout migratory route

* The sites with no annotations are thoroughly unremarkable.
** SG = small gorge, SF = small falls, SC = small cascade

TABLE 5: LARGE FALLS AND CASCADES

Site	Type	Height x Width (Feet)	Comments
Benjamin Falls	falls and cascades	320 (total) x 15-30	falls and cascades near Montpelier, secluded spectacular in spring pretty ravine 2,000-2,500 feet long
Marshfield Falls	large cascade	200	cascade 100 yds. long, hydro plant has been approved for this site but developer at this time has decided not to develop the site
Carver Falls	two falls and large gorge	120 (total) x 250	big dam & power plant
Mollys Falls	steep cascade	100 x 10-20	dam above; dry all year except the spring
Moss Glen Falls II	cascade plus falls	100 (total) x 10	mountain stream, popular recreational site, state natural area
Thundering Falls	large cascades	75 x 15	popular recreational site now degraded by logging and some construction
Crystal Cascade	large cascade	70 x 50	popular wooded site; pretty dry in summer
Fairfax Falls	45 degree cascade	60 x >100	dam and power plant
Barnet Falls	45 degree cascade	60 x 6	rock chute cuts across a cliff
Sutherland Falls	steep cascade	60 x 75 ?-100	dam, industrial plant badly polluted
Hamilton Falls	steep cascade	50 x 10	popular recreational site
Baldin Brook	falls	50 x 3	mountain stream, small dam, falls damaged by new road

TABLE 5: LARGE FALLS AND CASCADES (Cont.)

Site	Type	Height x Width (Feet)	Comments
Emerson Brook	cascade	40 x 30-50	important swimming area
Bingham Falls	falls and cascade	20 x 5, 20 x 5	mountain stream, popular recreational site
Moss Glen Falls I	steep cascade	30 x 10	mountain stream, popular recreational site, state natural area
Boltonville Falls	steep cascade	25 x 10	dam and power station, developed for hydro in 1984
North Hartland Falls	two cascades	both 25 x 10-20	dam; pretty site
Big Falls of Missisquoi	steep cascade	25 x ? 50	only undammed large falls on a large river
Web Falls	falls	25 x 50	large undammed falls
Old City Falls	falls	20 x 15	undisturbed ravine
Woods Falls	cascade	20 x 50	dam and powerhouse
Glen Falls	cascades	25 x 10	mountain stream, tiny dam above the site

TABLE 6: SMALL GORGES

SG = small gorge, LG = large gorge, SF = small falls, LF = large falls, SC = small cascade, LC = large cascade, PC = pool chain

Name	Other Features at Site	Comments
Flower Brook Gorge	SG	industrial site
Middlebury Gorge	SG, SF, PC	high priority site, very wild, fine rocks, exemplary biology, possibly rare mosses
New Haven River Cascades	SG, SF, SC	nice rocks, exemplary biology, pretty view, good swimming
Battell Gorge	SG	small gorge on large river, undammed, undisturbed, very pretty; threatened by hydro proposal
Highgate Falls	SG, SF	fine rocks, former site for Anemone multifida, needs more summer flow; dam to be raised (existing hydro site)
Ithiel Falls Gorge	SG	barely a gorge
Baldin Brook Falls and Gorge	SG, LF	fine falls on a small stream recently damaged by the access road to a small hydro dam, exemplary biology
Wrightsville Gorge	SG	old mill site
Nelson Brook Gorge	SG, SF, SC	granite gorge with exemplary mosses, only site for Neckera pinnata
Moretown Gorge	SG	small site
Bingham Falls	SG, LF, LC	spectacular rocks, fine sculpture, former site for Osmorhiza obtusa, popular site, perhaps threatened by housing developments
Texas Falls	SG, SF, PC	handsome rocks, exemplary, major tourist site in GMNF
Quechee Village Falls	SG	falls degraded by dam, Cinna arundinacea present
Saxtons River Falls	SG	dam being rebuilt
Twin Falls	SF, SC, SG	good swimming
Glen Falls	SG, LC	small dam at top of gorge for drinking water supply
Sheldon Falls	SG	waterfall has been destroyed by a dam
Belden Falls	SG	small gorge below a dam

TABLE 7: LARGE GORGES

Site	Dimensions*	Comments
Quechee Gorge	150+ x 1,000+	total depth about 160 feet; sloping walls, formerly many rare plants; dam at upper end
Bolton Falls	100 x 1,000+	major river; flooded by a dam at the bottom; used to have a falls where dam is
Carver Falls	80 x 500+	major river; "New York" type gorge with large falls at head of gorge; dam above falls; gorge gets little summer flow because of dam; flows reduced year round
Cavendish Gorge	80 x 1,000+	sculptured gorge, in places deep and narrow dam at head of gorge; fine mosses
Clarendon Gorge	75 x 800	wide gorge with vertical sides; fine mosses; chain of pools and cascades; popular recreational site
Brewster River Gorge	75 x ?	pretty woodland site, popular recreational area
Lime Kiln Gorge	70 x 700	major undammed gorge in an urban setting; formerly had six rare plants; now has two uncommon ones
Winooski Gorge	50-80 x ? 2,000	dammed gorge in industrial setting; formerly with the best limestone gorge flora in Vermont, but now much diminished by damming and alterations
Big Falls of Missisquoi	60 x 250	undammed gorge and large falls on a major river
Middlesex Gorge	60 x 1,000+	major river; flooded by dam on the lower end; no falls
Woods Falls	60 x ? 300	major river; "New York" type limestone gorge; dammed above gorge

TABLE 7: LARGE GORGES (Continued)

Site	Dimensions*	Comments
Brockway Mills Gorge	50 x 1,000	scenic, undisturbed gorges with pretty rocks and various small pools and cascades; threatened by a proposed dam
Sutherland Falls	50 x ? 400	"New York" type limestone gorge, dam above industrial plant on one bank and below
Williston Gorge	35 x 500+	dolomite gorge in industrial setting with two rare plants
Huntington River Gorge	40 x 200	very narrow sculptured gorge, formed from a chain of potholes; beautiful rocky; popular scenic attraction and recreational site
Great Falls of Clyde	50 x 800	"New York" type limestone gorge with vertical walls and a small cascade at the top; dam above, penstock along one wall, powerhouse below

* Maximum height of rock walls x length, in feet.

TABLE 8

SITES WITH MAJOR SCULPTURED FEATURES

Site	Comments
West Branch	rippled rocks, small potholes
Middlebury Gorge	sculptured gorge walls, rock-rimmed pools
Cavendish Gorge	sculptured gorge walls, rock-rimmed pools
Huntington Gorge	sculptured gorge walls, rock-rimmed pools
Texas Falls	sculptured gorge walls, rock-rimmed pools
Clarendon Gorge	sculptured boulders and pools
Woods Falls	sculptured walls and potholes
Hamilton Falls	large pothole pool
Devils Pothole	large potholes
Belden Falls	potholes, fissures in rock islands, stream channel makes tunnel under an island
Bingham Falls	potholes
Brockway Mills Gorge	potholes and sculptured rocks
Bristol Memorial Etc.	potholes
Web Falls	one sculptured ledge
Lime Kiln Gorge	small water-cut caves

TABLE 9

CHAINS OF POOLS AND CASCADES

Site	Comments
Woodbury Falls	small gorge and one-quarter mile chain of pools and cascades; remote and undisturbed site
Hamilton Falls	major cascade and recreational area near road; then one-half mile chain of pools and cascades, these largely remote and undisturbed
Terrill Gorge	one mile long chain of pools and cascades; partly near road and heavily used, part remote
Rock River Cascades	one-half mile chain of cascades and pools, wild and remote
Middlebury Gorge	deep ravine, fairly remote because inaccessible, with one mile of cascades and pools; also segments of gorge
Texas Falls	small carved gorge and 600 foot chain of pools and cascades; major tourist site in National Forest
Clarendon Gorge	one-quarter mile chain of pools and cascades within a large gorge; very popular recreational site
Cavendish Gorge	one-quarter mile long chain of pools and cascades in a gorge below a dam; wild but not remote, used for swimming; very pretty
Brockway Mills Gorge	about 1,000 foot chain of pools and potholes along a zigzag stream in a large gorge; wild and secluded but not remote; pretty place; threatened by a hydroelectric project
Sterling Brook Gorge	about 400 foot chain of cascades and pools, in a small gorge on a mountain brook; moderately remote and secluded, but gets local use; accessible by a jeep trail; some logging nearby
Mill Brook Cascades	remote set of low-angle cascades and pools in dense boreal forest; pretty but not exceptional, threatened with a dam
Granville Cascade Chain site	about one-quarter mile long chain of pools and cascades; lovely remote

5. BOTANY

As explained in Chapter 1, plant community surveys were done at all the sites, detailed vascular plant inventories at about two-thirds of the sites and detailed moss inventories at about one-third of the sites. As a result, we can give a nearly complete account of the vascular plant flora of gorges and waterfalls and a preliminary account of the bryophyte flora.

5A. Vascular Plant Communities

By a plant community, we mean a group of plants commonly found together at a site of a particular type. The notion of community thus implies proximity and usually some ecological uniformity. It does not imply mutual dependence or interrelatedness.

Any classification of communities is perforce a descriptive convenience and not a delineation of natural boundaries; hence, we do not concern ourselves overmuch with the nomenclature or exact enumeration of communities.

Many different plant communities occurred at our sites, but so far as we can determine, there is no community of vascular plants that is restricted to or even best developed in gorges or near falls. (There are, as will be discussed below, a few rare species more common here than elsewhere, but since they do not regularly associate with one another, they are not a community.) Falls and gorges tend to be places where different communities meet and this is because they are places where habitat and substrate change abruptly - soil meets rock, woods meet the open, dry meets wet, flat meets steep, and so on. Ecologically, they are a lot of different edges jumbled together, and their flora usually consists of a mixture of species - often the more tolerant or opportunistic ones - from several different communities.

The major plant communities of falls and gorges are very familiar ones in the state, and may be listed here without detailed description.

1. **Hemlock-hardwoods community.** Hemlock-maple-birch-beech woods, with a small group of understory plants, mostly ferns and a few spring wildflowers and a few asters. It is an extremely common community in wooded ravines in Vermont, and is found at well over half the waterfall sites we looked at.

2. **Spruce-fir community.** An even simpler flora, with ferns and about five herbs. It is rare, at least at the waterfalls we surveyed.

3. **Shaded ravine bottom and slope community.** This is a community of plants that like rich, wet, shady, soils near streams and falls. It is commonly found in springy places

on banks and in flat areas just above streams. Its composition varies with the amount of lime in the soil, and is often a lush but never a very diverse community. Common species are bulblet fern, wood nettle, jewelweed, etc. It is common throughout the state and was found near many woodland falls.

4. **Acid cliff and ledge crest community.** A sparse and common community of exposed acid rocks, consisting of mostly a few grasses, blueberries and a few other shrubs, often a few tree seedlings (especially birch, hemlock and pine), a sedge or two, and a few herbs.

5. **Dry limy cliff and ledge community.** This develops on open limestone ravine slopes and ledges: it is most characteristic of dry limy cliffs at low altitudes in western Vermont; it is never well developed at falls and gorges but can be seen to varying extents at Milton Falls, Missisquoi Big Falls, Sheldon Falls, etc. So far the limestone falls and gorges have not proved to have very diverse floras compared to the lime cliffs elsewhere in the state, but they still need more study.

6. **Wet limy cliff community.** This is a community best developed on cold, damp, partially exposed limestone cliffs, especially in the high mountains. The community as a whole is not seen on river cliffs, but interestingly enough, some of the rare species from that community have, as it were, second homes on river cliffs and in gorges. They will be discussed in the section on rare plants below. Otherwise this is a moderately diverse community, with a number of scarce species.

7. **Spray zone rocks and channel edge.** No real community; just a few vascular plants; mostly a few ferns and grasses.

8. **Gravel bar community.** Weedy species, including many annuals, developing late in the season on channel bars. Very common community all along rivers, not restricted to the falls: dogbane, several willows, cockspur grass, several love and panic grasses, etc.

The most important thing to note here is that none of these communities is peculiar to falls and gorges. The vertical walls of large gorges and the channel rocks of cascades and falls are spatially limited and often violent environments, and perhaps this is why they have not developed a more distinctive vascular flora.

The flatter parts of falls and gorges do not usually have interesting groups of vascular plants, and hence, there is rarely any conflict between the recreational use of a falls and the preservation of its botanical value. Such a conflict can occur when rare species are present, but so far most of the rare

species we have found are restricted to ledges and cliffs, and not in places where trampling or picking is a problem.

5B. Mosses and Liverworts

Mosses and liverworts - collectively bryophytes - are the dominant plants of moist rocky places, and important at many falls and gorges. A major object of this study was to identify the common species at the sites we visited and to determine how rich the sites were in species and whether rarities were present.

The results that follow are, at most, partial. Bryophyte identification is slow and technical, and so we were only able to investigate about a third of the sites, and are still uncertain about the identity of a number of species. Also, there are several interesting groups - the Pottiaceae, Mnium, Isoptyrigium and its relatives, Cephalozia, Lophozia - in which we were not able to identify the material to species at all.

Even with partial information, a number of conclusions are possible.

First, we identify about 100 bryophytes in all (Table 11, at the end of this section). Counting material that has not been identified yet we probably collected all 120 species. Doubtless others exist at the sites, but we were noting much repetition of species from one site to the next, and so would estimate, roughly, that the main bryophyte flora of gorges and waterfalls would include about 150 species. This is less than half the total vascular flora, but this is partially because we listed vascular plants from many different microhabitats, but limited our moss collecting largely to rock walls.

Second, diversity was high at the good sites. We identified about 40 species from our best sites and are sure that others are present at those sites. (Roy Perry, a bryologist from the University of Cardiff, Wales, surveyed Clarendon Gorge with us and estimated 50-60 species there.) This is about double the number of species found in a normal woodland or small wetland, and it seems that these gorges are most likely equal in diversity to the best bryophyte sites anywhere in the state.

High diversity sites are important since they are our richest localities and are our measure of how much can grow in one spot, and also since they are exciting places for naturalists to see and explore. Our preliminary survey indicates that the best falls and gorges are (as was suspected) among the most important sites for mosses and liverworts in the state.

Diversity varied a great deal: it was lower at acid sites than limy ones, low in the sites where there were great annual variations in the water level (which scour the channel and walls and limit the living space available), and low at open sunny sites. It was also low at some gorges where water was diverted

for power generation. We think, without having definite proof, that when water is diverted the humidity in a gorge decreases and that this harms the bryophyte community.

Third, as was the case with the vascular plants, the bryophytes at most sites were a mixture of species from several communities: woodland species, channel species, species of wet rocks, species of dry rocks and species of seepage areas. The species intermingle in many different combinations depending on what substrates and conditions occur next to one another, and it does not seem useful to us to separate them into communities. Instead we have chosen to just list the habitat preferences of individual species insofar as we can make them out.

Table 11, at the end of this section, lists the bryophytes found and their habitats. Table 15 lists important sites that either had high diversities or seemed to us good representatives of the type of community occurring at a particular kind of site.

5C. Rare Vascular Plants

Some 42 vascular plants that we believe to be rare in Vermont were formerly or are currently known from falls or gorges; in addition another ten species occur at one or more falls and gorges and are scarce in the state.* The rare plant records are listed by species in Table 13 and by site in Table 14, both at the end of this section.

Of the 42 rare species that have been recorded from waterfalls or gorges, we have current records for 36 (31 of these are known from rivers, five from other habitats). The other six (*Astragalus alpinus, Astragalus robbinsii* var. *robbinsii, Halenia deflexa, Lupinus perennis, Osmorhiza obtusa,* and *Pterospora andromeda*) are currently missing in Vermont, despite many attempts to find them. We think it likely that *Halenia,* which was formerly known from at least six Vermont towns, will be relocated. The other two were only known from a few stations each, and may very well have gone extinct.

The rare species are not all members of a single community: they include species of sandbars, woodlands, limy wetlands, limy ledges, acid ledges, dry sandy soil, and riverside thickets. But species of limy ledges predominate: about a third of the 42 rare species are normally restricted to limy rocks.

Most of the rare species are not restricted to falls and gorges, or even to riverside habitats. Many of them grow in limy woods, or on lake shores, or on acid and limy ledges that are not

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* To us, a rare plant is one known from fewer than ten contemporary stations in Vermont and a scarce plant is one known from ten to 50 contemporary stations.

near water. Several (*Vaccinium cespitosum*, *D. fragrans*, *Potentilla tridentata*, *Solidago randii*) are northern species that we normally see on alpine and subalpine cliffs. But nine of the 42 rare species are - in our area at least - only found along rivers. And two more species (*Erigeron hyssopifolius*, a rare species; *Trisetum spicatum*, a scarce species) are commoner on river ledges than in any other habitat.

Table 10 summarizes the status of the 12 species for which river ledges are the preferred Vermont habitat. As mentioned above, three are missing and two of these are feared to be extinct in Vermont. Another is very rare, while the others have substantial local populations and are not in any danger.

TABLE 10

STATUS OF RARE AND SCARCE SPECIES FOR WHICH RIVER GORGES ARE THE PREFERRED VERMONT HABITAT

Species	Historical Records	Current Records
Allium schoenoprasum	?	3
Anemone multifida	5	1 (one colony but in two towns, small population, threatened by a dam)
Astragalus alpinus	2	0 (searched for, not found, ? extinct in Vermont)
Astragalus robbinsii var. robbinsii	1	0
Aster tradescanti	9	about 10 (large local population)
Cinna arundinacea	?	10 (not principally on rocks)
Erigeron hyssopifolius	8	about 8 (large local populations)
Elymus wiegandii	?	4 (not principally on rocks)
Equisetum pratense	?	9 (not principally on rocks)
Halenia deflexa	4	0
Hypericum pyramidatum	?	3
Trisetum spicatum	25	>10 (occasional in Champlain Valley)

TABLE 10 (Continued)

Species	Historical Records	Current Records
Tofieldia glutinosa	5	3 (both along the Connecticut River)
Vaccinium caespitosum	9	about 6 (scattered locations)

Thus a total of four of the species restricted to river ledges, all formerly rare, have now become very rare or have vanished in Vermont. We do not know the reasons. All four are northern species, and it is possible that they have been affected by the warmer climate of the last 50 years. Several of them formerly grew in gorges that have been dammed; in some of the dammed gorges, part of the flow has been diverted, or summer flows are very low, or alternately the gorges have been partly flooded. Any of these changes might have eliminated populations, and we have no way of knowing which one or ones to blame. We do think that there was a definite cause for the decline of these species, and that they did not decrease as a result of chance fluctuations in small populations; our experience has been that small populations of cliff-dwelling plants tend to be resourceful and persistent, and can maintain themselves unless something interferes with their environment.

5D. Rare Bryophytes

Table 12 (end of this section) lists eight species of bryophytes which were only seen once or twice in the survey, and which may be rare or scarce in Vermont. At present there is no published compilation of bryophyte records for Vermont, and we have no way of knowing just how abundant many species are.

Other rarities are certainly present that we have not found. There are a number of sites with good bryophyte diversity that were not sampled. Also we certainly missed some rare species at the sites that we did sample. From the present survey we know that many of the gorges are dominated by bryophytes and have high species diversities; it is always true in field work that where you have high diversity and lush growth you get rare species, and so there is every reason to believe that many rarities occur besides the ones we noted.

TABLE 11

BRYOPHYTE FLORA OF WATERFALLS AND GORGES, WITH HABITATS*

Species	Habitat
Amblystegium riparium	rocks in channel
Amblystegium serpens	wet limy rocks in channel
Amblystegium tenax	rocks in channel
Amblystegium varium	rocks in channel or seepage
Anomodon apiculatus	limy rocks
Anomodon attenuatus	limy rocks
Atrichum undulatum	shaded soil and banks
Bartramia pomiformis	rocks, often limy, often spray zone
Bazzania denudata	shaded woods, on soil and stones
Blepharostoma trichophyllum	shaded limy schist
Brachythecium oxycladon	rocks
Brachythecium plumosum	wet rocks in channel
Brachythecium sp. (populeum ?)	moist rocks
Brachythecium rivulare	wet rocks and seepage, limy or acid
Brachythecium salebrosum	moist limy rocks
Bryhnia novae-angliae	limy rocks
Bryoerythrophyllum recurvirostrum	limy rocks in spray zone
Bryum pseudotriquetrum	limy seepage
Bryum sp.	weedy, sandy soil
Calypogeia trichomanis	wet soil in shade
Campylium chrysophyllum	wet limy rocks
Campylium sp. (polygamum ?)	wet limy schist
Cephalozia sp.	rocks, soil
Ceratodon purpureus	weedy, sandy soil
Climacium dendroides	moist soil
Cololejunea biddlecomiae	limy schist
Coniocephalum conicum	rocks in spray zone, common
Crateneuron filicinum	limy rocks
Dicranum fuscescens	rocks
Dicranum scoparium	shaded wood, rock, soil
Diplophyllum apiculatum	shaded limy rocks
Drepanocladus aduncus	wet limy rocks and seepage
Drepanocladus fluitans	rocks in channel
Drepanocladus uncinatus	dry limy rocks
Encalyptra ciliata	limy rocks
Entodon seductrix	limy rocks
Eurynchium hians	rocks in channel
Eurynchium riparioides	rocks in channel
Fissidens adiantoides	wet shaded rocks, spray zone
Fissidens bryoides	wet shaded rocks, spray zone
Fissidens cristatus	wet limy rocks
Fissidens taxifolius	limy rocks
Frullana sp.	limy rocks
Funaria hygrometrica	weedy, on soil
Grimmia alpicola	dry rocks or spray zone, limy or acid

TABLE 11 (Continued)

Species	Habitat
Gymnostomum aeruginosum	limy schist
Gymnostomum sp. (recurvirostrum ?)	wet limy rocks
Hedwigia ciliata	dry acid rocks
Herzogiella striatella	rocks and soils
Homallia trichomanoides	shaded granite
Homomallium adnatum	limy rocks
Hygrohypnum sp. (luridum ?)	rocks in channel
Hygrohypnum eugyrium	limy rocks in channel
Hylocomium splendens	soil, rocks, in shade
Hypnum curvifolium	shaded limy schist
Hypnum imponens	wood
Hypnum lindbergii	wet limy rocks
Hypnum sp. (Revolutum ?)	shaded granite
Isoptyrigium distichaceum	acid rocks in spray zone
Lejunea cavifolia	limy rocks
Leucobryum glaucum	shaded soil
Lophozia sp.	shaded rocks and soil
Marchantia polymorpha	wet limy rocks
Marsupelia emarginata	wet acid rock
Metzgeria conjugata	wet ? limy rocks, spray zone, in shade
Mnium (double-toothed group)	wet rocks
Mnium (single-toothed group)	wet rocks
Mnium punctatum	wet rocks
Mylia sp.	shaded limy schist
Myurella sibirica	shaded limy rocks
Paraleucobryum longifolium	shaded rocks
Pellia epiphylla	spray zone rocks, soil
Philonotis fontana	seepage areas
Philonotis marchica	seepage and wet rocks
Plagiochila asplenioides	rocks in channel and spray zone
Plagiothecium denticulatum	shaded rocks, often in spray zone
Plagiothecium laetum	acid rocks in spray zone
Platydicta sp.	limy schist
Pleurozium schreberi	shaded rocks, wood, soil
Pogonatum alpinum	rocks and soil, often in spray zone
Pogonatum urnigerum	rocks and soil, lime and acid
Pohlia cruda	? shaded soil
Pohlia wahlenbergii	limy seepage
Polytrichum juniperinum	soil
Polytrichum piliferum	dry acid soil and rocks
Porella platyphylloides	limy rocks
Preissia quadrata	limy rocks
Ptilidium pulcherrimum	wet rocks
Radula complanata	limy rocks
Rhacomitrium aciculare	wet rocks in channel
Rhynchostegium serrulatum	limy schist
Rhytidiadelphus triquetrus	shaded limy schist
Scapania nemorosa	shaded rocks in spray zone

TABLE 11 (Continued)

Species	Habitat
Sphagnum squarrosum	peaty wooded banks
Thamnobryum alleghaniense	wet limy schist
Thuidium delicatulum	rocks and soil in shade
Timmia megapolitana	limy rocks
Tortella tortuosa	limy rocks
Tricholea tomentella	moist limy schist in shade
unknowns from Pottiaceae	limy rocks

* A question mark after a species epithet indicates uncertainty in the identification beyond the genus level.

TABLE 12

BRYOPHYTES FOUND AT FALLS AND GORGES THAT MAY BE SCARCE OR RARE IN VERMONT

Species	Site
Bryhnia novae-anglia	Clarendon Gorge
Bryhnia novae-anglia	Baldin Brook Gorge
Entodon seductrix	Allen Falls
Homalia trichomanoides	Nelson Brook Gorge
Isoptyrigium denticulatum	Baldin Brook Gorge Woodbury Falls
Metzgeria conjugata	Rock River Cascades
Thamnobryum alleghaniense	Rock River Cascades
Timmia megapolitana	Clarendon Gorge Lulls Brook Ravine

TABLE 13

RECORDS OF RARE VASCULAR PLANTS FROM FALLS AND GORGES

(H = historical record, plant thought to be extinct at the site; C = contemporary record, plant currently exists at the site; rare = fewer than ten current Vermont stations; occasional = ten to 50 current Vermont stations.)

Species	Site	Type of Record	Status in Vermont
Allium schoenoprasum var. sibiricum	Quechee Gorge	H	three current records
	Sumner Falls	C	
Anemone multifida	Highgate Falls	H	one current station (proposed as a state endangered species)
	Lime Kiln Gorge	H	
	Quechee Gorge	H	
	Winooski Falls	C	
	Winooski Gorge	H	
Aster tradescanti	Big Falls of the Missisquoi River	C	ten current stations
	Lime Kiln Gorge	C	
	Middlesex Gorge	C	
	N. Hartland Falls	C	
	Bakers Falls	C	
	Sumner Falls	C	
	Williston Gorge	C	
Aster undulatus	Sutton Brook Falls	C	occasional, rare in north
Astragalus alpinus	Bellows Falls	H	no current stations
Astragalus robbinsii var. jesupi (= A. jesupi)	Sumner Falls	C	(in NH) two current stations, VT/NH endemic (proposed as a state endangered species)
Astragalus robbinsii var. robbinsii	Winooski Gorge	H	extinct, VT endemic

TABLE 13 (Continued)

Species	Site	Type of Record	Status in Vermont
Blephila hirsuta	Moss Glen Falls I	H	one current station (proposed as a state threatened species)
	Williston Gorge	H	
Carya glabra	Carver Falls	C	four current stations
Cinna arundinacea	Quechee Village Falls	C	ten current stations
Cypripedium arietinum	Lime Kiln Gorge	H	11 current stations (proposed as a state threatened species)
	Winooski Gorge	H	
Dryopteris fragrans	Bolton Falls	H	five current stations
Elymus wiegandii	Winooski Gorge	C	four current stations
Equisetum pratense	Frazer Falls	C	nine current stations
Eragrostis hypnoides	Bolton Falls	C	rare away from Lake Champlain
Erigeron hyssopifolius	Big Falls of the Missisquoi River	C	seven current stations
	Brockway Mills Gorge	C	
	Middlesex Gorge	C	
	Quechee Gorge	C	
	Williston Gorge	C	
Geranium bicknellii	Winooski Gorge	C	nine current stations
Halenia deflexa	Quechee Gorge	H	no current stations
Hieraceum venosum	Winooski Gorge	C	nine current stations
Hypericum pyramidatum	Sheldon Falls	C	three current stations
Isotria verticillata	Lime Kiln Gorge	H	one current record
	Winooski Gorge	H	

TABLE 13 (Continued)

Species	Site	Type of Record	Status in Vermont
Lechea intermedia	Sutton Brook Falls	C	occasional, rare in north
Lupinus perennis	Lime Kiln Gorge	H	no current records
Oryzopsis pungens	Winooski Gorge	C	one current station
Osmorhiza obtusa	Bingham Falls	H	no current stations
Panicum xanthophysum	Winooski Gorge	C	five current stations
Potentilla tridentata	Lana Falls	C	ten current stations
Pterospora andromedea	Lime Kiln Gorge	H	no current records
	Winooski Gorge	H	
Rudbeckia triloba	Marshfield Falls	C	ten current stations
Scirpus inflexus	Bolton Falls	C	rare away from Lake Champlain
Shepherdia canadensis	Lime Kiln Gorge	H	rare away from Lake Champlain
	Williston Gorge	C	
	Winooski Gorge	C	
Solidago randii	Middlesex Gorge	C	rare out of mountains
	Lime Kiln Gorge	C	
Solidago squarrosa	Big Falls of the Missisquoi River	C	rare in north
Spiranthes lacera	Winooski Gorge	C	three current stations
Sporobolus neglecta	Beldens Falls	C	two current stations
Stellaria alsine	Buttermilk Falls	C	two current stations
Tofieldia glutinosa	Quechee Gorge	H	two current stations (proposed as a state threatened species)
	Sumner Falls	C	(in NH)
Trisetum spicatum	Middlesex Gorge	C	rare away from Lake Champlain

TABLE 13 (Continued)

Species	Site	Type of Record	Status in Vermont
Trisetum spicatum (Continued)	Big Falls of the Missisquoi River	C	
	Bellows Falls	C	
Vaccinium caespitosum	Bakers Falls	C	six current stations
	Big Falls of the Missisquoi River	C	
Vitis aesitivalis	Winooski Gorge	C	rare in north
Woodsia alpina	Quechee Gorge	H	one current station (proposed as a state endangered species)
Woodsia glabella	Quechee Gorge	H	seven current stations

TABLE 14

FALLS AND GORGES AT WHICH RARE OR SCARCE SPECIES HAVE BEEN FOUND

(H = historical record, plant thought to be extinct at the site; C = contemporary record, plant currently exists at the site; rare = fewer than ten current Vermont stations; occasional = ten to 50 current Vermont stations.)

Site	Species	Type of Record	Status in Vermont
Allen Falls	Entodon seductrix	C	not known
Bakers Falls	Aster tradescanti	C	ten current stations
	Vaccinium caespitosum	C	six current stations
Baldin Brook Gorge	Bryhnia novae-anglia	C	not known
	Isoptyrigium denticulatum	C	not known
Beldens Falls	Sporobolus neglecta	C	two current stations
Bellows Falls	Astragalus alpinus	H	no current stations
	Trisetum spicatum	C	rare away from Lake Champlain

TABLE 14 (Continued)

Site	Species	Type of Record	Status in Vermont
Big Falls of the Missisquoi River	Erigeron hyssopifolius	C	seven current stations
	Vaccinium caespitosum	C	five stations
	Solidago squarrosa	C	rare in north
	Aster tradescanti	C	ten current stations
	Trisetum spicatum	C	rare away from Lake Champlain
Bingham Falls	Osmorhiza obtusa	H	no current stations
Bolton Falls	Dryopteris fragrans	H	five current stations
	Eragrostis hypnoides	C	rare away from Lake Champlain
	Scirpus inflexus	C	rare away from Lake Champlain
Brockway Mills Gorge	Erigeron hyssopifolius	C	seven current stations
	Astragalus alpinus	H	no current stations
Buttermilk Falls	Stellaria alsine	C	two current stations
Carver Falls	Carya glabra	C	four current stations
Clarendon Gorge	Bryhnia novae-anglia	C	not known
	Timmia megapolitana	C	not known
Frazer Falls	Equisetum pratense	C	nine current stations
Highgate Falls	Anemone multifida	H	one current station (proposed as a state endangered species)
Lana Falls	Potentilla tridentata	C	ten current stations
Lime Kiln Gorge	Anemone multifida	H	one current station (proposed as a state endangered species)

TABLE 14 (Continued)

Site	Species	Type of Record	Status in Vermont
Lime Kiln (Cont.)	Aster tradescanti	C	ten current stations
	Cypripedium arietinum	H	11 current stations (proposed as a state threatened species)
	Isotria verticillata	H	one current station
	Lupinus perennis	H	no current stations
	Shepherdia canadensis	C	rare away from Lake Champlain
	Solidago randii	C	rare out of mountains
Lulls Brook Ravine	Timmia megapolitana	C	not known
Marshfield Falls	Rudbeckia triloba	C	ten current stations
Middlesex Gorge	Erigeron hyssopifolius	C	seven current stations
	Trisetum spicatum	C	occasional, rare away from Lake Champlain
	Solidago randii	C	occasional, rare out of mountains
	Aster tradescanti	C	ten current stations
Moss Glen Falls I	Blephila hirsuta	C	one current station
Nelson Brook Gorge	Homalia trichomanoides	C	not known
N. Hartland Falls	Aster tradescanti	C	ten current stations
Quechee Gorge	Allium schoenoprasum var. sibiricum	H	three current records
	Anemone multifida	H	one current station (proposed as a state endangered species)

TABLE 14 (Continued)

Site	Species	Type of Record	Status in Vermont
Quechee Gorge (Continued)	Erigeron hyssopifolius	C	seven current stations
	Halenia deflexa	H	no current stations
	Tofieldia glutinosa	H	two current stations (proposed as a state threatened species)
	Woodsia alpina	H	one current station (proposed as a state endangered species)
	Woodsia glabella	H	seven current stations
Quechee Village Falls	Cinna arundinacea	C	ten current stations
Rock River Cascades	Thamnobryum alleghaniense	C	unknown
	Metzgeria conjugata	C	unknown
Sheldon Falls	Hypericum pyramidatum	C	three current stations
Sumner Falls	Allium schoenoprasum var. sibiricum	C	three current records
	Aster tradescanti	C	ten current sites
	Astragalus robbinsii var. jesupi (= A. jesupi)	C	(in NH) two current stations VT/NH endemic (proposed as a state endangered species)
	Toffieldia glutinosa	C	(in NH) two current stations (proposed as a state threatened species)
Sutton Brook Falls	Aster undulatus	C	occasional, rare in north
	Lechea intermedia	C	occasional, rare in north

TABLE 14 (Continued)

Site	Species	Type of Record	Status in Vermont
Williston Gorge	Aster tradescanti	C	ten current stations
	Blephila hirsuta	H	one current station (proposed as a state threatened species)
	Erigeron hyssopifolius	C	seven current stations
	Shepherdia canadensis	C	rare away from Lake Champlain
Winooski Falls	Anemone multifida	C	one current station (proposed as a state endangered species)
Winooski Gorge	Anemone multifida	H	one current station (proposed as a state endangered species)
	Astragalus robbinsii var. robbinsii	H	extinct, Vermont endemic
	Elymus wiegandii	C	four current stations
	Geranium bicknellii	C	nine current stations
	Hieracium venosum	C	nine current stations
	Isotria verticillata	H	one current station
	Oryzopsis pungens	C	one current station
	Panicum xanthophysum	C	five current stations (proposed as a state threatened species)
	Shepherdia canadensis	C	rare away from Lake Champlain
	Spiranthes lacera	C	three current stations
	Vitis aestivalis	C	occasional, rare in north
Woodbury Falls	Isoptyrigium distichaceum	C	not known

TABLE 15

IMPORTANT BOTANICAL SITES

Site	Botany
Baldin Brook Gorge	exemplary moss flora
Big Falls of the Missisquoi R.	important vascular plants
Clarendon Gorge	exemplary moss flora
Middlebury Gorge	exemplary moss flora
Nelson Brook Gorge	exemplary moss flora
New Haven River Gorge	exemplary moss flora
Quechee Gorge	formerly many rare vascular plants, but most of these may be gone
Rock River Cascades	exemplary moss flora
Sumner Falls	many rare vascular plants
Texas Falls	exemplary moss flora
Winooski Gorge	many important vascular plants

The following sites may have exemplary moss floras but have not been studied yet:

Moss Glen Falls I, II

Bingham Falls

Brockway Mills Gorge

West Branch Falls

Old City Falls

Battell Gorge

The following sites need to be resurveyed for rare vascular species:

Woods Falls

Carver Falls

TABLE 15 (Continued)

The following sites have small populations of a single very rare species:

Site	Botany
Beldens Falls	Sporobolus neglecta
Sheldon Falls	Hypericum pyramidatum
Winooski Falls	Anemone multifida (Proposed as a state endangered species.)

6. USES

Falls and gorges are commonly used for recreation and to generate power.

6A. Power Plants and Dams

Power generation requires head (water higher than the generator) to drive the machinery, and usually a reservoir to hold water for use when natural flows are low. Commonly in Vermont, a waterfall or cascade or steep gorge is used to supply the head. A typical installation consists of a low dam upstream of the gorge or falls that stores water, a penstock diverting water under pressure downhill and around the site, and a powerhouse at the base of the site. Less commonly, the storage dam is made high enough to supply the head, and the powerhouse is right at the foot of the dam.

Dams are common: 32 out of the 78 sites we visited that had gorges or falls had dams, and of the 31 sites where there was a large falls or cascade or gorge, 17 had dams. If we look only at large falls or gorges on the five largest rivers, out of the 11 such sites in the state, nine have dams. And if we look at all sites on the five largest rivers, 14 out of 17 have dams.

The effects of dams vary. In some cases they completely alter the appearance and biology of the site. In others, they hardly intrude. In still others, they are not physically obtrusive but alter the flow and character of the water. This last case is particularly interesting because it leaves the site physically unchanged but may have great biological effects.

While the situation differs from dam to dam, in general, power dams create periods of very low flows. Where the flow is diverted around the site, the whole falls or gorge may be without water year round and flows below the powerhouse may be alternately high and low.

Often problems with low flows are worse at old dams which have been used to generate electricity for a number of years because their operating licenses do not contain any provisions for maintaining flows. We saw a number of sites where the only flow over a falls or through a dam came from leaks in the dam or the flashboards.

Dams may alter the quality as well as the amount of water delivered to a gorge or falls. Several water quality problems are associated with artificial impoundments. These include low dissolved oxygen levels due to loss of aeration over the falls, hypolimnetic water withdrawal by the hydroelectric facility, and algal respiration and increased water temperature due to increased travel times through the river reach, increased exposure to solar radiation, loss of tree canopy and more extensive shallow zones.

Again, these problems can be worse at the older installations. Some newer sites have small impoundments and less effect on water quality. Also, one new site artificially reoxygenates the water after it leaves the powerhouse.

* * *

The diversion of flow has several biological effects. Aquatic animals have to deal with raised temperatures, lowered oxygen concentrations, lowered current, and narrower and shallower streams. The effects are often severe, and fish and invertebrates die or move downstream. With reduced flows, stagnant eddies and pools may form, and if the water is fertile, these become choked with algae and may turn septic. Finally, reduced flows alter the temperature and humidity around the falls or within a gorge. This in turn will effect plant growth; many of the mosses and those vascular plant species that are restricted to riverside ledges demand high humidity, and we suspect that some species decline when the humidity is reduced.

We cannot prove that the reduced humidity hurts gorge plants, but we have a number of instances of plants that have vanished from altered sites, and we never found a diverse bryophyte community at a site where the flow was diverted and the gorge was dry.

The diversion of flow is usually detrimental to recreation: swimming holes may dry up, fish may move away, and the site may become stagnant and smelly.

Table 16 lists a number of sites that are very dry and where we think biological damage has occurred.

TABLE 16

SITES WHERE FLOW IS DIVERTED AND DRYING MAY HAVE DONE BIOLOGICAL DAMAGE

Carver Falls	restoration of low flows would be desirable
Woods Falls	restoration of low flows would be desirable
Highgate Falls	restoration of low flows would be desirable
Mollys Falls	restoration of low flows would be desirable
Sutherland Falls	restoration of low flows would be desirable
Bakers Falls	restoration of low flows would be desirable
Williston Gorge	restoration of low flows would be desirable

5B. Recreational Use

We found 33 sites at which there was swimming. After much testing, we rated the swimming at ten sites as fair, at 15 as good, and at eight as great.

A good deep swimming hole, with falls to look at and rocks to sun on and to dive from, is of course a treasure; think of how many people in the country never swim in clean natural water and never have jumped from a high ledge into a rock-walled pool. In Vermont you can do this (and of course should do this), and moreover you can do it at many different places. But even so, it is important to realize that the number of fine swimming holes is limited. Even if there are another 30 we have not seen, there are still 8,117 people per swimming hole, so we clearly need to preserve every one we have.

There are also a number of sites that are not really good swimming places, but which are attractive enough for people to come to wade and picnic and party and bathe. When we could identify such use in the field we noted it in the reports, but have not attempted a separate tabulation of the best picnic and party sites. It might be noted in passing that such use is substantial and traditional, and that many of our falls are favorite gathering places and have for many years played a noticeable role in local courtship, relaxation, and celebration.

Table 17 is a list of sites where the swimming was at least fair. It should be noted that there are some hazards involved with swimming at any of these sites such as slippery rocks, eddy currents and submerged rocks. Due caution should be used and private property should be respected.

TABLE 17

SWIMMING HOLES*

"Great"	Middlebury Gorge	Clarendon Gorge
	Woods Falls	
	Cavendish Gorge	
	Sumner Falls	New Haven River Gorge
	Web Falls	
"Good"	Jelly Mill Falls	Rock River Cascades
	Pikes Falls	Buttermilk Gorge
	Battell Gorge	Ithiel Falls
	Dogs Head Falls	Twin Falls
	Terrill Gorge	North Branch Falls
	Moretown Gorge	
	Big Falls of the Missisquoi River	

TABLE 17 (Continued)

"Fair"	Devils Pothole	West Branch
	Boltonville	Willoughby River
	North Hartland Falls	Highgate Falls
	Falls of Black River	Sterling Brook
	Middlesex Falls	Moss Glen II
	Sucker Brook Cascades	Brewster River Gorge
	Granville Cascade Chain	

* Fatalities have occurred at some of these sites. Caution and use of common sense are essential.

Comparatively few sites are famous enough and accessible enough to attract many tourists and sightseers. In all, there are ten or so sites that are well known and well marked and get heavy use by visitors, and probably another 20 that have been published or are shown on maps and get a few visits from tourists. Table 18 (next page) lists the sites that we are certain are popular with visitors.

A number of the sites in this table - Quechee, Big Falls, Brockway Mills, Barnet Falls, North Hartland Cascades - are principally scenic attractions in the sense that they are sites that most people do not go into or get very near to but rather stand back from, often on bridges, and look at and photograph.

TABLE 18

POPULAR TOURIST SITES

North Hartland Falls	scenic cascade, pretty view from bridge
Lana Falls	woodland cascade near large state park
Big Falls of the Missisquoi River	undammed large waterfall and gorge on major river
New Haven River Cascades	cascades and falls right by road
Huntington Gorge	deep sculptured gorge
Buttermilk Falls	fine small falls and swimming area
Quechee Gorge	very deep long gorge; good view from bridge
Brockway Mills Gorge	large handsome gorge; good view from bridge
Bingham Falls	pretty falls near Mt. Mansfield
Barnet Falls	unique cascade in a chute angled across a cliff
Texas Falls	small carved gorge developed as a National Forest recreation site
Moss Glen Falls I	scenic attraction
Moss Glen Falls II	beautiful large falls
Old City Falls Ravine	large falls, developed for recreation
Bristol Memorial Forest Park Gorge	large gorge and small falls, developed for recreation
Brewster River Gorge	deep mountain gorge

The popularity of these sites, and hence, their importance to tourism, is very great: Quechee is certainly one of the most photographed natural features in Vermont.

* * *

Many falls and gorges are certainly important fishing spots. We have no detailed or comparative information on this.

* * *

Recreational use of any kind is potentially destructive to vegetation. But, praise native good manners and the bottle bill, most sites we visited have only minor amounts of litter and minor damage to vegetation. A number of sites certainly would be improved by occasional policing, but the extraordinary accumulations of trash seen elsewhere do not occur.*

Trampling and vegetation damage are also only minor problems. The popular sites certainly look well used, but the rocks can take it and the rare plants and rich moss communities are mostly on rock walls and in other spots where they are not damaged by visitors. There is no way that a major recreational site is going to look like virgin ground, but in our judgement, the major sites can take the use they currently receive, and we know of no cases where the presently-occurring use should be restricted to preserve the site.

We did find several spots that are currently very private and undisturbed and which we feel might be damaged by increased use. We have recommended that these not be included in any public listing.

* * *

In several instances, visitors may not endanger the site but do endanger themselves. There have been a number of fatal accidents at Hamilton Falls, Moss Glen Falls I, Huntington Gorge, Twin Falls, Putnamville Falls, and Quechee Gorge. Probably they occur elsewhere as well. The problem revolves partly around a common sort of young man who possesses a good tolerance for heights and a poor tolerance for alcohol, and partly around the desire of tourists to climb down into interesting gorges to get a better look, ignoring while doing so the most elementary climber's rules about exposure, footwear, and route selection. Various signs attempt to caution or restrict visitors: we suspect that they have very little effect.

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*For example, at Barberville Falls in Poestenkill, New York, where 20 large garbage bags of bottles and cans accumulated one year from June to August, or at some of the Adirondack lakes accessible to four-wheel-drive vehicles, where the rangers expect to pick up and carry out as much as a pickup load of garbage each weekend.

7. CONSERVATION AND RESTORATION

The principal conclusion to be drawn from our study is that the supply of waterfalls and gorges is limited and that many sites have already been altered or destroyed, commonly by hydroelectric dams.

We estimate that there are under 40 large falls or gorges in the state. About half of them have dams.

On the five largest rivers in the state* there are 17 waterfalls and gorges. Fourteen of these are dammed.

Winooski Gorge and Quechee Gorge, botanically the two finest limestone gorges in New England, both are dammed. Whether for this or other reasons, they are greatly reduced in value as botanical sites compared to what they once were.

Looking at all the sites we surveyed, both large and small, about one-third of them have dams.**

Not all of the dammed sites are damaged, but all are less wild and scenic because of the dam, and many have lost much of their biological or recreational value. The first period of dam building occurred in the late 1700's and early 1800's for mechanical water power. A large number of dams were also constructed during the industrial revolution of the 1800's. Between 1910-1960, about half of the state's most important waterfalls and gorges were destroyed or devalued when they were used for the generation of hydroelectric power.

Hence, it makes sense to look on the state's falls and gorges - especially the major ones - as a resource that has already been heavily used and consider it very important to conserve the natural value of the remaining sites. We seem to be entering into a second major period of dam building, and it would be very unfortunate if we lost the other half of our major falls and gorges in the next 50 years.

It is not inconceivable that this might happen. Many applications for hydroelectric projects are now pending. There are under 40 important sites that are large enough to be potentially useful for hydropower and which do not already have dams. Allow one to be dammed every year, and 40 years from now there would not be any.

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* The Lamoille, Missisquoi, Winooski, Connecticut and Poultney Rivers.

** This figure does not take into account the substantial number of sites at which a falls has been destroyed or obscured by dam construction: there are at least ten and perhaps 20-30 such sites in the state.

After some discussion, we have taken a fairly strong position with respect to conservation: we wish to see every fine site that remains to be preserved. By preserved, we either mean undeveloped or developed in such a way that it retains all its qualities as a natural area if that can be done without compromising the site's values.

We take a strong position because our survey, by taking us to so many sites that have been developed for power, has made us uncomfortably aware of what has been lost. Less than a century ago there were large falls on the Connecticut, the Lamoille, the Winooski, and the Missisquoi which were still in their natural condition, and where you could stand and see and hear what the Indians saw. In West Haven you could see the Poultney River go over a horseshoe-shaped falls 250 feet wide, and then drop 120 feet into a narrow gorge. Today only one of these sites - the Big Falls of the Missisquoi River - is in its natural condition; at the others there are dams and dried up falls that mostly only flow in the spring and powerhouses and penstocks and powerlines and impoundments.

It is impossible to visit one such site after another without longing to see them as they once were, and without coming to resent the expediency and thoughtlessness that industrialized almost every major waterfall and gorge in Vermont within about 50 years.

* * *

Our recommendations are as follows:

1. Major waterfalls and gorges should be acquired by the state and preserved as natural areas. We would especially recommend the following sites: Big Falls of the Missisquoi River, Brockway Mills Gorge, Cavendish Gorge, Clarendon Gorge, Battell Gorge, Huntington River Gorge, and possibly Terrill Gorge.

2. Middlebury Gorge should be acquired and preserved by the Green Mountain National Forest.

3. The state should attempt the restoration of Carver Falls, the largest falls in the state, by acquiring land and access to the area below the falls, instituting a licensing proceeding to guarantee summer flows over the falls, and getting the abandoned penstock removed.

4. When considering the development of one of the sites we have listed as important, the state should not allow a dam to alter the site. The state should not compromise by trying to figure out a way to dam them a little, their naturalness is one of their most valuable attributes, and we might as well do right by them and keep them completely natural.

5. Do not dam an unsurveyed site without doing a physical and biological survey to see if it is important.

6. Do not dam any site without investigating how much use it gets and whether it has cultural or historical values: the reader should remember that this survey did not investigate cultural values and only guessed at the amount of use.

7. If a dam is to be constructed on a site for which rare plants are present, try to preserve at least half the population.

* * *

Our recommendation in four that the naturalness of an important site be respected is the most difficult point to argue, and the one most likely to create conflict. We can only state our feeling, which is that since many sites are in settled countryside, with roads and farms and buildings nearby, the ones that are or feel wilder are special, and that specialness needs protecting. We do not know how widespread this feeling is: it might be that fishermen and swimmers do not mind a dam or powerhouse at all as long as the fishing and swimming is still good... or it may be that they do mind it. We advise, that in cases where the naturalness of a site is at stake, some research be done to find out how people really feel before proceeding with a development.

* * *

The essence of these recommendations may be stated as follows: many falls and gorges, whether privately owned or not, are, by tradition and use, part of the commons - the property valuable to everyone and available to everyone. Our recommendation is that the public's rights to the commons - to natural beauty, to the availability of recreation, and to the continuance of the historical landscape - <u>always</u> be considered before the claims of power development. If this requires that the state occasionally buy a waterfall to preserve it, our feeling is that there are <u>few</u> better things it could do with its money.

* * *

Restoration & Care

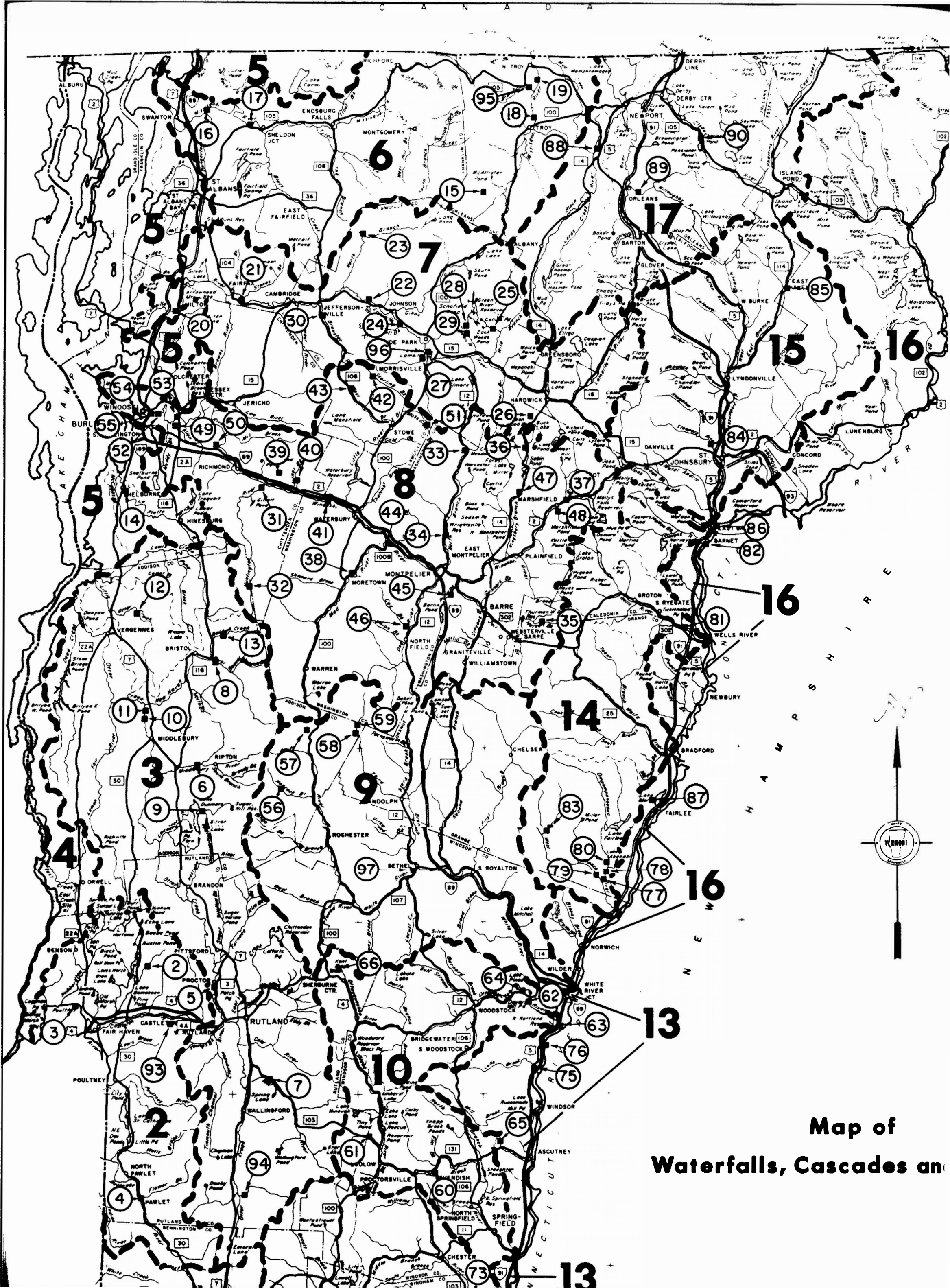
The waterfalls, cascades and gorges in the state are enormously important for recreation and tourism, and in contrast to other recreational sites, are rarely publicly-owned and receive almost no care. As we mentioned in Section 5, despite this, they remain remarkably clean and do not suffer from use.

Every resource can profit from care, and the falls and gorges are no exception. We suggest that two things could be done to improve their recreational value.

First, either the state parks division or the towns should assume the responsibility for picking up litter at popular sites.

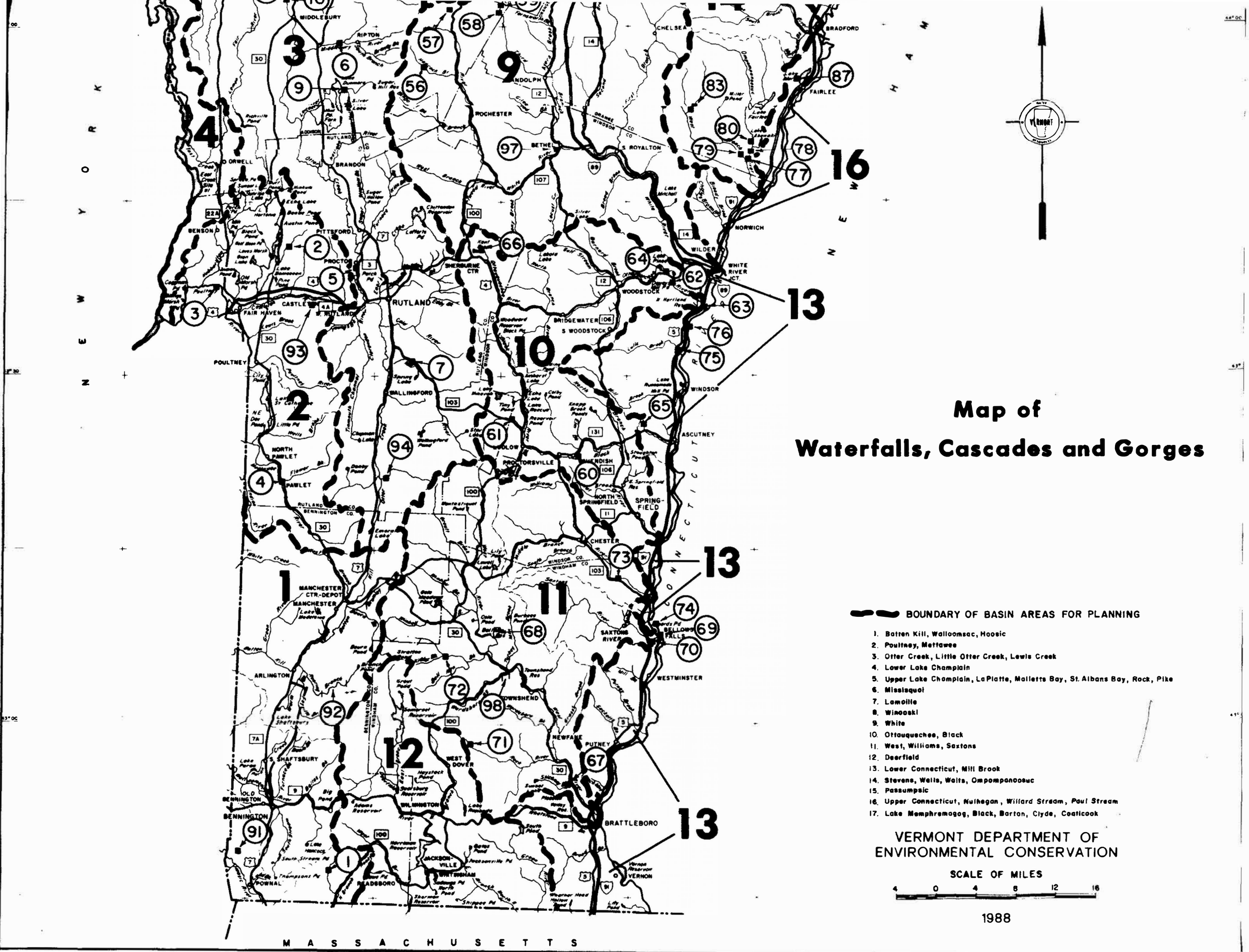
Second, something should be done to bring existing dams up to modern standards by assuring adequate flow below the dam, reviewing and mitigating any dissolved oxygen problems and spilling sufficient water over the dam to protect the values of the waterfalls and cascades. We don't permit towns to use inadequate sewage plants just because the plants were made before there were water quality regulations, and the same should apply to dams. There should be one standard for flows and oxygen below dams and existing dams should meet as stringent environmental requirements as new dams do. The state should promulgate new regulations, give existing dams a year to comply, and if they do not, the state should open proceedings against them. If we started doing this next summer we would immediately improve the fishing and swimming in many gorges, lessen downstream pollution, and possibly begin the restoration of vegetation that has been damaged by drying out.

NOTE: The State Department of Water Resources and Environmental Engineering conducted a study in 1982 to investigate all existing hydro projects in the state, to identify problems and to make recommendations for mitigation. These recommendations will be presented to FERC, the Public Service Board, the Public Service Department and the utilities for implementation. Many of the recommendations contained in the draft of "The Waterfalls, Cascades and Gorges of Vermont" have already been incorporated into the recommendations of this hydrostudy and the Department of Water Resources and Environmental Engineering has begun acting on the recommendations.



Map of

Waterfalls, Cascades an


Map of
Waterfalls, Cascades and Gorges
BOUNDARY OF BASIN AREAS FOR PLANNING
1. Batten Kill, Walloomsac, Hoosic
2. Poultney, Mettawee
3. Otter Creek, Little Otter Creek, Lewis Creek
4. Lower Lake Champlain
5. Upper Lake Champlain, LaPlatte, Malletts Bay, St. Albans Bay, Rock, Pike
6. Missisquoi
7. Lamoille
8. Winooski
9. White
10. Ottauquechee, Black
11. West, Williams, Saxtons
12. Deerfield
13. Lower Connecticut, Mill Brook
14. Stevens, Wells, Waits, Ompompanoosuc
15. Passumpsic
16. Upper Connecticut, Nulhegan, Willard Stream, Paul Stream
17. Lake Memphremagog, Black, Barton, Clyde, Coaticook
VERMONT DEPARTMENT OF
ENVIRONMENTAL CONSERVATION
SCALE OF MILES
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1988
NEW YORK
NEW HAMPSHIRE
CONNECTICUT
MASSACHUSETTS
VERMONT
MIDDLEBURY
RIPTON
CHELSEA
BRADFORD
FAIRLEE
RANDOLPH
ROCHESTER
BETHEL
S ROYALTON
ORWELL
BRANDON
BENSON
PITTSFORD
PROCTOR
CASTLETON
FAIR HAVEN
RUTLAND
SHERBURNE CTR
WOODSTOCK
WILDER
NORWICH
WHITE RIVER JCT.
BRIDGEWATER
S WOODSTOCK
POULTNEY
WALLINGFORD
LUDLOW
PROCTORSVILLE
WINDSOR
ASCUTNEY
NORTH POWLET
POWLET
CHESTER
SPRING-FIELD
MANCHESTER CTR-DEPOT
MANCHESTER
ARLINGTON
SAXTONS RIVER
BELLOWS FALLS
WESTMINSTER
S. SHAFTSBURY
OLD BENNINGTON
BENNINGTON
WILMINGTON
WEST DOVER
NEWFANE
PUTNEY
BRATTLEBORO
READSBORO
JACKSONVILLE
WHITINGHAM
VERNON
POWNAL
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16

8. FORMAT FOR SITE REPORTS

The reports use a uniform format, though not all contain information on every point. The format is:

Report number, site name, river, town, county, state.

Water Resources number, date of visit, initials of surveyor.

Brief description.

Map number in Vermont Atlas and Gazetteer, USGS quadrangle, directions to site.

* * *

Setting and surroundings.

Description of stream and water quality.

Description of site.

Particulars about the rocks.

Botany of site.

Use of site, cleanliness.

Prettiness and quality.

* * *

Importance

Summary

Recommendations