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European vs. American Engineering: Pierre Charles L'Enfant and the Water Power System of Paterson, N.J.

Russell I. Fries

At the end of the American Revolution, the new country faced the task of turning hard-won legal independence into true independence, which meant that America would have to become less dependent upon Europe for both the necessities and the luxuries of life. Alexander Hamilton was perhaps the most farseeing of the men who looked for a course that America should follow. Hamilton was doubly fortunate in that he was placed in a position to help bring about his vision, first as a leader in the movement to replace the Articles of Confederation with a stronger form of government, the Constitution, and second through his position as the first Secretary of the Treasury under the new Republic. As a Revolutionary officer, Hamilton had moved through New Jersey and visited the Great Falls of the Passaic River, formed when that river broke through the 800-ft. ridge of the Watchung Mountains west of New York City. (Figure 8-1 shows the detailed topography of the falls area today.) Thus it was entirely fitting for Hamilton to play a leading role in establishing the industrial city called Paterson, which depended upon the Great Falls as its source of power, power that was to make America independent of Great Britain in fact as well as law.

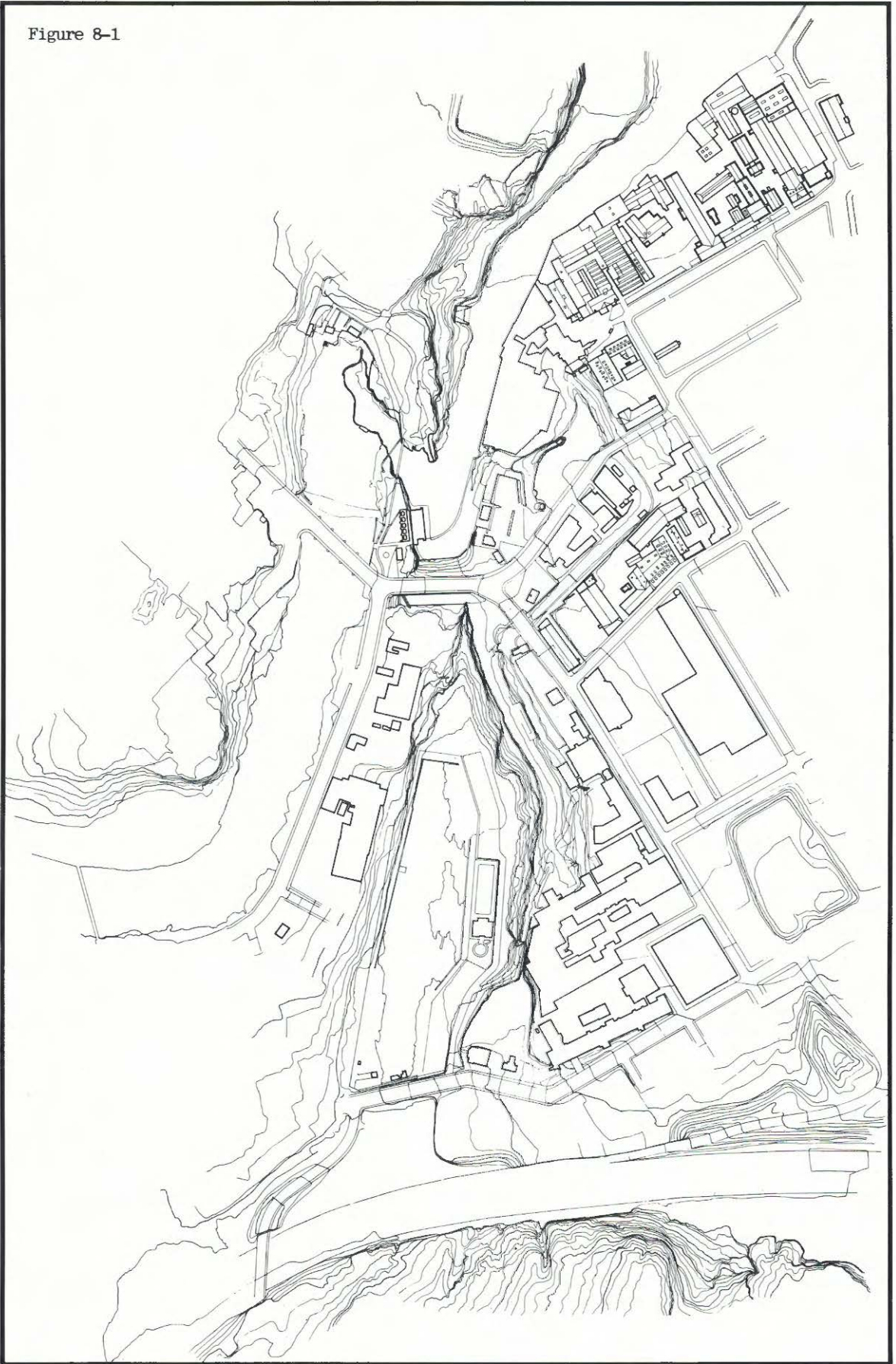
Hamilton chose to set up a private corporation capitalized at \$600,000 to accomplish his vision. Acting at his prompting, Hamilton's friends, led by William Duer of New York, secured a charter from the State of New Jersey incorporating the Society for Establishing Useful Manufactures (S.U.M.) in December of 1791. At the same time Hamilton himself prepared his famous *Report on Manufactures*, which set out his vision for all to see. The S.U.M. was to be the embodiment of this vision, demonstrating to American businessmen that American manufacturing ventures could be not only socially desirable but also economically profitable.

At the heart of the establishment of American manufactures lay the problem of

large-scale engineering ventures. Nothing less than a large factory would show other Americans that competition with the British could be both nationalistically and monetarily satisfying. If it was to be a large-scale development, then ample power would have to be available--i.e., the engineering development of a major river for power purposes. Americans had never faced this sort of problem before, and it was not strange that many of the early engineers on the project either were foreigners or had received their engineering training abroad. To escape from dependence on Europe, Hamilton and his friends were forced to use the services of the European-trained engineers, at least until America could develop its own. Yet European talent was not always successful in answering American needs. Pierre Charles L'Enfant was a competent engineer, and yet his plan for Paterson was not an immediate success. This paper attempts to show the sequence of power development at the Great Falls, and to explain why it was that the L'Enfant plan for Paterson was rejected. In the process, it elucidates the problems of early engineering developments in America.

Given the laws of practical hydraulics it is not remarkable that there was a certain congruity among the various plans for developing the water power of the Passaic Falls in Paterson. The topography of the falls and the surrounding area created both the potential for power development and the common problems that all the developers had to face. Three plans were evolved. One, the relatively visionary and expensive Duer-Allon plan, was as much concerned with land speculation as with hydraulics. A second, that of Pierre Charles L'Enfant, provided for an extensive water power system using European-type engineering. The third, by Peter Colt, was the American adaptation of the L'Enfant scheme, a plan that stripped the hydraulic system to the bare minimum necessary for any power.

Figure 8-1



The conflict among the various plans is perhaps the most interesting aspect of the project, for it shows the constant interaction of various factors such as cost, scope, time, and the availability of skilled workers. Presented with two plans for large-scale development using complicated construction techniques, the Society for Establishing Usefull Manufactures chose to disregard the counsel of both the land speculators and the professional civil engineer, L'Enfant, and instead used the Colt plan developed by inexperienced American talent, which had the virtues of being less costly, less complicated, and less time-consuming for the untrained local workmen to execute. However, both of the earlier and more visionary plans were ultimately vindicated. The Duer-Allon plan closely resembled that of the Morris Canal, built after 1828 from tidewater at Newark, New Jersey across the state to the Delaware River. Similarly, the original Colt plan at Paterson was modified and expanded between 1800 and 1846 until it resembled nothing so much as the original L'Enfant plan. The conflict between L'Enfant's ideas and those of the Directors of the S.U.M. shows both the problems of dealing with a proud and touchy individual and also the difficulty of adapting a foreign technological style to the solution of domestic problems.

Specifically, L'Enfant envisioned a combined hydraulic power and transportation canal using the entire flow of the Passaic River. The design included a standard European aqueduct carrying the canal, towpaths, and a carriage road. L'Enfant suggested the transportation portion of the canal so that local suppliers could bring products such as building stone, timber, and agricultural items down the Passaic right to the factories.¹ All the features that L'Enfant planned, including full command of the flow of the Passaic River and the locks for transportation, were ultimately incorporated in the S.U.M. canal system, with the single exception of the aqueduct. Despite this vindication in practice, L'Enfant's plan has been labeled visionary and impractical by both contemporary critics and historians of the S.U.M. The S.U.M. Directors at that time, and Joseph S. Davis recently, criticized L'Enfant's plan as too expensive and grandiose at an early stage of the project.²

Levi R. Trumbull unjustly accused L'Enfant of the absurdity of wanting to carry the water some seven miles before using it, something that any engineer would have

seen as undesirable unless there were substantial additional benefits to be realized by such a course. Trumbull is probably confusing the L'Enfant plan with the Duer-Allon scheme for a transportation canal to tidewater.³

Many considerations were involved in selecting a location for a manufacturing site. Of primary importance was an adequate water supply, something that involved many considerations besides simply the volume of the stream, such as the vertical drop (head and fall) available, the distance over which this drop takes place, the topography of the surrounding terrain, and the seasonal fluctuations of the stream flow. Given an adequate supply of water power, then other economic factors became important: access to raw materials; transportation facilities; labor availability; building supplies; and price and availability of food. Together these factors had to be considered in light of the economic situation affecting the whole project. Capital availability determined the extent of the project because a small mill power was cheaper to build, although more costly per horsepower. Until the late 18th- and early 19th-century improvements made the steam engine a cheap, reliable, and smoothly rotating power source, it was absolutely necessary to balance all these factors since water power was the only feasible way of operating the mills, whatever might be the desirability of locating in the major commercial cities.

Selection of the manufacturing site involved the consideration of all these factors, but few people in the country had any experience with hydraulic problems. Prior to the organization of the Society for Establishing Usefull Manufactures with its Charter of Incorporation, the location of the Society had already been more or less narrowed down to the State of New Jersey, based on political and financial considerations--the hope of bringing in both New York and Pennsylvania investors, and of stimulating native New Jerseyans to boost their state out of its relatively obscure and powerless position. On the hope of securing a charter, Hamilton and others began to look around the state for suitable locations, long prior to the actual issue of the charter by the state on November 22, 1791.⁴

In August 1791, Hamilton appointed William Hall and Joseph Mort, English workmen who had recently come to America, as employees of the Society by authorization from some of the subscribers to the S.U.M. prospectus. He promptly dispatched

them throughout New Jersey to look for adequate sites for the water power, suggesting the Passaic Falls as one. Hall reported to Hamilton September 4, 1791 that he and Mort found the Passaic Falls to be "one of the finest situations in the world," with everything necessary available in abundance. Thus, as early as 1791 attention was already focused on the Passaic River as the possible site for the factory. Hall's evaluation of the site seems to have been primarily impressionistic, and he made no detailed estimate at that time of the cost for providing this power to the Society.⁵

William Marshall, another English workman employed by Hamilton, was better acquainted than Hall with all the requisite factors affecting site development. Rather than relying on a simple single examination of the site, Marshall wrote the following to Hamilton:

... if there is not a regular and constant Supply of Water in the driest of Seasons Sufficient to work the Mill 23 hours per Day, the Interest of the Subscribers will severely suffer. To prevent this, Sir, it will be Necessary to be Acquainted with the Source (if easily possible) of the River, the Situation of the Country through which it runs, the Number of other streams that empty themselves into it, and from whence or by what means they are supplied. From these and Similar Observations together with the best Information that can be obtained from those who have long known the River & its particularities, a Judgment may be form'd what Effect a Dry or Wet Season has on it; that is, Sir, whether in a drought there will be a Sufficiency of Water to Supply the Works, and when heavy or continued rains happen, what Effects are to be Apprehended either from its Overflowing, or the Accumulated Impetuosity of its Current ... the Speed of the Water must be taken (by which the Interior heavy Wheels are regulated) together with the Quantity of Water it is capable of delivering in a given time; the Fall must likewise be measured.⁶

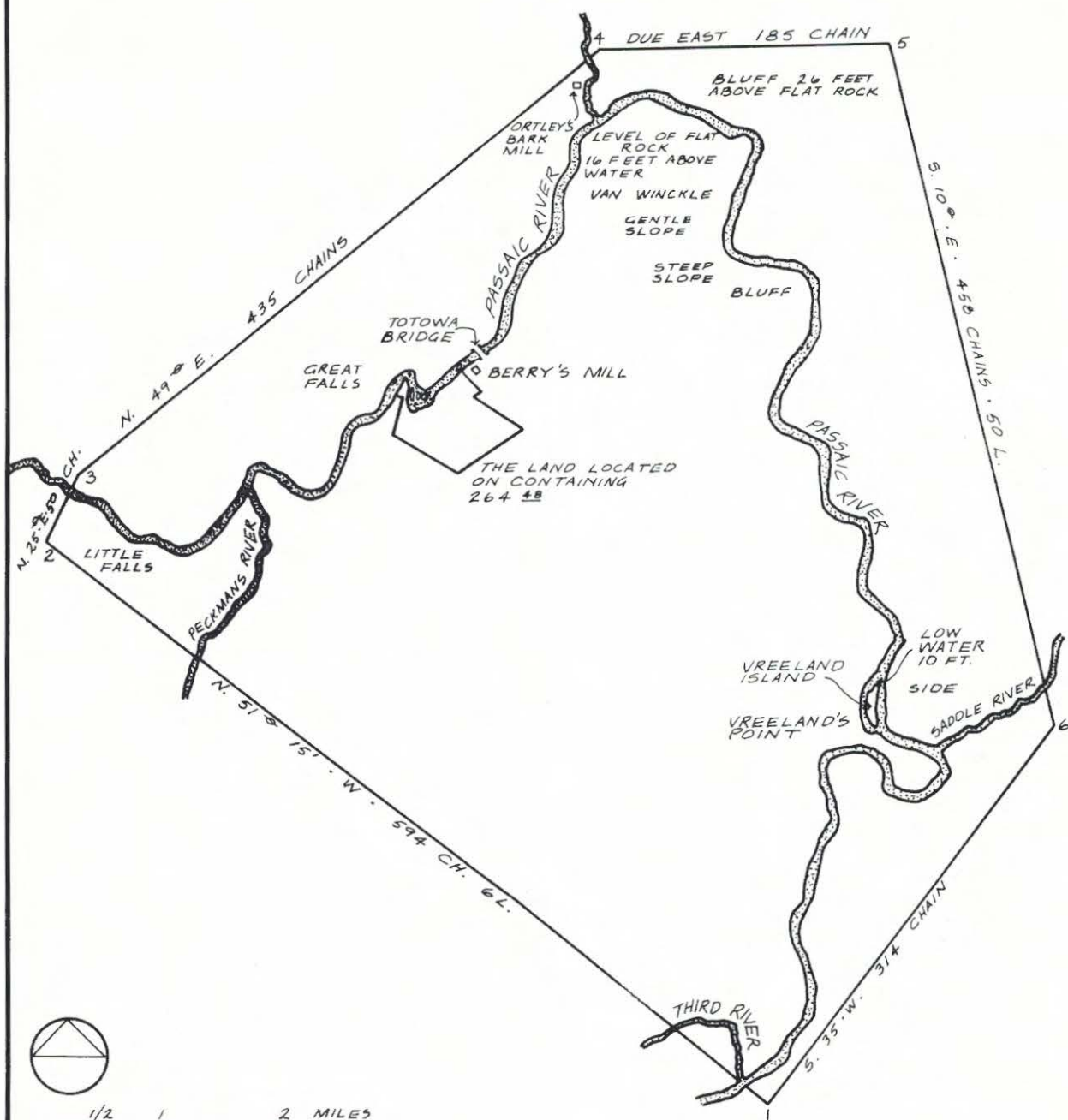
In this quotation Marshall proposed a complete hydrographic survey of the area under consideration, and a quantitative one at that. Whereas modern hydraulic engineers would have access to better formulas, techniques, and historical information, Marshall's concern for the full knowledge of the potential develop-

ment area reflected well on his experience in practical work. All engineers would be equally concerned with Marshall's three primary measuring criteria: velocity, quantity, and fall (head). Marshall went on to stress the topographic and engineering aspects of the site for building location, such as the underlying rock at the site and the ease of providing for direct (convenient) flow to the wheel and drainage of the wheel.

However, the Society did not adopt Marshall's advice for a full engineering study in anything but the most superficial manner owing to pressure to get the project underway. Marshall toured sites in New Jersey searching for locations that warranted detailed investigation, such as Rahway Brook, Stony Brook, the Millstone River, and the First, Second, and Third Rivers near Newark. He found each site unacceptable for good reasons, except the Second River.⁷ Meanwhile, William Duer, the promoter and first Governor of the Society, persuaded Marshall to visit the Passaic Falls, in company with a Frenchman named Allon with whom Marshall was totally unable to converse. Marshall's trip was something less than an effective inspection because Duer told him not to give any indication of what was afoot for fear of raising the price the Society would have to pay for land. Allon also got them lost in the woods and seemed to have no idea of the proper spots near the river actually designated for the cut by which water was to be taken out of the river and put to work. These limitations prevented Marshall both from getting a good idea of the topography of the area and from learning anything about other factors he considered important, such as stream flow in high and low months, rainfall, and average conditions.⁸

Apparently as a result of this trip and others, Duer and Allon proposed their plan for development, but without Marshall's help. We know little about the plan proposed by Duer himself in conjunction with Allon, except its general attributes, but this may result from its sketchiness rather than lack of sources. This plan did indeed prove to be more than the Society could undertake, even in the buoyant period of the S.U.M.'s flotation, when capital was eagerly subscribed before the books had been opened. Basically the Duer-Allon plan involved two parts. One was a transportation-hydraulic power canal from the Passaic Falls all the way to the head of navigation on the Passaic River at Vreeland's Point.⁹ From

Figure 8-2



PATERSON, INCORPORATED, [1792]

THIS MAP REFLECTS THE EARLY PROPOSAL OF HAMILTON, ET. AL. FOR INCORPORATING A LARGE AREA OF THE PASSAIC RIVER BASIN FROM LITTLE FALLS DOWN TO THE THIRD RIVER NEAR NEWARK, NEW JERSEY.

SOURCE: S.U.M. RECORDS PATERSON BOARD OF FINANCE

MAP PREPARED BY THE HISTORIC AMERICAN ENGINEERING RECORD, HAER.

the land purchases at Vreeland's Point undertaken by William Duer through Samuel Ogden (see Figs. 8-2 and 8-3, showing attention to rock in the area and height above tide), it would seem clear that the second part of the Duer-Allon plan involved the creation of a manufacturing town at the east end of the canal, at or close to the point where it reentered the Passaic River at the head of navigation (near modern Passaic). Figure 8-4 shows this plan conceptually. Although the contours shown are those that existed as of 1955, it is believed that the route would have been equally practical for a canal in the 1790's, allowing the retention of the entire head of the Passaic River at the falls of some 115 ft., less the necessary hydraulic gradient, with only minor level gaps to be bridged. It is also quite possible that the waste of water over that distance owing to leakage would have been more than compensated by acquiring the water of several of the minor tributaries to the Passaic below the falls which would naturally flow into the canal. At Vreeland's Point, the transportation canal would have allowed the passage of boats to the river through a series of locks, whereas the mill sites

would have been located along various tiers of raceways following the natural contours of the hill at roughly 20-ft. intervals on perhaps five levels before the water was returned to the Passaic. The Vreeland's Point mill sites of the S.U.M. would have been able to compensate for the use of water in the transportation section of the canal by having a larger available head than the 65-ft. head at Paterson.

The engineering feasibility of the scheme is amply demonstrated by the later construction of the Morris Canal to tidewater along a more or less parallel route, although that canal was built too late and too small to compete successfully with railroads (see Figs. 8-10, 8-11). However, engineering feasibility must be carefully distinguished from the practicality of a plan that involved the enormous task of cutting and embanking more than seven miles of canal, providing mill sites and mill races, and building locks, as well as one or two small aqueducts or embankments to carry the canal over gullies or valleys.

Despite the fact that Mort, Hall, Marshall, and Allon had all visited a substantial number of water power sites in

Figure 8-3. Detail from Paterson Incorporated [1792], Fig. 8-2, showing the Vreeland's Point area, now Passaic, N.J., one of the destinations of the Duer-Allon plan. The numbers in the figure refer to heights above tidewater, presumably for planning raceway and factory sites. (S.U.M. Records, Paterson Board of Finance. Traced from the original by H.A.E.R.)

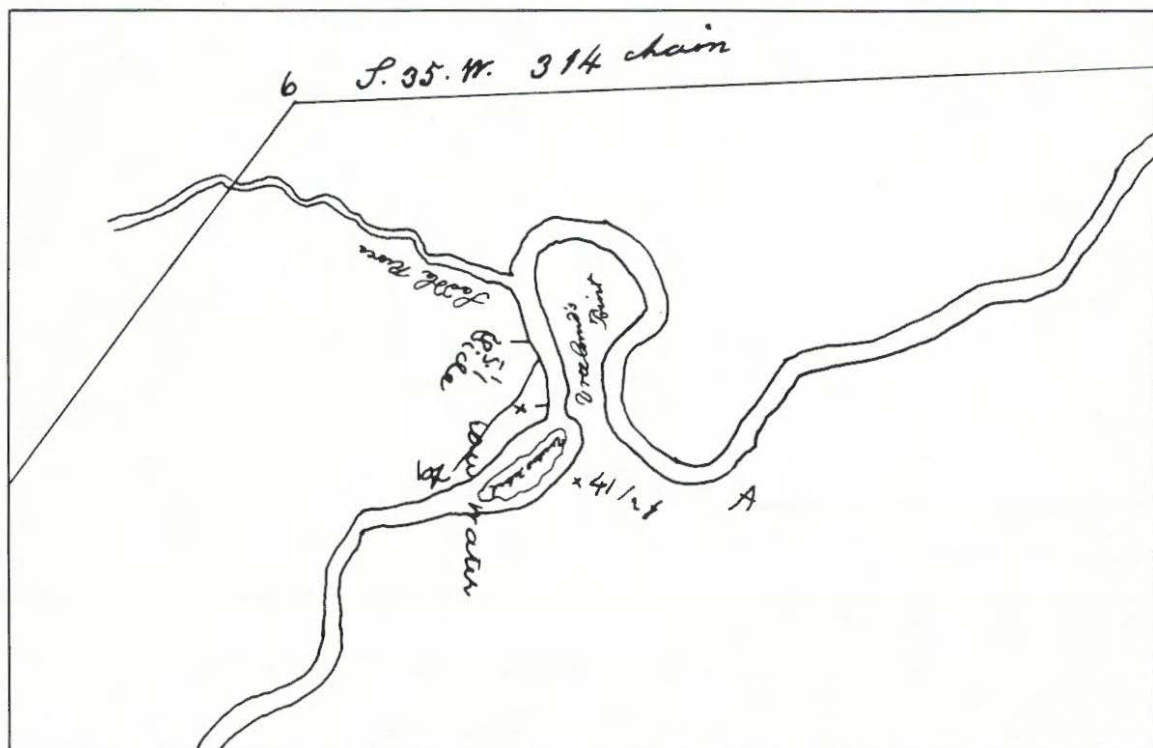
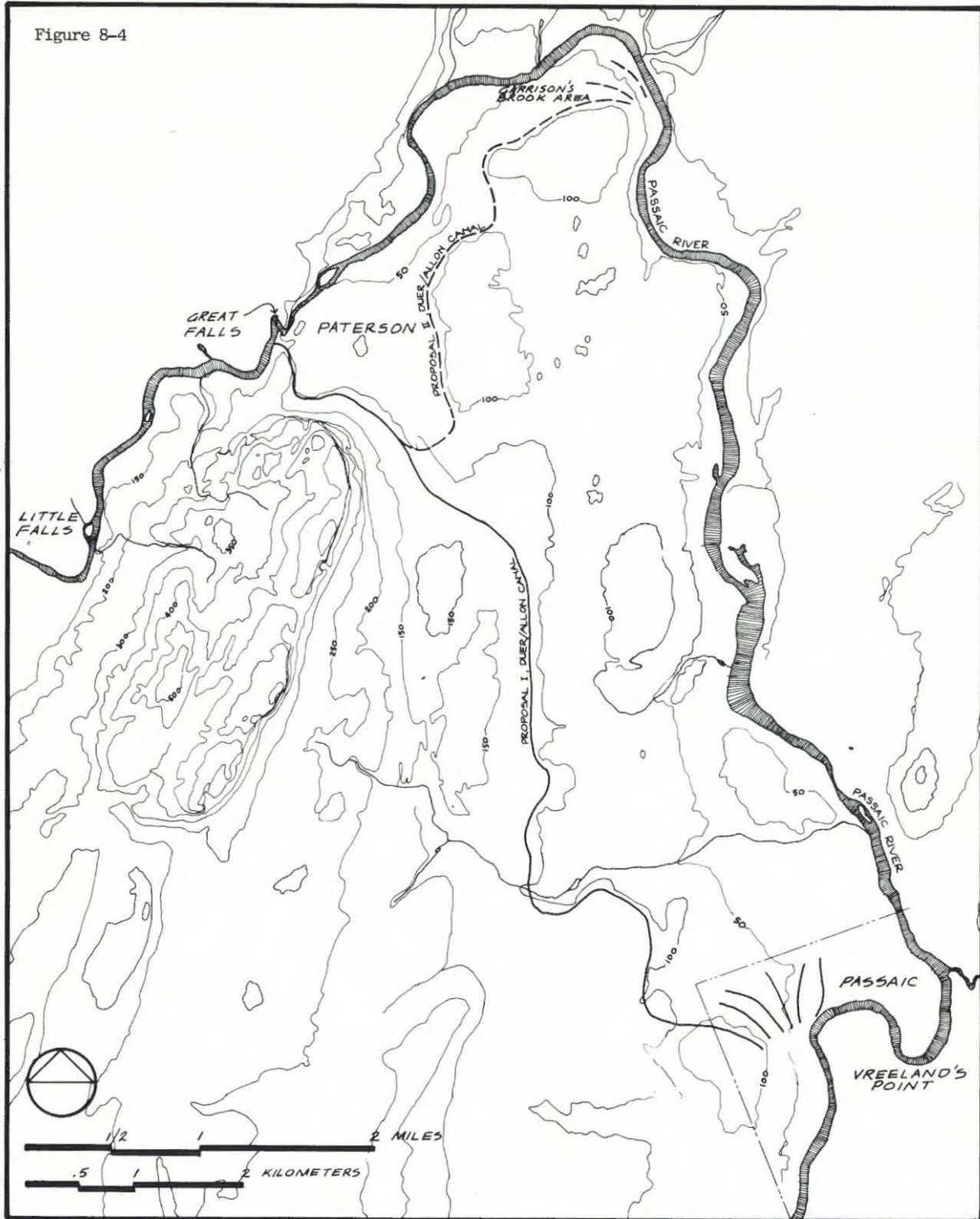


Figure 8-4



DUER-ALLON PLAN, [1792]

MAP OF THE PASSAIC RIVER BASIN, PATERSON TO TIDEWATER, SHOWING HYPOTHETICAL ROUTE FOR DUER-ALLON CANAL TO VREELAND'S POINT [PASSAIC], NEW JERSEY AND GARRISON'S BROOK [N.E. PATERSON].

SOURCE: TRACED FROM USGS MAP OF PATERSON, 1955.

MAP PREPARED BY THE HISTORIC AMERICAN ENGINEERING RECORD, HAER.

the state by the time of the Society's incorporation, no immediate decision was made on the location of the factory. This choice was undoubtedly wise in the sense that it allowed time to secure other sources of advice on the ultimate site, and also to ask for more information relative to all sites. The Board of Directors met December 9, 1791 for the first time and appointed a committee to evaluate the various sites and proposals. Under Governor Duer's signature, the committee published an advertisement in the state newspapers asking the localities that were interested in getting the factory to submit full and detailed information of the water power, land, subsistence, population, transportation, and building materials in the vicinity. This advertisement was sound from the standpoint of securing the best information possible and the widest number of sites, but also represented a careful political move which might demonstrate to a suspicious public that the Society was not trying to be secretive about its plans and operations, but rather sought to act in an open and completely frank manner.¹⁰

Apparently the caution of most of the Directors in settling on the final site did not appeal to some of the more speculative-minded, such as Duer and Maccomb. In a letter Maccomb urged Duer to buy lands at the Passaic Falls to avoid speculative inflation of the price, should it become known that it was a favored site.¹¹

The committee appointed to investigate the site reported at the next meeting, January 17, that it was unable to decide among three principal contending rivers, the Delaware, the Raritan, and the Passaic. The Board then delegated a second committee the authority to choose the final location without reporting back to the Board.¹² They were aided in making a selection by individual or groups of citizens from the competing localities who offered inducements to have the S.U.M. select their area. However, as far as can be discerned, the committee took no noticeable action after the January 17 meeting until May.¹³ Duer continued meanwhile to act on his own, arrogating to himself the assumption that he knew better than the others the best location for the factory, and apparently purchased an option on land at Vreeland's Point through secret negotiations by Samuel Ogden.¹⁴ This would involve the transportation and power canal system of the full Duer-Allon plan, and probably the expenditure of an enormous amount of money, if ratified.

The overly optimistic hopes of William Duer can be measured by the fact that he actually began to implement the plan for this transportation-water power canal by the purchase of the requisite land. Allon's estimate to Duer for the construction of the whole canal was a great underestimate at £2000, which, if correct, would have been economically feasible.¹⁵ Probably this low estimate encouraged Duer in the more grandiose plan, and his inexperience in engineering matters left him unable to discriminate between a bad estimate and a good one. Shortly afterward, Duer became involved in the financial panic of mid-March 1792 and never again played an active role in the operations of the Society, dying in debtors' prison in New York in 1799.¹⁶ The Duer-Allon plan died with Duer's departure from the governorship of the S.U.M.

The panic of 1792 came close to crippling the Society as well as its governor, both in terms of immediate losses and future prospects for attracting additional investment. The Society lost about \$68,000 immediately in funds placed with Duer, Maccomb, and others.¹⁷ Perhaps more importantly the panic killed off the streams of eager new investors as well as the buoyant psychology that had prevailed at the outset of the project. Duer was perhaps the least important loss to the company, for although he was a great projector he seemed to possess few of the talents necessary to carry such projects to a financially rewarding conclusion. Similarly, as shown by his secret agreement to purchase land at Vreeland's Point, he was given to acting secretly on his own, even if the purchase had proved to be advantageous for the Society.

In view of the atmosphere created by the panic, it was probably a much more financially conscious and conservative committee that met in May to consider the problems of selecting a water power site. Acting on the information available, carefully using what talent they could draw on to consider their hydraulic problems, the Board of Directors picked the location of the Passaic Falls as the single water power site for consideration, and ordered a committee, "that the town of Paterson be located upon the Waters of the River Passaick at a distance of not more than six Miles from the same [Falls] on each or either side thereof between the Seat of Mr. Isaac Gouverneur near the town of New Ark and Chatham Bridge."¹⁸ After this momentous decision, the Board appointed a three-member committee, com-

posed of Nicholas Low (who saw the S.U.M. through most of the rest of its early years as Governor), John Bayard, and Elisha Boudinot to make the land purchases and site location for the town. Although the Duer-Allon plan was not out of consideration entirely, it was clear that the committee was to rethink the entire matter of the canal without reference to Duer's commitment of the Society to the lands purchased at Vreeland's Point.¹⁹

The new committee worked quickly to procure a good plan for the site of the company factory and town. On May 29, they visited the Great Falls area, accompanied by General Philip Schuyler, Alexander Hamilton's father-in-law, "and several other Gentlemen well acquainted with the country and the nature of Water Works in general,"²⁰ Philip Schuyler was probably one of the most technically experienced men in America at the time. In conjunction with Joseph Hornblower from England, Schuyler had put up the first steam engines in the United States for pumping water from his mines in New Jersey. At this time Schuyler also was involved in the plan for the Western Inland Lock Navigation Company, predecessor to the Erie Canal.²¹

Schuyler was probably as responsible as any single individual for the general location of the water power canal. Hamilton was asked for his opinion on the proper plan for use of the water power, and he indicated in his reply that he had sought advice from Schuyler on the various plans for using the water and locating the factory. As a result, Hamilton concluded that "... I now Entertain no doubt doubt [*sic*], that the most advisable course is to abandon for the present the Idea of a Canal And to erect the necessary buildings near the Great Falls"²²

There is a further indication that Schuyler was the planning force for the location of some of the principal races. At the time that Schuyler met with the committee, they also "employed proper Persons to make surveys and levels."²³ This survey was undoubtedly the basic one both used by the Directors in advertising for contractors on the job and referred to by L'Enfant in his report to the Directors.²⁴ From that it would seem obvious that the basic direction of the system was already laid out, since the plan refers to stakes with particular numbers, which were set by the surveying party, probably acting under Schuyler's advice. Unfortunately, this plan has disappeared.

Although there is no direct evidence, it is suggested that Christopher Colles may have been one of the "Gentlemen well acquainted with the country and the nature of Water Works in general ..." who accompanied the committee to the Great Falls at the end of May.²⁵ Colles was located in New York, was a civil engineer by profession, and was known to Philip Schuyler, who was on the inspection trip. He came to the American Colonies in 1766 after having worked on the navigation of the River Shannon. In 1774 he was the author of the plan for New York's first water system, although the effort was aborted by engineering problems and the financial and practical dislocations attending the Revolution.²⁶ Schuyler was well acquainted with Colles because Colles was perhaps the first to suggest the general idea of a transportation canal along the Mohawk River from Lake Erie to the Hudson River, a project that Schuyler attempted to bring to fruition through his Western Inland Lock Navigation Company between 1795 and 1808. The property and route of the old company were later taken over by the Erie Canal project. Schuyler himself was no engineer, as he recognized, and he may have asked for Colles' expert assistance in looking over the scene.²⁷

Hamilton's letter²⁸ urged the abandonment of the Canal plan "for the present" rather than as a totally unfeasible project, and his reasons for rejecting it were financial rather than practical. Thus, the abandonment of the Duer-Allon plan in favor of the more limited one of the use of the water power at the immediate vicinity of the Great Falls represented the compromise between the grandiose but far-reaching plan of Duer and the pinch of limited resources, caused in part by the financial misdealings of Duer himself. The Duer scheme was more acceptable in the rosy financial era that preceded the 1792 panic. Yet the dream of a transportation canal remained alive, for even Hamilton, the practical financier, advised the purchase of the lands all the way from the Little Falls, several miles above Paterson on the Passaic, to "the head of navigation of the Passaic," an area of almost 84 square miles, which would encompass the present Passaic Valley cities from Little Falls to Newark. It was an almost incredible expanse of land by modern standards, and one that would have included almost every significant water power site on the river and kept open the land for the potential transportation canal route to a mill site

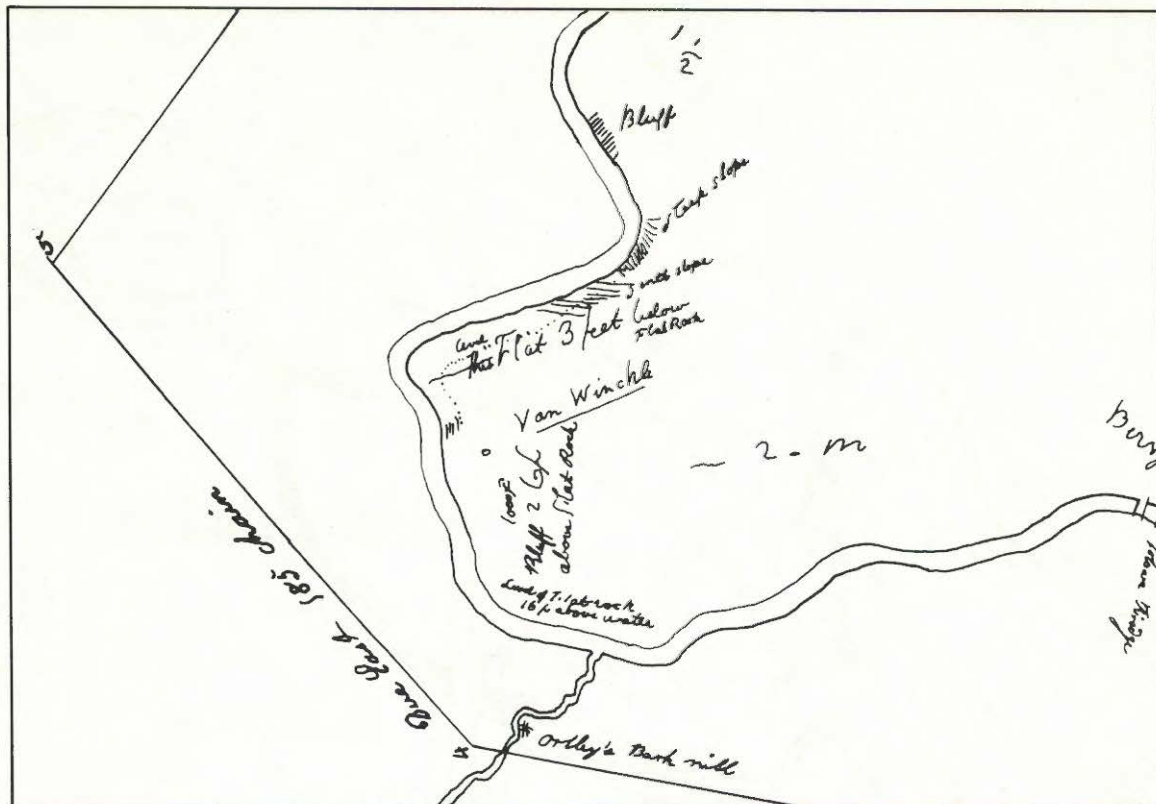


Figure 8-5. Detail from Paterson Incorporated [1792], Fig. 8-2, showing the "Garrison's Brook" area referred to as the other possible destination in the Duer-Allon plan. The numbers indicate detailed concern with the topography of the area. (S.U.M. Records, Paterson Board of Finance. Traced from the original by H.A.E.R.)

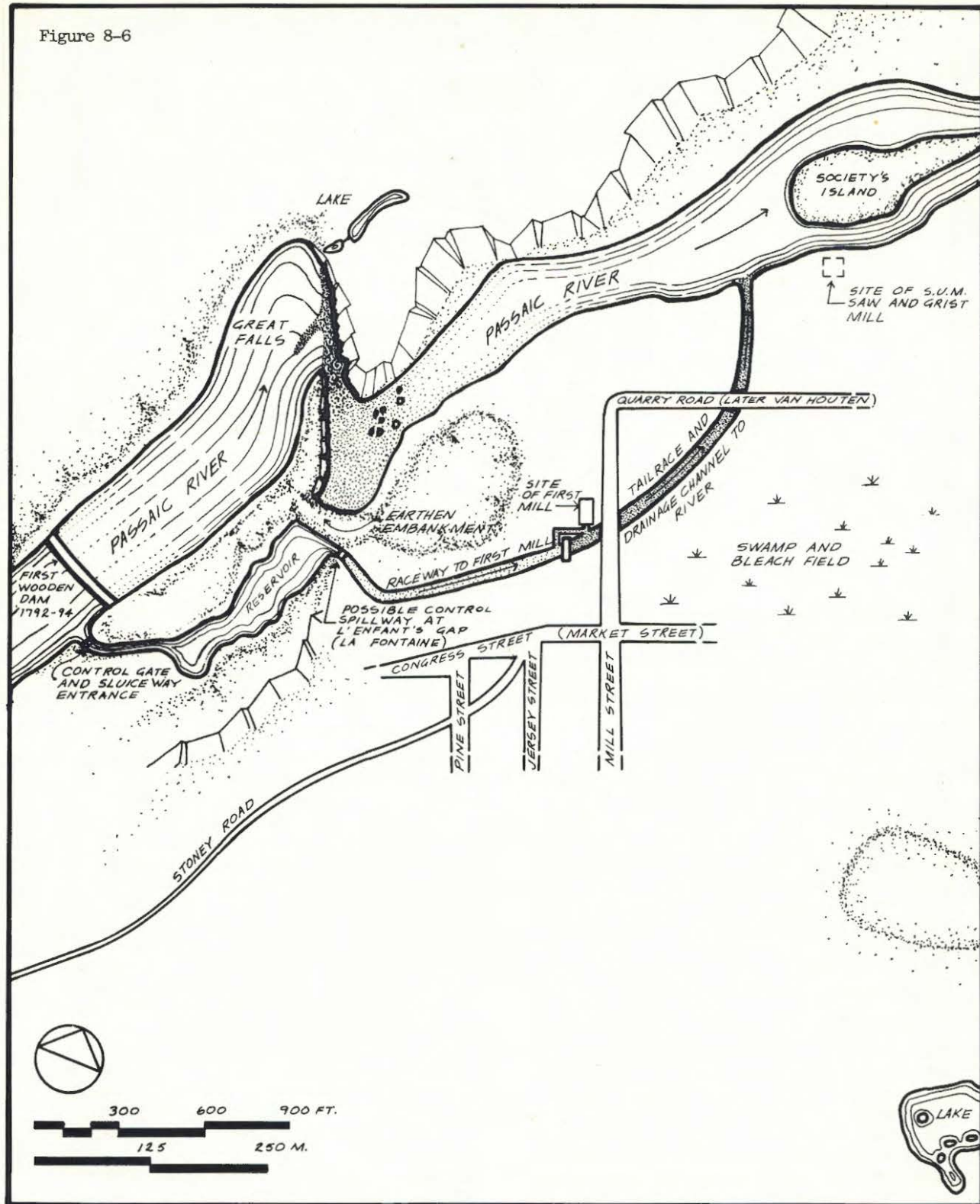
near Passaic (Figs. 8-2, 8-5, and 8-11 show the area considered and canal plans.)

At the Board of Directors' meeting July 4, 1792, the Directors ratified the selection of the location of Paterson near the Great Falls itself, and the abandonment of the Duer-Allon scheme. Hamilton's plan for the purchase of a large block of land was eliminated in favor of the purchase of only that land for Paterson itself, still a sizeable piece of about 700 acres. Colonel Samuel Ogden was advised to cancel Duer's options for land purchase downriver at Vreeland's Point, thus eliminating the possibility of building the town at tidewater. At the same meeting, the Directors rejected the similar plan for making a three-mile transportation canal that would not reach tidewater. (See Figs. 8-4 and 8-5 for this proposed route and location.) Although this would have been less expensive than the proposed six-mile canal, it would not have provided the crucial benefit of access to cheap water transport all the way up to the factory site.²⁹

Both the Duer-Allon plan for the canal and the other shorter transportation canal

to Garrison's Brook were vetoed July 4, 1792, and it was agreed to establish the works in close proximity to the Great Falls. On July 5, the Directors took action to commence building the canal. Thereafter, plans were primarily a matter of engineering and expense rather than location changes. In part, this fact was determined by the topography. The main problem facing all the builders was that the falls were formed where the river cut between uplifted ridges of stone, with the steep uplifted face to the east forming cliffs. To bring water from the river above the falls to an area of less precipitous terrain, the engineers had to deal with two problems. First, a channel from the river bed had to be cut through the rocks in order to draw water from the river. Second, it was necessary to cross the large gully behind the rocks bordering the river, which was an overflow channel of the river itself (see Fig. 8-6). If some means were found to carry the water over the gully, then yet a third problem faced the developers in the form of the main ridge that blocked the course of

Figure 8-6



PATERSON RACEWAYS, [1792-99]

THIS SHEET DEPICTS THE FIRST RACEWAY PLAN ORIGINALLY DESIGNED BY PIERRE CHARLES L'ENFANT AND MODIFIED BY PETER COLT. WATER FROM THE PASSAIC WAS DIVERTED INTO THE RACEWAY SYSTEM BY A WOODEN DAM. WATER FELL INTO A RESERVOIR AND THEN PASSED THROUGH THE RACEWAY TO THE FIRST S.U.M. MILL. AFTER LEAVING THE MILL, WATER FLOWED BACK INTO THE PASSAIC THROUGH A DRAINAGE CHANNEL.

SOURCE: CONCEPTUAL MAP BASED ON HISTORICAL DOCUMENTATION AND 1"=100' MAP. MAP PREPARED BY THE HISTORIC AMERICAN ENGINEERING RECORD, HAER.

the stream to the east. This had to be cut for the passage of the canal. Once beyond this point, the problem became the relatively simpler one of cutting and filling for a canal to take water to the mill sites. The problem of the gully and the rocks brought forward at least three or four different plans for the engineering accomplishment of the task of getting water to the mills.

The first draft was that of Alexander Hamilton, who probably worked up the report in conjunction with the committee that had inspected the area around the falls plus Schuyler and anyone accompanying him at that time. The Hamilton draft involved three alternative schemes for getting the water to the mill sites. Hamilton proposed that a committee of three be appointed to receive bids for his three basic alternative plans, probably hoping that a clear choice of the three plans would emerge from the bids received from contractors. Hamilton's first plan was to bring the water across the gully by means of wooden troughs or trunks supported by a wall, after cutting the requisite channel into the river bed. Hamilton then proposed carrying the water on to the mill site with a guaranteed head at that point, although the specified head was left blank in the draft. The second alternative was for the contractor to let the water into the mill channel. From the mill channel at surveying stake No. 14 it was again to be led down to the mill with an as yet unspecified head. This was probably the alternative with the lowest preserved head. The third alternative involved a combination of alternative one with a plan to preserve the full head of the river. The contractor was to bring the water across the gully in a canal on top of a dam, with the top of the canal high enough to preserve the full height of the river across the gully. The contractor was then to bring the water to the mill with the usual unspecified head at that site.³⁰

All these alternatives were designed to accomplish essentially the same purpose--the end of the canal at the mill site was the same in each case. The purpose of the three alternatives in the Hamilton resolution was to give the Directors the choice of three possible bids from the contractor, so that they could select the cheapest, or be able to select one if it was a more permanent type and only slightly more expensive than the others. This alternative bidding procedure reflects the general uncertainty over the various possible methods of dealing with hydraulic

problems and the lack of definite knowledge of costs of construction in different materials.

A second draft resolution, a modification of the Hamilton one, was adopted and printed in the minutes and involved a somewhat more liberal procedure for the contractor, in that he was not tied to a particular *means* of getting the water to the mill, but rather the *route* for the canal was specified with the method of construction left open to the contractor. The Society's next move was to send out for bids on the basis of the second draft proposal. On July 5, the Directors resolved "that this Board do immediately take measures to bring the Water from above the Great Falls across the Gap to Station No. 14."³¹ The Draft Resolution was embodied in an advertisement published in local newspapers, which gave the contractors only one method of construction across the gully.³²

The advertisement called for bids "To cut a Canal from the River Passaic beginning at a point near a Station where stands a Stake marked No. 1 & continuing thence to the brink of a precipice at or near a rock marked No. 3. This canal must be thirty feet wide and must be sunk to a level with the surface of the water in the driest season." The articles went on to specify the construction of flood gates, "near the brink of the precipice," and a dam in the river to be four feet above the water level at dry seasons. The Directors specified that the gully was to be crossed on a dry wall, with a trough (construction material not specified) on top of the wall. Despite the single suggested method for crossing the gully, the advertisement also allowed some leeway by allowing bidders to suggest "any other methods which shall occur to them for constructing a competent wall across the gully from Station No. 3 to Station No. 6 and for conveying the Water from thence to Station No. 7."³³

Despite this encouragement to come up with original and less costly solutions, there is no evidence that many outside contractors took an active interest in the Paterson hydraulic system. On August 2, 1792, the S.U.M. opened the few bids and found that most were for only part of the work and all were very much higher than their estimate. Thinking that they could do the job better and cheaper, the S.U.M. decided to enter the construction and hydraulic engineering business. Probably one factor that deterred contractors from bidding was the fact that they were

asked to guarantee the work for seven years after completion, which was unrealistic, given the business and construction uncertainties of the time.³⁴

Faced with undertaking the job itself, the S.U.M. now had to transform itself from a primarily financial operation into an operating corporate organization. The transition was neither very rapid nor successful, and the result was divided authority and no clear leadership. It was not until 1793 that the Society successfully resolved the problem of its superintendency. In looking for a superintendent, the S.U.M. Directors turned once again to their prime source of talent and advice, Alexander Hamilton.³⁵ Hamilton recommended Pierre Charles L'Enfant, who attended a special Directors meeting.³⁶

Pierre Charles L'Enfant was born at Paris, August 2, 1754, the son of a "painter in ordinary to the King in his Manufacture of the Gobelins." He had a relatively undistinguished childhood, although he did receive at least some instruction in engineering and architecture. At the age of 23 he came to the United States to fight for independence on the side of the Revolutionaries. He was promoted to major in the engineers May 2, 1783, and then retired in 1784. His principal project was work on designs for the plan of the proposed Federal Capitol at Washington. By June 22, 1791 he had produced the major principles of his Washington design, based at least in part on European models and principles. Owing to difficulties over the integrity of his plans and control over operations, he was dismissed February 27, 1792. Although both Washington and Jefferson hoped to find some means of resolving the difficulties so that he could continue to work on the project, L'Enfant proved adamant and incapable of accommodating or adjusting to any changes or cooperation. He was thus available for other projects by early 1792. After his ultimate departure from Paterson, he designed houses in Philadelphia, including that of financier Robert Morris (which reputedly helped bankrupt Morris). L'Enfant died in the United States in relative poverty and obscurity June 14, 1825.³⁷

Meeting with the Directors August 1, 1792, L'Enfant promised to look over the condition of the S.U.M.'s plans for the raceway system and city and to report to the committee with his own observations and plans for both.³⁸ Hamilton gave L'Enfant his highest recommendation in a letter to the Governors and Directors of the S.U.M. from Philadelphia dated August

16, 1792. In it, he indicated that the problem of bringing water across from the river to the mills was the principal difficulty, commenting,

On this point I beg leave to say that nothing ought to be risked. Efficacy and solidity ought to outweigh considerations of expense if within any reasonable bounds. I feel persuaded beforehand that those attributes will belong to whatever plan Major L'Enfant may propose; and I doubt not it will meet with the attention it shall merit.³⁹

Thus both Hamilton and the Directors clearly felt the need for further expert advice in this pioneering hydraulic project. They hoped L'Enfant would provide the answers to the problems.

L'Enfant was appointed Superintendent of the Society at the meeting of August 20, 1792, possibly even prior to the reading of his report on the hydraulic system and town, which was presented to the Directors at that same meeting. This report, dated Town of Paterson, August 19, 1792, represented the first look at the site by a professional civil engineer. Unfortunately, L'Enfant removed the plan of the canal system and the town when he left the service of the Society later on, and these documents were never recovered and supposedly lost to fire.⁴⁰

L'Enfant's plan fell into three major divisions. In the first he dealt with the plans as proposed by the Society and the difficulty of carrying them out given the geological character of the area. In the second he dealt with the problem of a direction for the canal, and offered two possible solutions, stating that he preferred the second and shorter alternative. In the third section he spoke about the method for carrying the water across the ravine, or "cove" as he called it, and proposed to use an aqueduct of stone arches to carry the canal, a towpath, and road, rather than a solid wall of stone as proposed by the S.U.M.⁴¹

One of the S.U.M. plans envisioned bringing the water into the ravine and closing the end of the ravine with a dam. L'Enfant's criticism of this particular proposal was that it did not take account of the quality of the stone in the vicinity, which was, according to him, "but a mass of Rock heaped in broken pieces," and which he was sure would preclude the possibility of a watertight reservoir behind the dam. Instead, the water would escape underneath the dam and through the rock

on all sides, so that much would be lost. L'Enfant proposed to carry the water across the ravine on a wall, rather than allow it to flow into the ravine at all.⁴²

L'Enfant also criticized the second plan, which involved letting the water out of the river further downstream and then carrying it across the ravine on top of a wall. Instead, L'Enfant suggested moving the entrance upstream and more in line with the current of the river, which would consequently help to create flow through the channel. This was a minor change in alignment, but L'Enfant reserved his most scathing criticism for the proposal to use a wall to carry the canal across the ravine. He said that this was "so contrary to the first principals of Mechanics to admit of no discussion"⁴³ Instead, L'Enfant put forward the classic European solution to the problem, the construction of a major aqueduct on a base of equidistant stone piers, arched between the piers to carry the trunk of the canal. Perhaps the most radical part of his solution was an arch width sufficient not only for the flow of the Passaic River through the canal, but also the provision of a "Towing Path and Carriage way on each side."⁴⁴ Thus the structure was altered from the simple transport of water in the S.U.M. plans to the multipurpose function of canal barge and vehicular traffic. L'Enfant's objection to the wall proposed by the S.U.M. was that it would be subject to immediate breaches owing to the enormous and probably uneven water pressure from above on such a mass of rough-fitted masonry. Some idea of the dimensions of such a structure can be gained from the measurement that L'Enfant specified for the canal across the ravine, which was to be 33 ft. wide and probably 7 ft. deep. At the very minimum, the carriageway and towpath required an additional 20 ft., making the overall width of the piers and aqueduct about 55 ft., rivaling the Roman aqueduct at Pont-Du-Gard in France, which may possibly have influenced L'Enfant since it also carried a road on the lower tier of arches in addition to the upper level watercourse.

At the end of the canal across the ravine, L'Enfant proposed a reservoir about 100 ft. wide and 10 ft. deep to act as a small storage basin for evening out flow from the river under changing demand. Exiting from this basin he had two main raceways for carrying water to the mills. Each had a basin similar to the larger reservoir to serve a number of mills.

L'Enfant proposed to build only one of the raceways at the moment for the S.U.M. mills, leaving the other raceways until until demand for water increased over and above the Society's own needs. The two major raceways would have about the same head as the Passaic itself, but there could be perhaps three or four other races below this highest level, using water from the first level a second and third time on its way to the river.⁴⁵

How did L'Enfant's plan suit the situation? Most previous authors who have dealt with his contribution have reported him as being an impractical visionary who spent money like the very water he proposed to bring to the mills.⁴⁶ Trumbull considers him as a wholly negative influence, who was neither a good engineer nor a careful superintendent of expenses.⁴⁷ Most of the justified aspects of these criticisms relate to the construction phase of the operation, when L'Enfant's personality did create problems. However, there was certainly no opposition to his plan at the outset, and for what is worth, history has proved him right on most counts. He envisioned a multipurpose structure to carry water, canal boats from above the falls, and a roadway to eliminate the problem of going over the ridge, as did the Stoney Road of that date. All these aspects were eventually made part of the canal system, and at present one of Paterson's main roads, McBride Avenue, follows the edge of the raceway from the river (see Fig. 1-2, Article 1). When the raceway was extensively modified in 1828-30, a canal lock was built into the rock so that barges could come down from the Little Falls area bringing building materials. Perhaps only the completion of the Morris Canal prevented an extension of the system all the way to tidewater at a later date. L'Enfant planned to bring water across the ravine rather than down through it as a reservoir; this design was ultimately carried out in 1846 and is still a feature of the present raceway system. The dam across the ravine adopted by Peter Colt broke down for just the reason foreseen by L'Enfant--leakage--and ultimately had to be abandoned.⁴⁸ The sole elements of his plan never incorporated in the raceway system were the small reservoirs and the method of crossing the ravine on an aqueduct. In that respect L'Enfant's plan ultimately proved impractical, not because it could not be done from an engineering standpoint, but because that type of construction was better adapted to European rather than Amer-

ican wages, skills, and background. Only when L'Enfant attempted to bring European solutions to bear on American problems did his engineering sense fail him. All in all, his plan must be called a success, if ultimate adoption and use is the measure of an engineering plan.

L'Enfant's appointment created ill feeling among the very men he would have to work with and supervise, for William Hall and Joseph Mort, two of Hamilton's early appointees, had also offered a plan for the hydraulic system after the bids had proved unacceptable. The success of L'Enfant's proposal could not but rankle Hall and Mort.⁴⁹ They proposed to execute the dam and canal for (£?)1945 as far as the gully according to the committee's plans three and one. They offered to carry out the whole project for (£?)4070, including bringing the water across the gully and to the mill site, and promised the additional advantage of a sawmill in the gully using excess water that would have been wasted at the cotton mill.⁵⁰ It is neither very difficult to believe that L'Enfant's subsequent appointment over these men created problems of labor relations, nor to suppose that they were willing to denigrate L'Enfant's plans at any opportunity.

With the acceptance of L'Enfant's design, the focus of activity shifted to actual construction operations. Here the most immediate problem was one characteristic of many early American enterprises of this nature--supervision. Theoretically, L'Enfant held the position of "Agent for superintending the erection of the works [and buildings]"⁵¹ ordered by the Directors⁵² However, at the same time, John N. Cumming was made the agent for procuring workmen and materials at a salary of \$600. Cumming was a stagecoach operator in Newark and a stockholder and director of the S.U.M.⁵³ He was unable to give all his time to the new undertaking, and L'Enfant proved equally unable to stick to the problem of supervision. Thus, in the early period a general lack of direction from above for the actual construction operations impeded the execution of the project. In fact, the appointment of an overall superintendent with direction of all the Society's affairs did not take place until Peter Colt was chosen well along in 1793.

L'Enfant began work on the canal almost as soon as he had presented his plan, August 19, 1792. On August 21, he wrote to Hamilton that he wished "to assure you that your favorite Child will be carefully

nursed and bread up to your satisfaction without Involving the parents in to Extravagant or useless Expence. My sole Embition being to deliver it worthy of its father and capable of doing honor to his Country."⁵⁴ Less than a month later he reported to Hamilton that

The ground through which this is to be carried is already cleared of all timber and immense Rock removed from the way of operation so that I am in hope in a few week to be enabled to make a beginning of the fundation of the grand aqueduc--also to open the Rock across the [h]ill and to make a beginning Every way proportional to the number of hand as shall be collected the which daily Increase in number.⁵⁵

However, L'Enfant also mentioned that construction on the buildings could not proceed as rapidly as it would in New York because all the materials except the stone had to be brought in from a distance. In contrast to what most people have reported, including Davis, L'Enfant seems to have been generally very interested in the problem of the canal, and perhaps even more so than the buildings, although workers were digging 50 foundations for houses. He clearly recognized that the principal object, "that of the canal," was necessary for the success of the whole, and said that everything would be carried along "to be ready with the canal," indicating that he, like the Directors, knew that the rest was useless without it, and found this the most crucial part of the scheme.⁵⁶

The problem of direction for the S.U.M. remained despite the appointment of L'Enfant as head of the works and buildings. The Society needed someone who would be competent to manage all aspects of the enterprise and be on the site at all times to direct operations. At this period in U.S. history, the problem was almost insuperable. None of the Directors was really competent to deal with the engineering aspects of the water power system, since they were primarily merchants, ship-owners, and land speculators, rather than engineers. The necessity to appoint L'Enfant had already demonstrated the paucity of such engineering talent among the native population. But the position also required the business and accounting skills developed in the countinghouse and mercantile trade. This skill was certainly available in America, and probably some of the Directors had it. However, the

talented ones were fully immersed in their own personal affairs and could not or would not take a very active role in the Society's day-to-day dealings. They probably felt that their function was to supply the capital and control long-term policy and important decisions, rather than to exercise active operational control. Lastly, the position required administrative skill--the ability to harmonize and direct the actions of a large number of individuals toward the accomplishment of a single goal. This supervisory function was certainly complicated by the number of strong competing personalities in and around Paterson. Joseph Mort, William Pierce, Thomas Marshall, and William Hall, to say nothing of L'Enfant, all had ideas of the proper way to run the organization, and each felt that his way was the only correct one.⁵⁷ The ultimate solution was to appoint someone over all these competing individuals, essentially a manager, who had some experience of manufacturing and business problems.

The first attempt to find a superintendent met failure. Nehemiah Hubbard, the man chosen for the task, rejected the position in early 1792 for undisclosed reasons.⁵⁸

The remainder of 1792 passed without a superintendent, although apparently there was a possibility in October that Samuel Ogden was being considered for the position. Ogden was the brother-in-law of Gouverneur Morris, a speculator who also operated an iron-making works on the Delaware for Robert Morris. Hamilton wrote in October, arguing against his nomination. He claimed that Ogden was disliked by all the workmen because of his arrogant manner, that he was undisciplined, and that he was so opinionated and prejudiced that Ogden claimed L'Enfant "knows nothing of water works when it is well known that he was regularly bred to this as part of his profession. He would drive L'Enfant off the ground in a week." Ogden was never formally offered the position. Hamilton's concern was undoubtedly a major reason.⁵⁹

Despite Hamilton's rejection of Ogden, he continued to press the Society to find a superintendent. In a letter to the Directors written October 12, just three days after disparaging Ogden, he wrote a "Minute of Matters which appear to require the attention of the Directors . . .," and first on the list was the appointment of a superintendent, "if an unexceptionable person should present; but if none such should occur it may be still most advisa-

ble to defer till the buildings shall be erected and the works in operation."⁶⁰ 83

The search for a superintendent continued during the fall and winter of 1792-93. In October, the Directors selected a committee to investigate possible candidates and report at the next meeting. The committee eventually eliminated Samuel Ogden and recommended in January that they meet instead with Peter Colt of Hartford, February 1. Colt finally appeared at a Board of Directors meeting February 19 and was immediately ratified as "Superintendent of the Factory" at an annual salary of \$2500, or \$1000 more than L'Enfant's salary.⁶¹

Peter Colt may have come to the attention of the Directors, like so many of the other individuals associated with the S.U.M., through the contacts and personal referral service that the Secretary of the Treasury operated from Philadelphia. In the process of obtaining information from manufacturers on the present state of American industries for his *Report on Manufactures* in 1791, Hamilton received reports on the Hartford Woolen Manufactory.⁶² This was one of the largest and relatively most successful new companies in America. George Washington reportedly wore a suit of cloth woven in the Hartford factory for his inauguration. Peter Colt had been Deputy Commissary-General for the Eastern Department during the Revolution, Agent for Jeremiah Wadsworth, and was at the time of the S.U.M. offer the Treasurer of the State of Connecticut.⁶³ He seems to have had the complete confidence of the Directors throughout the S.U.M.'s operations. His experience with financial and business dealings certainly stood him in good stead in the Paterson position. However, and Colt was perfectly willing to admit this himself, he knew nothing of the machinery for textile manufacture and was not himself an engineer at that time.⁶⁴ His capabilities were limited primarily to the management and careful control of an operating organization, and the direction of subordinates.⁶⁵ His principal problem was the touchy pride of the individuals working under him, coupled in some cases with incompetence. Most of the workmen, particularly Joseph Mort and William Hall, harbored the idea that *they* should have been offered the position of superintendent. Hall and Mort had already submitted a proposal for the hydraulic system, and their noses were certainly out of joint because the Frenchman L'Enfant's plan had been approved over their's.⁶⁶ Peter Colt's direction and control over manufacturing

84 operations were too much for them, and all except William Marshall left, although for most the break was not immediate.

Pierre L'Enfant was a special case. He was both better paid than the other workers, and at the same time even more sensitive about his professional skill. L'Enfant found it difficult to play a subordinate role in any operation. Yet it seems that in this case he was not solely to blame for the situation leading to his departure from Paterson. Davis has accused L'Enfant of excessive absence, carelessness, and extravagance.⁶⁷ It is probably safe to say that he may be acquitted of the last two charges, but the first is at least partially true owing to his misunderstanding of the problems of the Society and American engineering works in general. Briefly, L'Enfant developed the plan for the engineering of the Paterson raceway system, carried on construction into the fall, and then departed, leaving subordinates in charge of executing the plan. It is hard to know what more was expected of him, for it was not uncommon in those days for engineers to direct a project only through the planning and layout stages, then to depart for other ventures.⁶⁸

Also, it was not usual for work on construction to continue during the winter season. Instead, the hands were furloughed when the ground began to freeze because it was too expensive to pay laborers when so little could be accomplished. This seems to be what happened in the Paterson situation. L'Enfant first put his workers to the task of clearing timber and rock from the paths of construction. The obstacle to continuing excavation of the canal and work on the aqueduct primarily resulted from the necessity for having good weather for the former and cut stone for the latter. "Stone is extracting from the quarry and provision of Every sort making to Enable a beginning of the principals and most necessary building for the manufacture and the Employed--for whom in waiting til the building are compleated I have ordered a number of barrack to be Erected suitable to the various purposes." He reported that progress on the canal "will depend greatly of the duration of good weather and temperry of the approaching season."⁶⁹

These steps taken, L'Enfant left Paterson for the winter season. From L'Enfant's letter of September 1792 until February 1793 there is a hiatus in correspondence, and we simply do not know what was going on, if anything. However, with Peter

Colt's arrival on the scene after his appointment February 19, 1793, the picture of steady progress that L'Enfant painted for Hamilton in the fall was viewed differently. Colt found the principal workmen dissatisfied with their jobs, the progress on the buildings poor, and the absence of L'Enfant inexcusable:

Several Buildings which have been ordered for manufactures, are extremely wanted, as well as a durable building for the purposes of general Magazine or Store House; but Majr. L'Enfant, to whom this part of the Business has been confided, not being here, nothing can be done; and our weavers are working by the day in such wretched Sheds, that they loose half their time. In short no arrangments can be made for puting things on a more durable & advantageous footing untill the Majr. returns on the ground.⁷⁰

Colt's complaints were echoed in a second letter of his to Nicholas Low prior to March 4, and repeated in a letter of Nicholas Low to Hamilton on March 4. Colt wrote the following:

The Absence of Maj. L'Enfant of whom I get no Intelligence becomes every Day more distressing not a day passes without Applications for Employmt. of Mechaniks & for House Lotts & ca. I do not feel myself at Liberty to take a single Step in this business without consulting him as I am totally uninformed as to his Plans of the Town and the general Arrangements made for building thereon.⁷¹

Low seconded this complaint in his letter, asking, "What can be the Cause of Maj. L'Enfant's extraordinary long absence? Will you speak to him and advise him to come forward immediately."⁷²

In both cases these complaints dealt primarily with the buildings rather than with the canal. Probably L'Enfant's absence was owing in part to his assumption that no useful work could yet be done on the canal in the early spring, and that since the buildings were more advanced than the canal there simply was no problem. He had provided temporary working quarters (the barracks referred to in September) and probably failed to realize the importance of having permanent and solid working quarters for the construction and trial of machinery, even if the raceway system was not in operation. He probably felt that demand for house-lots would oc-

cur after the start of factory operations, rather than at present.

L'Enfant returned to Paterson at the end of March to begin work, and reported,

I have fund Everything at Paterson in as good a state as I had promised from the arrangement made previous to my leaving the place and Judging from the progress making in reducing the Rock I would Continue to indulge the flatering hope of happily Ending the operations of this season,⁷³

Such was not to be the case, for Samuel Ogden appeared on the scene and disarranged the plans of the Society, in the process further alienating L'Enfant from the S.U.M. Directors and Peter Colt, and thus helping to bring about L'Enfant's departure from Paterson.

Some time in March, Ogden broached his "new" scheme for water power development. The basic plan was the once-rejected Duer-Allon proposal for taking the water from the Great Falls down to Vreeland's Point and building the factory at that location. Ogden had been Duer's agent for the land at that time, and may have hoped to recoup losses from that venture. It is curious that Low had been on the committee responsible for the change of site from Vreeland's Point to Paterson. Motives for his change of mind can only be guessed at, but the most likely one seems to be Ogden's promise to build at a fixed price, rather than the risk that L'Enfant's plan might exceed his estimate of cost (about \$30,000, according to L'Enfant's report of the limitation placed on him by the Board of Directors).⁷⁴ Ogden offered to build the whole canal and purchase the necessary lands at Vreeland's Point for the price of £20,000 (around \$80,000).⁷⁵ Low brought this proposal forward at a March meeting (probably the 26th) at which Boudinot, Colt, and L'Enfant were present. L'Enfant became understandably irritated at the thought that his whole plan was to be replaced and his successor given more money, but Low tried to smooth things over by saying that none of L'Enfant's work would be lost and that he could continue with construction according to plan since it would all be part of Ogden's system eventually. L'Enfant was not convinced, and all agreed that there should be a delay in the start of the year's construction until a final decision was made. L'Enfant laid off those workers already assembled in Paterson and told new arrivals at the site that they would not be needed until April 20. This delayed con-

struction a month. A scheduled Board of Directors meeting was postponed until April 16 to secure full attendance for making the important decision to accept or reject the Ogden proposal. Boudinot urged Hamilton to attend, "if you do not wish to forsake your child."⁷⁶

Despite the decision to postpone hiring hands and dismiss temporarily those already at Paterson, L'Enfant modified his resolve and put many men to work at various projects. According to Colt, "Previous to Maj L'Enfant's setting out for Trenton, he directed a number of additional hands to be employed in clearing the ground for the foundation of the canal, as well as braking up Stone for the pillars &c."⁷⁷ Thus little time was actually lost, although the work may not have been pushed as rapidly as it would have been under normal circumstances. Behind the scenes the two forces prepared for the April 16 meeting. Although we do not know who voted for which plan, it seems evident that Hamilton favored the *status quo*, and he may have talked with or written others of his feelings. His opinion of Ogden ("Mr Ogden is generally what may be called a Projector & of course not a man of sound views"⁷⁸) had already been expressed to some of the Directors, and there is no reason to think that his opinion of Ogden's proposal would have differed from his earlier reaction to the Duer-Allon plan, which was negative. Hamilton wrote directly to L'Enfant that "I cannot imagine that the Directors will adopt the change. If you are still in a situation to go on with propriety I wish you by all means to do it. You may be assured I shall not be unmindful of the business."⁷⁹

Hamilton proved correct in his hypothesis, for the Directors did not change their plans. On April 16, Low presented Ogden's proposal, but, "the same being taken into consideration it is agreed that the Society has proceeded too far in their present plan to receed or adopt any other."⁸⁰ On the other hand, the meeting was no vindication for or ratification of L'Enfant's plan. The S.U.M. faced serious financial problems as a result of both the financial panic and the depressed price of government securities, in which subscribers could pay part of the installments on their stock. The Directors attempted to get L'Enfant to concern himself solely with the problem of the canal, and leave grand plans for urban avenues to a more auspicious time. Officially they passed a resolution that limited L'Enfant to

supervising the construction of the aqueduct, "in the speediest manner possible," and gave Colt the supervision of all other buildings.⁸¹ In practice they acquiesced to L'Enfant's wish to continue both with the general town plan and the construction of the cotton mill. In return, L'Enfant promised that he would bring the water power into use during the working year and still give them some cash with which to operate the mills.⁸² Thus, within eight months of assuming the position, L'Enfant had lost at least some of his expert standing and power. From that time forward both he and the aqueduct were clearly on trial.

The trial did not last very long, and was apparently complicated by the fact that both Colt and L'Enfant were absent from Paterson for some time--L'Enfant for unknown reasons and Colt because his family in Hartford was severely ill with smallpox.⁸³ As the spring season progressed, it became apparent to the Directors that L'Enfant would not be successful in fulfilling his promise to bring the water across to the mill during that working year, and that money for the workers on the project was continuing to flow out at an alarming rate. Accordingly, a group of the Directors met June 9. L'Enfant was missing, despite a request from the Directors that he attend. At the meeting the Directors decided that the plan for the aqueduct would have to stop for two reasons. First, L'Enfant was too slow in getting water to the mills. Second, "... the funds of the Society are altogether inadequate to support the expense of the plan, however well they might approve of it [the aqueduct] if they had wealth sufficient to accomplish it."⁸⁴ L'Enfant may have returned to Paterson shortly thereafter, but the news that he was removed from power caused him to leave again, never to return so far as is known. Davis argues that the Directors tried to ease the break by keeping him on the payroll and giving him authority to hire an assistant, but this results from the misattribution of a letter of August 1792 to August 1793 instead.⁸⁵

L'Enfant left Paterson with the plans for the raceways and city in his pocket; unfortunately, these documents were never obtained by the S.U.M. and were reportedly burned at some time so that they are lost to history.⁸⁶ Eventually the S.U.M. abandoned the documents and paid L'Enfant the balance of his account, closing L'Enfant's association with Paterson completely. He was invited to, but did not attend, a Directors meeting July 16, 1793.⁸⁷

Several conclusions can be drawn from L'Enfant's participation in the Paterson hydraulic project. It is apparent that his personality was a major problem, just as it had been on the Washington job. His inability to accept criticism or to adapt his projects to lower-cost results played a major part in his firing by the Directors. L'Enfant obviously thought that he was to be in charge of all aspects of the work except the machine-building, and when some of these were removed from his control he began to lose interest. Nevertheless, L'Enfant's plan for getting the water from the Passaic River was a solid and practical large-scale engineering scheme. Ultimately, the S.U.M. adopted almost all his proposals, and thus paid for them twice. His real weakness was in using plans that were better suited to European skills and European finances. Despite the relatively generous amount of capital collected by the S.U.M., it was not prepared to pay for the workers necessary to build an aqueduct such as those of old Rome or France. Cost of skilled labor was relatively higher in America than in France, and L'Enfant simply assumed that the same number of cheap, skilled stonemasons would somehow be available to accomplish his task. Obviously in this case his assumption was incorrect. In early America engineering consisted less in building solid, permanent structures than in building cheap, temporary facilities that would suffice for a short time.

L'Enfant's departure from Paterson left Peter Colt in full control of the project--buildings, raceways, and housing--but it certainly did not end the construction problems. Colt followed the simplest and least complicated plan, in an attempt to keep both labor costs and engineering requirements low. Instead of carrying the water *across* the ravine, the ravine was used as a reservoir. From the reservoir water passed through the gap in the rocks (cut by L'Enfant and extended by Colt) and into a single raceway, which continued only to the site of the cotton mill. Both the excess water and the water used on the wheel were run across what was then a marshy expanse of ground back to the Passaic, as Fig. 8-6 shows.⁸⁸ The advantage of this plan over L'Enfant's was that a masonry project was converted to an earthmoving operation. Blasting operations continued to open a channel from the river to the reservoir, probably in exactly the same spot as originally planned, since all the sources report that L'Enfant had already blasted a con-

siderable gap in the rock on both sides of the ravine.⁸⁹ Colt began this work at least by July of 1793 after his return from Hartford, and recorded that "We are progressing with our work with as little interruption as could be expected."⁹⁰

Unfortunately we have few letters from Colt for the period from July 1793 to January 1794, and are therefore unable to gauge all the problems he encountered. However, his efforts were no more successful than L'Enfant's in getting the water power system in operation during 1793. Much of Colt's time was taken up in dealing with the various workmen and machine builders in the factory. As under L'Enfant's direction, work was suspended during the winter season, and not reopened until about the end of mid-March.⁹¹ March brought rain, and Dutch holy holidays interfered with progress in April, but by May 18 Colt hoped that fine weather would see the canal finished up to the mill. By May 21 the canal was approaching the mill, only to have a storm and consequent flood damage the work in progress.

Last night at 11 O'Clock I left the Dam & canal--as I supposed perfectly Safe; but the person I left to watch the water, being called off to save the Gristmill--the water in the Canal unexpectedly increased so as to run over the bank at the end near the Cotton mill, & before we could stop [the flow] carried away the earth so as to under mine the wall that supports the Trough that had been made to bring the water on the wheel & filled the cellar of the mill--I was fearful it had injured the foundation of the mill, but there is no appearance of any damage to the House since we have drained off the water and I hope the only damage we shall sustain there is the labour in rebuilding the wall & replacing the earth &c--....⁹²

Damage from this flood further slowed the progress of the work by putting the sawmill, where the company had all its lathes for wood and iron, out of action for some time. Despite the damage Colt allowed his chief millwright and carpenter, one Usher, to leave June 7, since substantially all that work was complete.⁹³ Further delays took place at the end of June when the bank at the end of the canal near the mill proved sandy and insubstantial, requiring extensive additional buttressing.⁹⁴ Despite these delays, Colt was able to get the water power system for the mill into operation

87 during late June or early July 1794. After trial operations, Colt reported in mid-July that Marshall in the cotton mill was preparing to "set on water Spining as a Constant Business."⁹⁵ One phase of the S.U.M. operations was complete.

With the water power now available, Colt turned his attention to two other areas of importance for the Society. The major concern, up to suspension of the Society's operations in 1796, was the spinning business in the mill buildings, and the associated trades of weaving, bleaching, and printing. Yet there was very little that Colt or any of the Directors of the S.U.M. could do personally to advance this business because they lacked the technical expertise to question the foremen of the various branches on any decision. The S.U.M. could only support men who seemed knowledgeable, pay the wages and material bills as they came due, and hope that they were not being cheated and that business prospered before the Society's funds ran out. They were certainly disappointed in this last hope, for the S.U.M. suspended manufacturing operations in January 1796, dismissed all hands, and halted temporarily the great experiment planned by Hamilton.⁹⁶

The second area of concern had to do with the future of the water power development in Paterson. The Society had just spent an enormous sum to bring the water to its cotton mill. Even though Colt had reduced the potential head available by allowing water to fall into the ravine, wasting about 20 ft. of head, the Society still had a volume of water available that was more than sufficient to run the single small factory it had built. Should the Society extend the raceway system to make this surplus power available at other locations? Should the Society allow others to develop the surplus water power and possibly compete with the Society itself? If the Society did grant power privileges to other individuals, should the grants be an outright sale, or should the Society lease them? If so, what price or rental should they charge? These were questions no one had ever answered before on such a scale, since such a vast power project had never before been undertaken in America. Although not of any great importance prior to 1796 when the Society ceased direct manufacturing operations, the answers had great importance to the later revival of the S.U.M.⁹⁷

After 1800, the S.U.M. became primarily a power developer and real estate firm, rather than the active manufacturing corporation that Alexander Hamilton had

planned. Manufacturing ventures were and continued to be relatively risky, and the Society, in the person of its most important Governor, Roswell Colt, chose to avoid these hazards for the somewhat more traditional and conservative course of real estate promoter and developer. In effect, the S.U.M. Governor and Directors admitted that they could not hope to exercise corporate supervision and control over the nascent industries of that period because neither machines, business, nor personnel were yet standardized enough to be easily evaluated by investors. The rewards for backing a Samuel Slater might eventually be high, but the wait was long and there were probably ten people who claimed to know everything about the machine textile business for every one like Slater who was really competent.

Colt's opinions on the development of the water power were based primarily on his calculation of the cost of the canal and dam, and the value of the land over which the raceway system passed. He estimated this cost at \$5000, and consequently argued that mill seats 40 by 100 ft. ought to sell for about \$500, including the right of drawing enough water to turn a set of millstones (probably about 0.5 sq. ft. of water with a 20-ft. head). However, he suggested that the first few lots should be sold for somewhat less, and offered a mill lot to one Crosbie for \$400. Colt's main worry was with the form of contract for sale of land and water rights, and he seems to have accepted from the very start that the S.U.M. should sell water lots to outside manufacturers. Colt questioned whether at such a low price the buyer of the lot should not assume the liability of interrupted flow owing to accidents that prevented the S.U.M. from supplying the stipulated quantity of water, citing as his reason the recent failure of the earthen bank of the canal which interrupted the flow and led him to distrust the reliability of the supply system.⁹⁸

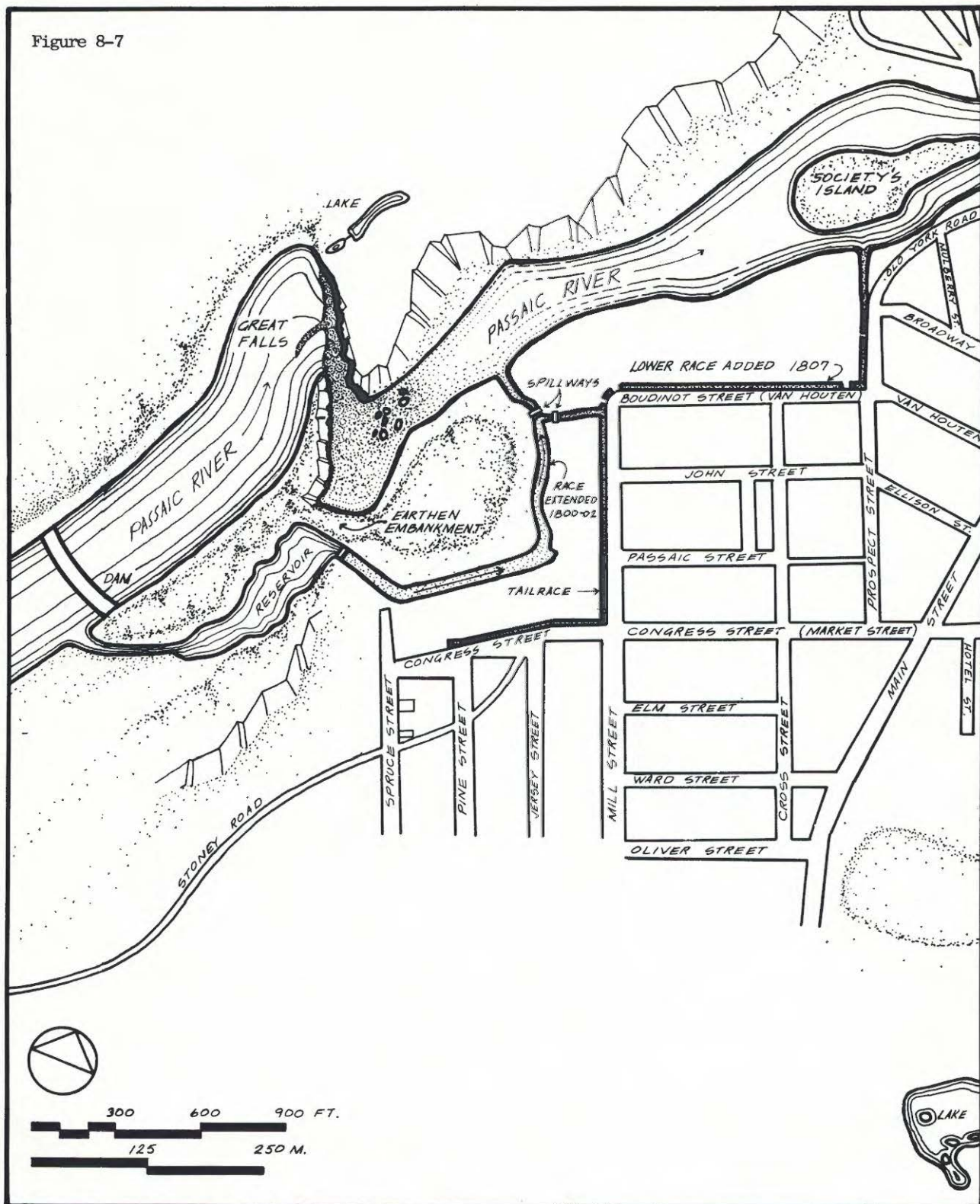
Colt also seems to have had little doubt from the very start that the water power system of the Society would have to be extended beyond its 1794 limits. He apparently envisaged the second part of the present middle canal (shown in Fig. 8-7) going north from the location of the first mill at Passaic and Mill Streets parallel with Mill Street along the side of the hill toward the river. He also planned to use the tailrace from the cotton mill to drive another set of mills

along the brow of the hill above the river itself (corresponding to the present lower canal along Van Houten Street). The only problem with carrying out this part of the plan immediately was that during the construction of the cotton mill water was encountered in the basement excavation. To drain the water, workers constructed a trench below the basement level in a northeasterly direction across the bleach field to the hill near the river (approximately the site of the present Harmony or Industry mill lots, as they are now known). Rather than construct a second trench as a tailrace to carry off the water used on the wheel of the mill, or any waste water overflow, they used the drain for the mill as the tailrace also. The drain was some 3 or 4 ft. lower in elevation than was actually necessary for a tailrace, and consequently this much potential power was simply wasted. Colt felt that the only long-term solution was to dig a second separate tailrace that would maintain the necessary level going north along Mill Street and then turn east along Van Houten Street, as the present lower canal actually does. When it reached the Harmony-Industry mill lots, the canal would have to be built over the other drain, which was still necessary to carry off water from the cotton mill.⁹⁹

The credit for these later ideas cannot be definitely assigned. Probably L'Enfant, Peter Colt, Usher (the millwright), and the constraints of topography all deserve a share. Peter Colt's plans were not brought to fruition during the early period of the S.U.M.'s activities, since the interruption caused by the failure of manufacturing operations in 1796 brought any thoughts of expansion to a temporary halt. Colt himself left Paterson with the thanks of the Directors in 1796, and went to work with Philip Schuyler on the Western Inland Lock Navigation Company.¹⁰⁰ He eventually returned to the New Jersey area ca. 1811, and his son, John Colt, became the agent and principal engineer of the S.U.M. during its period of greatest growth after 1812.¹⁰¹

Peter Colt's ideas were the substance of the evolution of the water power system as it was gradually enlarged from 1800 to 1807 (Fig. 8-7). These additions were sufficient to satisfy all demand until the late 1820's, when the first major realignment of the hydraulic system took place to enable construction of an entirely new upper tier of mill seats (Fig. 8-8). Thus the modest Colt plans were sufficient

Figure 8-7

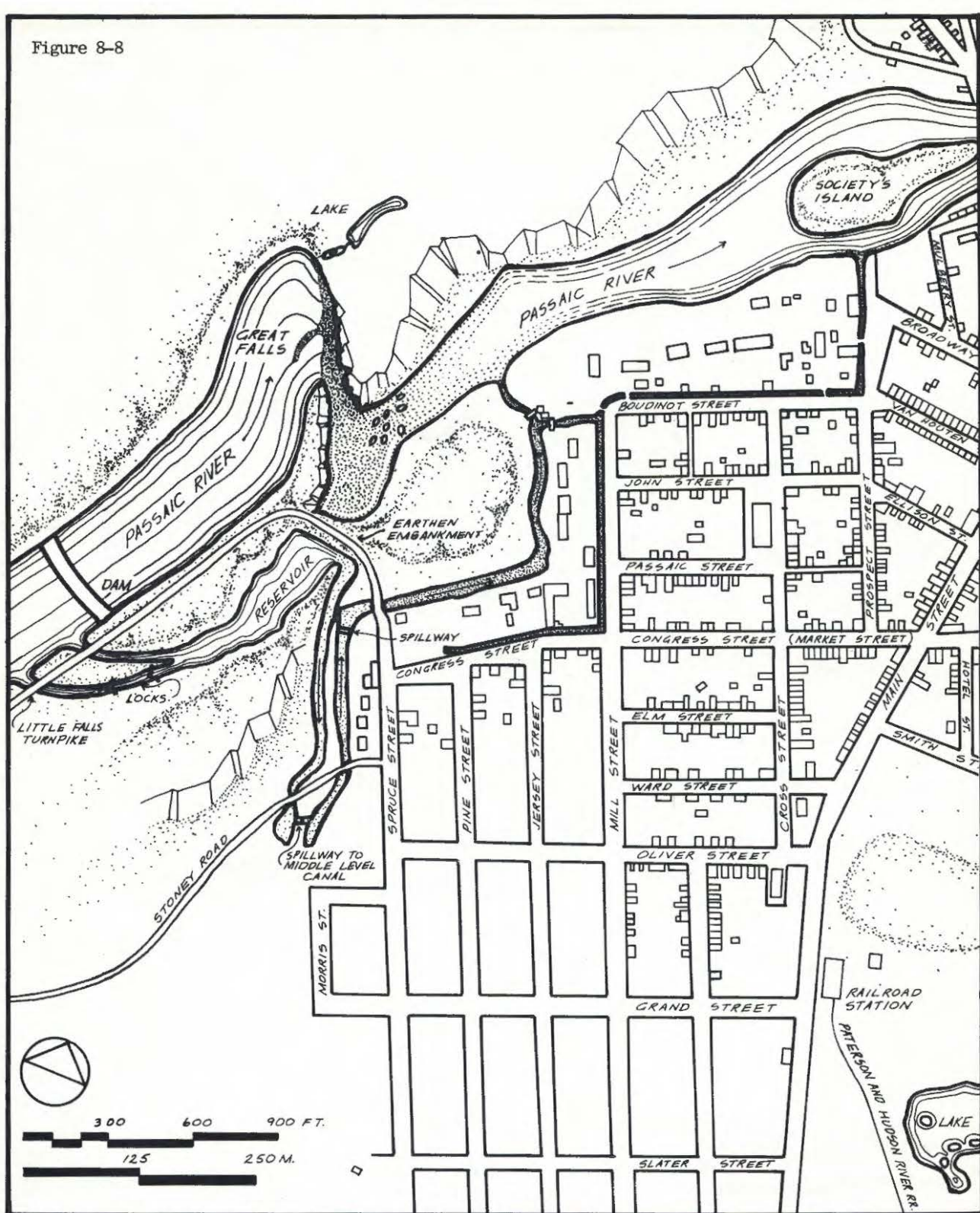


PATERSON RACEWAYS, [1800-27]

THIS SHEET SHOWS THE EXPANSION OF THE RACEWAY SYSTEM, WHICH BEGAN IN 1800, WITH THE EXTENSION OF THE RACEWAY ALONG THE SIDE OF THE HILL BEYOND THE SITE OF THE FIRST MILL TO SUPPLY THE ESSEX MILL WITH WATER. IN 1807 S.U.M. ADDED A RACEWAY ALONG BOUDINOT (NOW VAN HOUTEN) STREET AND THE TAILRACE ALONG MILL STREET, ELIMINATING THE OLD DRAINAGE DITCH.

SOURCE: CONCEPTUAL MAP BASED ON HISTORICAL DOCUMENTATION AND 1" = 100' MAP.
MAP PREPARED BY THE HISTORIC AMERICAN ENGINEERING RECORD, HAER.

Figure 8-8

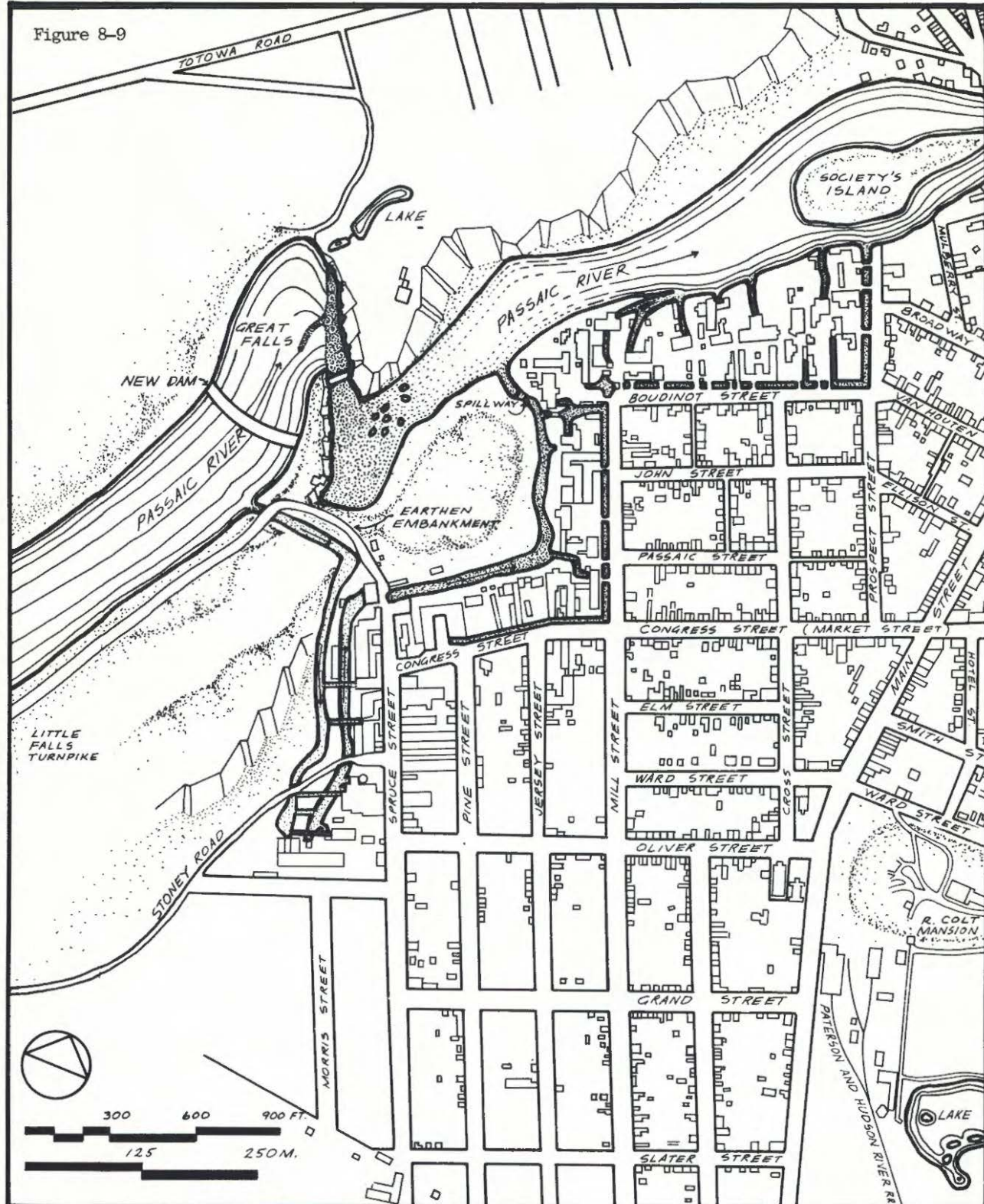


PATERSON RACEWAYS, [1828-37]

THIS SHEET DEPICTS A MAJOR MODIFICATION IN THE RACEWAY SYSTEM, BEGUN IN 1827 DUE TO A LACK OF WATER FOR ADDITIONAL MILL SITES. THE S.U.M. RAISED THE EARTHEN EMBANKMENT BLOCKING THE RESERVOIR FROM FLOWING INTO THE PASSAIC, THEN TURNED THE WATER AROUND TO THE TIP OF THE ROCKS AT L'ENFANTS GAP INTO A NEW 'UPPER LEVEL' RACEWAY WITH A PARALLEL TAILRACE BELOW WHICH LED INTO THE PREVIOUS SYSTEM ALONG A NEW LINE.

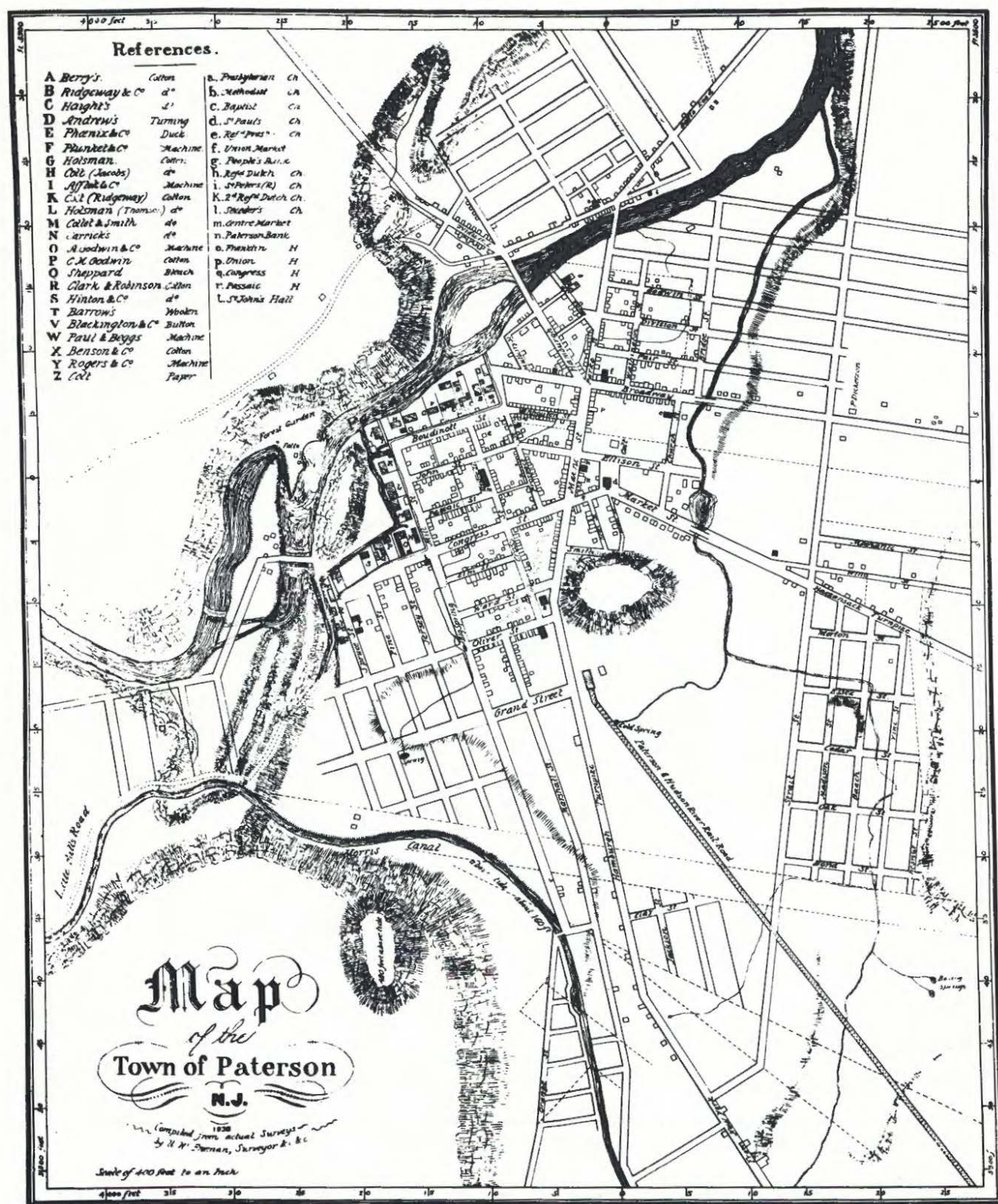
SOURCE: CONCEPTUAL MAP BASED ON HISTORICAL DOCUMENTATION AND 1" = 100' MAP. MAP CULTURE FROM PATERSON, N.J. MAP, 1850, BY J.C. SIDNEY, PUBLISHED BY M. DRIPPS, NEW YORK, NY. PREPARED BY HAER.

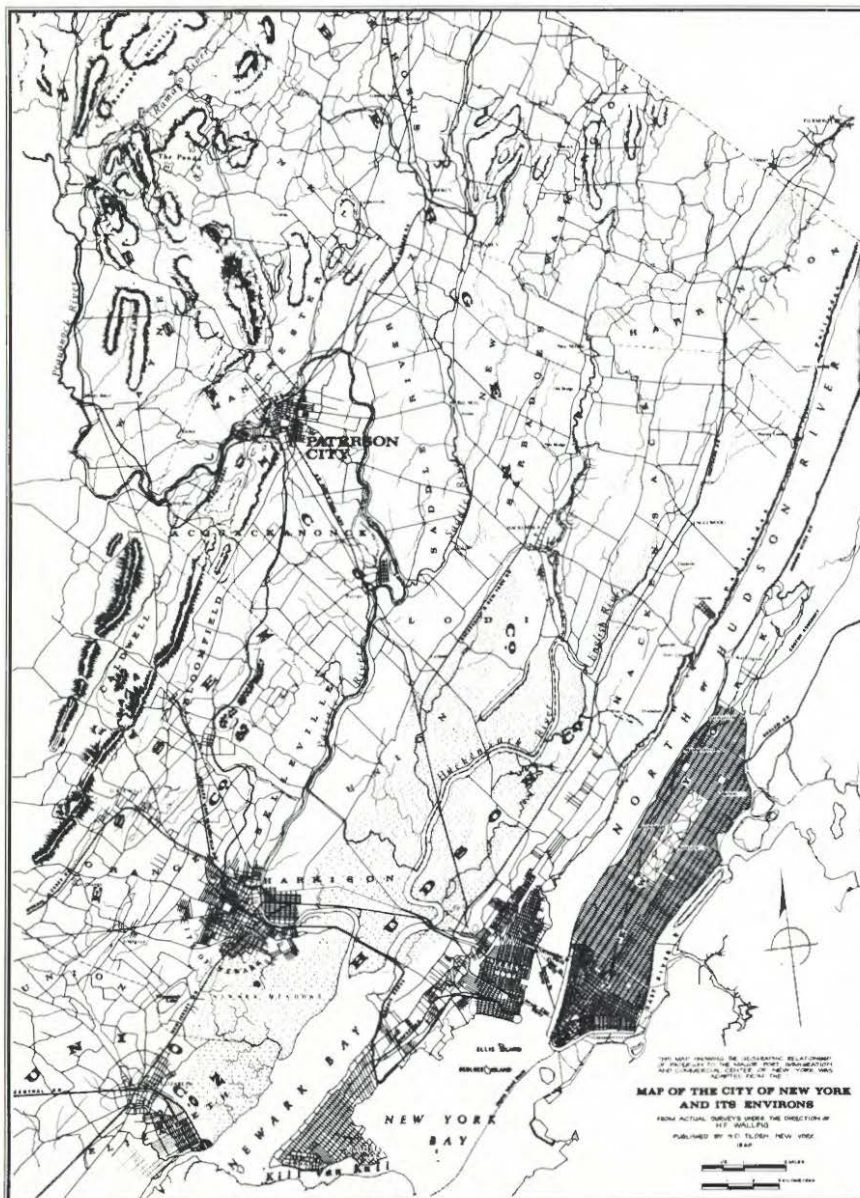
Figure 8-9



PATERSON RACEWAYS, [1838-PRESENT]

THIS SHEET DEPICTS FINAL ALIGNMENT OF THE U.S. RACEWAY SYSTEM. LEAKAGE THROUGH THE EARTHEN EMBANKMENT FORCED THE S.U.M. ENGINEER TO ABANDON THE RESERVOIR AND CHANNELS FROM THE RIVER. INSTEAD HE BUILT A MASONRY DAM DOWNSTREAM AND TURNED THE RIVER INTO THE RACEWAY THROUGH A NEW CHANNEL CUT INTO THE ROCKY RIVER EDGE. THE WATER WAS THEN CARRIED ACROSS THE GULLEY ON TOP OF THE EARTHEN EMBANKMENT WHICH HAD SERVED AS A DAM FOR THE RESERVOIR. IN THE LATE 1800'S S.U.M. FILLED THE RESERVOIR AND SOLD THE LAND. SOURCE: CONCEPTUAL MAP BASED ON HISTORICAL DOCUMENTATION AND 1"=100' MAP. CULTURE FROM PATERSON, N.J. MAP, 1850, BY J.C. SIDNEY, PUB. BY M. DRIPPS.





GREAT FALLS S.U.M. HISTORIC DISTRICT

PATERSON, NEW JERSEY

THE ABUNDANT POWER POTENTIAL OF THE GREAT FALLS OF THE PASSAIC RIVER AND THE PROXIMITY OF THE NEW YORK MARKET AND IMMIGRANT LABOR FORCE COMBINED TO MAKE THE AREA, LATER TO BE KNOWN AS THE CITY OF PATERSON, A LOGICAL LOCATION FOR INDUSTRIAL DEVELOPMENT DURING THE LATE 18TH AND EARLY 19TH CENTURIES. ALEXANDER HAMILTON AND TELLO COKE INSPIRED A GROUP OF CAPITALISTS UNDER THE LEADERSHIP OF WILLIAM DUER TO FORM THE SOCIETY FOR ESTABLISHING USEFUL MANUFACTURES (SUM) IN 1791. PIERRE LEFEBVRE, THE PLANNER FOR WASHINGTON, D.C., HAD THE FIRST ENGINEER FOR THE SUM AND WAS SUCCEEDED IN 1793 BY PETER COLT. RODWELL COLT CONSULTED TO PETER, PURCHASED MOST OF THE SUM STOCK AFTER 1800 AND SERVED AS GOVERNOR OF THE SOCIETY DURING PATERSON'S GROWTH TO PROMINENCE AS ONE OF AMERICA'S FOREMOST INDUSTRIAL CITIES.

AMONG THE SUM'S MOST NOTABLE ACHIEVEMENTS WAS THE DEVELOPMENT AND CONSTRUCTION OF AN ELABORATE CANAL SYSTEM WHICH TURNED THE WATERS OF THE PASSAIC INTO A SOURCE OF POWER FOR THE MACHINERY IN THE MILLS. INITIALLY INVOLVED IN THE MANUFACTURING OF TEXTILE PRODUCTS, THE SUM SOON DIVERSIFIED AND DRAWING UPON ITS CONSIDERABLE EXPERIENCE WITH THE TEXTILE INDUSTRY, IT EXPANDED INTO THE AREA OF MACHINE MANUFACTURE. BY MID-CENTURY PATERSON WAS KNOWN THROUGHOUT THE COUNTRY AS A CENTER OF RAILROAD LOCOMOTIVE AS WELL AS TEXTILE MANUFACTURE. BY THE THIRD QUARTER OF THE 19TH CENTURY, IT WAS THE SILK CAPITAL OF THE WORLD.

DURING THE SUMMERS OF 1975 AND 1976 A SURVEY DESIGNED TO DOCUMENT AND RECORD THE INDUSTRIAL AND ENGINEERING WORKS AT PATERSON WAS CONDUCTED BY THE HISTORIC AMERICAN ENGINEERING RECORD, A PROGRAM OF THE NATIONAL PARK SERVICE IN COOPERATION WITH THE GREAT FALLS DEVELOPMENT CORPORATION OF PATERSON, NEW JERSEY. Ongoing AT THE SAME TIME WAS A SALVAGE ARCHEOLOGY PROJECT, SPONSORED BY THE NEW JERSEY DEPARTMENT OF TRANSPORTATION AND THE GREAT FALLS DEVELOPMENT CORPORATION TO INTERPRET THE BELOW-GROUND REMAINS OF THE RECENTLY DESTROYED WORKS OF THE ROGERS, GRANT AND COOK, LOCOMOTIVE COMPANIES, AND TO RETRIEVE SIGNIFICANT ARTIFACTS. THE CONTINUED EFFORTS OF THE TWO TEAMS MUTUALLY SUPPORTED ONE ANOTHER'S INVESTIGATIONS. TOGETHER THEY HELPED SOLVE PROBLEMS OF HISTORICAL INTERPRETATION CAUSED BY CONSTANT REBUILDING OVER MORE THAN A CENTURY OF INDUSTRIAL USE AND HELPED TO PERFECT FIELD TECHNIQUES FOR THE EMERGING DISCIPLINE OF INDUSTRIAL ARCHEOLOGY.

THE FIELD WORK, MEASURED DRAWINGS, HISTORIC DOCUMENTATION, AND PHOTOGRAPHS WERE PREPARED UNDER THE GENERAL SUPERVISION OF DOUGLAS L. GRIFFIN, CHIEF, HISTORIC AMERICAN ENGINEERING RECORD. THE PROJECT DIRECTOR WAS ERIC DELONY, PRINCIPAL ARCHITECTURALIST. THE SURVEY TEAM FOR 1975 CONSISTED OF T. A. GORDON, PROJECT SUPERVISOR (WASHINGTON STATE UNIVERSITY), RUSSELL L. FRIES, PROJECT HISTORIAN (UNIVERSITY OF MARYLAND), TONI RISTAL, ASSISTANT SUPERVISOR, WILLIAM D. GAVZY, ARCHITECT (PETERSEN LEAK POND, TECHNICAL INSTITUTE), THOMAS P. HARTUNG, ARCHITECT (PENNSYLVANIA STATE UNIVERSITY), BRUCE T. CAVIN, STUDENT ARCHITECT (UNIVERSITY OF NEBRASKA), AND JOSEPH FORBES, JR., STUDENT ASSISTANT (DON BOSCO TECHNICAL HIGH SCHOOL). THE TEAM FOR 1976 CONSISTED OF VETERAN RUSSELL FRIES, PROJECT SUPERVISOR AND HISTORIAN, TONI RISTAL, ASSISTANT SUPERVISOR AND BRUCE CAVIN, ARCHITECT. NEW MEMBERS WERE JOHN M. KAPLAN, PROJECT SUPERVISOR (CANE WESTERN RESERVE UNIVERSITY), JOHN SANGUILLANO, ARCHITECT (COLUMBIA UNIVERSITY), AND GEORGE COLE, ASSISTANT HISTORIAN (WESLEYAN UNIVERSITY). THE PHOTOGRAPHIC RECORDS WERE MADE BY JACK E. DOUGHERT, HISTORIC AMERICAN ENGINEERING RECORD. EDWARD S. RUTSCH DIRECTED THE SEPARATELY SPONSORED ARCHEOLOGY SALVAGE PROJECT.

Figure 8-11

for about 30 years of operation, perfectly adequate given the desire for low expenditures and quick returns on the part of American capitalists and engineers. L'Enfant's plan, if adopted at the outset, would have led to the lowest total capital cost, since the system had to be rebuilt again between 1838 and 1846 with a new dam and inlet from the river (Fig. 8-9). However, the S.U.M. and its Board of Directors were clearly less concerned about the total capital outlay than they were about the necessity to balance capital outlay against funds available. Peter Colt was better adapted to strike this balance, since he had the same American background himself, than was the foreigner L'Enfant, who was never quite able to understand the American attempts to economize on first cost at the expense of greater ultimate cost. The Paterson hydraulic system represented one of the first conflicts between European engineering experience and American conditions. The conflict was not successfully resolved until the Paterson venture, the Middlesex Canal, and the Erie Canal created a school of native engineers that could better appreciate the realities of the American position, and, in effect, create a new engineering.

NOTES

1. *Minute Book of the Society for Establishing Useful Manufactures*, pp. 59-65. The original is in the Paterson Public Library. (Hereafter the *S.U.M. Minutes*.) 2. Draft letter from the Directors of the S.U.M. to Pierre C. L'Enfant, June 8, 1793, Paterson Board of Finance. Joseph S. Davis, *Essays in the Earlier History of American Corporations*, Vol. 1, Harvard University Press, Cambridge, Mass., 1917, pp. 468-69. (Hereafter Davis, *S.U.M.*) 3. Levi R. Trumbull, *A History of Industrial Paterson*, Carleton M. Herrick, Paterson, 1882, p. 34. 4. Davis, *S.U.M.*, pp. 374-78, 403. 5. Harold Syrette, ed., *The Alexander Hamilton Papers*, Columbia University Press, New York, 1961-, Vol. IX, p. 171. (Hereafter *Hamilton Papers*.) 6. Thomas Marshall to Alexander Hamilton, July 24-31, 1791, *Hamilton Papers*, XVIII, pp. 571-73. 7. Davis, *S.U.M.*, p. 403. 8. Thomas Marshall to Alexander Hamilton, Oct. 2, 1791, *Hamilton Papers*, IX, pp. 267-69. 9. Hamilton's letter to Nicholas Low, John Bayard, and Elisha Boudinot, Esqrs., Counsellors of the Directors for Establishing Useful Manufactories, New Ark, New Jersey, n.d. (June 1792) says, "... And I now entertain no doubt doubt [*sic*] that the most advisable course is to abandon for the present the idea of a Canal [i.e., a transportation canal]," *Hamilton Papers*, XI, pp. 611-12. 10. Davis, *S.U.M.*, pp. 402-404 gives the advertisement

as published in the *Brunswick Gazette*, Dec. 20-Jan. 3, and other papers of the same period. 11. Undated letter, postmarked New York, Dec. 12 (1791), in *Duer Papers*, ii, 262, as cited in Davis, *S.U.M.*, pp. 404-405. 12. *S.U.M. Minutes*, pp. 15-17. 13. *S.U.M. Minutes*, pp. 42-43. 14. *S.U.M. Minutes*, pp. 34-35. 15. *S.U.M. Minutes*, p. 34. 16. Davis, *S.U.M.*, pp. 278-338, 410-26. 17. Davis, *S.U.M.*, p. 415. 18. *S.U.M. Minutes*, p. 37. 19. *Ibid.* 20. *S.U.M. Minutes*, pp. 42-43. 21. Davis, *S.U.M.*, p. 421; Carroll W. Pursell, Jr., *Early Stationary Steam Engines in America*, Smithsonian Institution Press, Washington, D.C., 1969, pp. 5-7; Ronald E. Shaw, *Erie Water West: A History of the Erie Canal, 1792-1854*, University of Kentucky Press, Lexington, Ky., 1966, pp. 12-16. 22. Alexander Hamilton's letter to Nicholas Low, John Bayard, and Elisha Boudinot, Esqrs., Counsellors of the Directors for Establishing Useful Manufactories, New Ark, New Jersey, n.d. (June 1792), *Hamilton Papers*, XI, pp. 611-12, which undoubtedly only repeated the conclusions that Schuyler had already expressed to the committee. 23. *S.U.M. Minutes*, p. 43. 24. *S.U.M. Minutes*, pp. 45-46. 25. *S.U.M. Minutes*, pp. 42-43. 26. Dumas Malone, ed., *Dictionary of American Biography*, Vol. 2, Charles Scribner's Sons, New York, 1963-, pp. 301-302. (Hereafter *Dictionary*.) 27. Shaw, *Erie Water West*, pp. 12-21. Colles was recommended, along with John Hills of Philadelphia, as one to perform a survey of sites (*S.U.M. Minutes*, pp. 15-16). 28. Of June 1792 (see note 22). 29. *S.U.M. Minutes*, pp. 42-43. 30. Draft of a Resolution for the Society for Establishing Useful Manufactures (July 5, 1792), *Hamilton Papers*, XII, p. 10; original in the Passaic County Historical Society. 31. *S.U.M. Minutes*, p. 44. 32. *National Gazette and N.Y. Journal*, July 1792, quoted in *Hamilton Papers*, XII, pp. 23-26; original draft in Passaic County Historical Society. 33. *Ibid.* 34. *S.U.M. Minutes*, pp. 56-57. 35. Davis, *S.U.M.*, pp. 458-63. 36. *S.U.M. Minutes*, pp. 56-57. 37. *Dictionary*, XI, pp. 165-69. 38. *S.U.M. Minutes*, pp. 56-58, meeting of Aug. 20, 1792. 39. *Hamilton Papers*, XII, p. 217. 40. See the letter from Peter Colt to Nicholas Low, Paterson, July 28, 1793, in Peter Colt MSS, Rutgers University Library, in which Colt mentions an unsuccessful attempt to get L'Enfant to relinquish the plan. A second attempt was made by the S.U.M. Directors in Jan. 1794 by writing to L'Enfant (*S.U.M. Minutes*). Earl Horte, in *Historic New Jersey* (copy in Passaic County Historical Society S.U.M. File), said that the maps had been "destroyed by fire." 41. *S.U.M. Minutes*, pp. 59-65. 42. *Ibid.* 43. *Ibid.* 44. *Ibid.* 45. *Ibid.* 46. Davis, *S.U.M.*, pp. 276, 466-69, is perhaps the most judicious, although he does not deal directly with the practicality of L'Enfant's plans. 47. Trumbull, *Industrial Paterson*, p. 34. 48. *S.U.M. Minutes*, pp. 155-61, 165-66, 200. 49. See William Hall's letter to Elisha Boudinot, Esq., Paterson, Aug. 4, 1792, Alexander Hamilton Papers, MSS, Library of Congress, 1791-92, pp. 15-16. 50. *Ibid.* There is also an undated letter in the Passaic County Historical Society's S.U.M. File labeled "William Hall Letters," which coincides fairly closely with this proposal. That specified a cut through the rock

to let the river into the gully, and then a stone dam across the gully for "2000. currency" (Passaic County Historical Society, n.d.). Yet another proposal, this one unidentified, specified £1200 for a permanent dam across the river and letting water into the gully, £1900 for a dam across the gully, and £1300 for bringing the water to the mill (Passaic County Historical Society, S.U.M. MSS, "Unidentified," n.d., n.a.). 51. Bracketed words were inserted in Draft Minutes of Aug. 1, 1792 in Hamilton's writing; *Hamilton Papers*, XII, pp. 140-42. 52. *Ibid.* 53. *S.U.M. Minutes*, pp. 56-59; Davis, *S.U.M.*, p. 425. 54. Pierre L'Enfant to Alexander Hamilton, Aug. 21, 1792, *Hamilton Papers*, XII, pp. 262-63. 55. Pierre L'Enfant to Hamilton, Paterson, Sept. 17, 1792, *Hamilton Papers*, XII, pp. 388-90. 56. *Ibid.* 57. Peter Colt commented that "An English Manufacturer cannot bring himself to believe that a French Gentleman can possibly know anything respecting manufactures. From this quarter I believe has arisen much of the uneasiness amongst the head workmen, ..." (Peter Colt to Alexander Hamilton, Hartford, May 7, 1793, *Hamilton Papers*, XIV, pp. 419-22). 58. Hamilton's letter to Nehemiah Hubbard, May 3, 1792, in *Hamilton Papers*, IX, p. 355. 59. Hamilton's letter to James Watson, Esqr., Philadelphia, Oct. 9, 1792, in *Hamilton Papers*, XII, pp. 538-40. 60. *Hamilton Papers*, XII, pp. 549-51. 61. *S.U.M. Minutes*, pp. 73-80; Davis, *S.U.M.*, pp. 459-60. 62. Tench Coxe to Peter Colt, Oct. 19, 1791, Tench Coxe MSS, Historical Society of Pennsylvania. 63. *Hamilton Papers*, XIV, pp. 171-72. 64. See, e.g., Peter Colt's letters to Nicholas Low, dated Paterson, Apr. 10, 1793, and June 7, 1794, in Peter Colt MSS. 65. Peter Colt to Nicholas Low, Paterson, Jan. 27, 1794, in Peter Colt MSS. 66. Undated proposal, ca. Aug. 2, 1792, accompanying Elisha Boudinot's letter to Hamilton of Aug. 4, 1792, Alexander Hamilton Papers, MSS, pp. 15-16. 67. Davis, *S.U.M.*, pp. 276, 459. 68. See L.T.C. Rolt's *Isambard Kingdom Brunel*, Longman's, Green & Company, Ltd., New York and London, 1957, for a history of Brunel's exploits showing that he was very seldom present beyond the initial planning phases, leaving execution to others. 69. Pierre L'Enfant to Alexander Hamilton, Paterson, Sept. 17, 1792, in *Hamilton Papers*, XII, pp. 388-90. 70. Peter Colt to Alexander Hamilton, Paterson, Feb. 28, 1793, in *Hamilton Papers*, XIV, pp. 170-72. 71. Extract of letter from Peter Colt to Nicholas Low, Alexander Hamilton Papers, MSS, cited in *Hamilton Papers*, XIV, p. 189. 72. Nicholas Low to Hamilton, New York, Mar. 4, 1793, *Hamilton Papers*, XIV, p. 189. 73. L'Enfant to Hamilton, Paterson, Mar. 26, 1793, *Hamilton Papers*, XIV, pp. 248-50. 74. L'Enfant to Hamilton, Paterson, Mar. 26, 1793, *Hamilton Papers*, XIV, pp. 248-49. 75. Elisha Boudinot to Hamilton, Newark, Mar. 26, 1793, *Hamilton Papers*, XIV, pp. 245-47. 76. *Ibid.* Also L'Enfant to Hamilton, Mar. 26, 1793, *Hamilton Papers*, XIV, pp. 248-49. 77. Peter Colt to Nicholas Low, Paterson, Apr. 10, 1793, Peter Colt MSS. 78. Hamilton to James Watson, Philadelphia, Oct. 9, 1792, *Hamilton Papers*, XII, pp. 538-40. 79. Hamilton to L'Enfant (Philadelphia), Mar. 29, 1793, *Hamilton Papers*, XIV, p. 258. 80. *S.U.M. Minutes*, p. 86.

81. *S.U.M. Minutes*, p. 83. 82. Peter Colt to Hamilton, Hartford, May 7, 1793, *Hamilton Papers*, XIV, pp. 419-22. 83. *Ibid.* 84. Draft of letter from the S.U.M. Directors to L'Enfant, June 8, 1793, signed by Nicholas Low, Abijah Hammond, Cornelius Ray, James Watson, James Ricketts, and Elisha Boudinot, in the Paterson Board of Finance records. 85. Davis, *S.U.M.*, pp. 467-68. The letter referred to is dated Aug. 21, 1792, in *Hamilton Papers*, pp. 262-63. 86. Peter Colt tried to get L'Enfant to turn these plans over to the Society at first by persuasion, and then by holding up payment of L'Enfant's bills (Peter Colt to Nicholas Low, July 28, 1793, Peter Colt MSS). Earl Horter, in *Historic New Jersey*, reported that the plans were destroyed in a fire (L'Enfant to Hamilton, New York, Oct. 16, 1793, *Hamilton Papers*, XV, pp. 363-65). 87. Nicholas Low to Hamilton, New York, June 27, 1793, *Hamilton Papers*, XV, p. 30. 88. William Nelson, *Conversation with John Colt*, typescript in the New Jersey Historical Society, pp. 3-4. Transcription of shorthand notes taken by Nelson on the occasion of a visit to John Colt at Seabright, New Jersey, Aug. 8 and 18, 1875. Ph[ilemon] Dickerson, *A Lecture on the City of Paterson: Its Past, Present and Future*, Paterson Educational Association, Paterson, 1856, p. 8. 89. Nelson, *Conversation with John Colt*, p. 7. 90. Colt to Low, Paterson, July 28, 1793, Peter Colt MSS. 91. Colt to Low, Paterson, Mar. 17, Mar. 31, 1794, Peter Colt MSS. 92. Colt to Low, Paterson, May 31, 1794, Peter Colt MSS. 93. Colt to Low, Paterson, June 7 and 9, 1794, and Mar. 5, 1794. Usher reportedly went north to work for General Philip Schuyler on the Western Inland Lock Navigation Company. 94. The composition of this bank was verified in the summer of 1973 when the G.F.D. Salvage Archeology Project and the N.J. D.O.T. found sand during a test through the raceway about 400 ft. west of the described location. 95. Colt to Low, Paterson, June 24 and July 15, 1794, Peter Colt MSS. 96. *S.U.M. Minutes*, p. 119. 97. Colt to Low, Paterson, July 3 and 13, 1794, Peter Colt MSS. 98. Colt to Low, July 13, 1794, Peter Colt MSS. 99. *Ibid.* There is presently a large brick drain in the basement of the old Industry Mill, discovered during the H.A.E.R. survey, which may possibly be a later replacement and modification of the drain referred to by Colt. Although large in diameter, it was not traced further than about 100 ft. from its entrance owing to safety considerations. 100. *S.U.M. Minutes*, pp. 120-25. Resolution of Western Inland Lock Navigation Company, June 8, 1796, Philip Schuyler Papers, Box 7, New York Public Library, New York. 101. Nelson, *Conversation with John Colt*, p. 18.

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