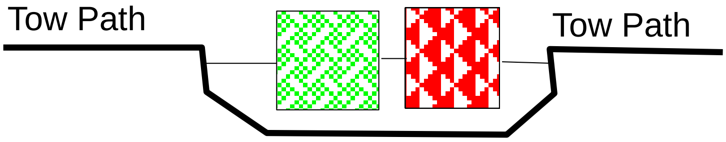
Case Study
Canal Projects in the Early 19th Century

Before the invention of railroads, canals offered the most cost-effective alternative to shipping freight by horse-drawn carts along poorly maintained gravel roads. This case develops engineering-based cost and service functions for both modes of transportation in order to examine whether or not an investment in canals was likely to be attractive to potential users and therefore profitable for potential investors.

Introduction

Canals were among the first major civil engineering projects in the United States, as in many other countries. Until railroads were invented, land transportation was cumbersome, slow, and expensive. Water transportation – when available - was much cheaper, more reliable, and provided the only means of handling large volumes of freight, which of course was why cities grew up at the best harbors and along the major navigable rivers. The first canals simply bypassed rapids so as to avoid costly transshipment of goods. Later canals linked major cities to their hinterlands. The early canals were designed with a tow path on either side so that a horse or a team of horses could pull the canal boats along the canal (Figure 1). The average speed would be only 2-3 miles per hour, and the distance traveled per day would only be 20-30 miles. More ambitious projects, such as the Erie Canal, sought to open up western regions and thereby promote development (not to mention the importance of the port city whose citizens promoted the project).

Figure 1 Cross-section of a typical 19th century canal.
The canal would be barely wide and deep enough to allow two small boats to pass. The boats would be towed by a horse that walked along the tow path next to the canal.

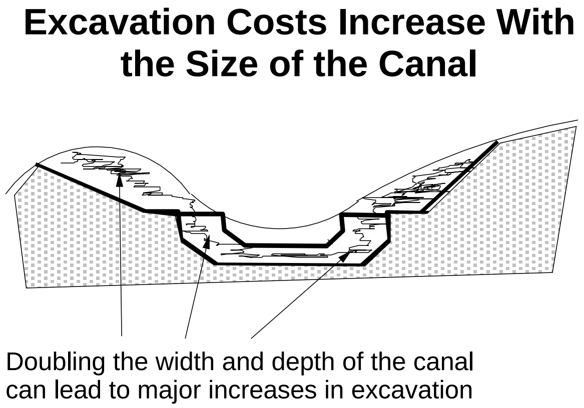


Canals must be close to level to allow safe, easy movement in both directions. To create a level route in uneven topography, it is necessary to construct locks. A lock is a chamber with two sets of gates. The water level is higher on one side of the lock than it is on the other side. By opening one gate at a time, it is possible to adjust the water level within the chamber to match either the high side or the low side. The depth of the lock must be sufficient to accommodate canal boats when the water is low; the height of the gates above the low water level limits the extent of the lift that can be achieved by one lock. Several locks can be operated next to each other or in close proximity to each other if the terrain requires more lift than can be achieved with a single lock. The time required for a move through a lock includes the time to position the canal boat (or boats) in the lock, the time required to raise or lower the water, and the time required for the boat(s) to move out of the lock.

Figure 2 Remnants of the C&O Canal can still be seen in Georgetown in the District of Colombia. Note the long narrow shape of the boat, which is sized to squeeze into the locks, such as the one at the back of this picture.

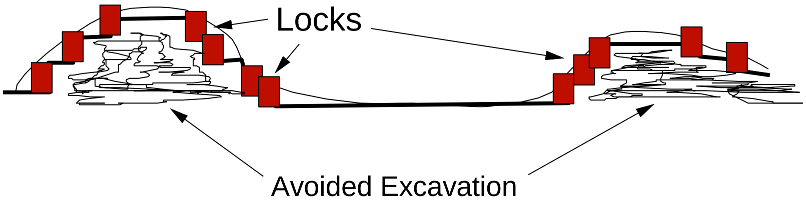
The width and depth of a canal and the size of the locks determine the size of the boats that can use the canal. Figure 2 shows a lock on the Chesapeake and Ohio Canal in the Georgetown neighborhood of Washington D.C. Note that the lock is much narrower than the canal, and it has a lift of less than 10 feet. There is only one channel in this location, but if more capacity were required a second lock could have been built right next to this one.

The deeper and wider the canal, the more material that must be excavated and the more expensive the project (Figure 3). The larger the locks, the more expensive they become and the more water that is required to operate the system. Hence, there are fundamental design issues concerning the size of the canal and the type of boats that will be accommodated. The canal must either be wide enough for two boats or provide periodic basins where opposing boats can pass. It must also be deep enough to provide the required draft for the largest boats that are allowed to use the canal. Some of the early canals could only handle small boats with a capacity on the order of 15 tons; these boats required a draft of only twelve inches when loaded. Larger canals could handle larger boats, e.g. boats that could carry 75 tons along canals providing more than four feet of draft. As suggested by Figure 3, increasing the width and depth of a canal can requ

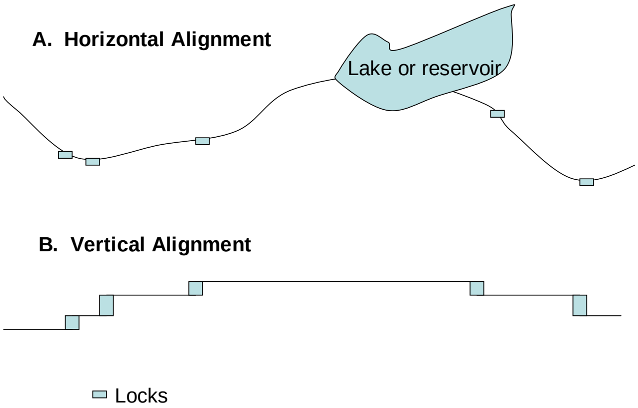


The number of locks required is a function of the route and the size of the locks. The topography of the route
determines th nning and end
of the canal. ut through the
intervening h g a level route
reduces the n ong the canal.
However, it r

Locks Reduce Excavation, But Reduce Speed & Capacity



Each time a boat moves up stream through a lock, the lock fills with water; when a boat moves downstream, the lock is emptied. If a canal is to move from one watershed to another, there must be a reliable water supply in order to support the functioning of the locks (Figure 5).



Service and Capacity of a Canal

Customers who might use the canal to move freight would be concerned with two aspects of service: the time that it would take to move along the canal and the maximum size for a canal boat. First let's consider the time that it would take to complete a 120-mile trip along a nineteenth century canal. We can assume that boats could tie up for the night at either end of the canal or at frequent locations along the length of the canal (as shown in the photo of Regent's Canal in Figure 6). At two miles per hour, a 120-mile trip would require 60 hours of travel time, which would be six ten-hour days; at three miles per hour, the same trip would require only 40 hours of travel, or four ten-hour days. Thus a reasonable estimate of the travel time could be stated as "five days plus or minus a day" or "less than a week". This may strike you as a fairly imprecise estimate, but before worrying too much about how to refine it, think about what else goes into the travel time. First of all, there are likely to be locks located every few miles along the canal, and it will take an hour or two to get through each lock, perhaps much longer if the canal is very busy and there are queues of boats waiting to get through the busiest locks. If the 120-mile trip has 40 locks, then the time spent in the locks could well be 40-80 hours, which is as long as and more variable than the travel time along the canal. There is also the possibility that bad weather, high or low water, lock maintenance, or other problems will limit or prohibit travel along the canal. Thus, the estimate that it will take about 50 hours to travel along the canal between locks is probably the most reliable portion of the overall estimate of travel time. Adding in locks and considering the possibility of major weather-related delays, the trip would likely be estimated as a journey of "two to three weeks".

Figure 6 Regent's Canal, London
England's canals remain busy, but the old canal boats have been converted to house boats suitable form mobile homes or for weekend get-aways. Dozens of boats may tie up for the night at a convenient and picturesque spot such as this.

The capacity of a canal (maximum throughput measured in tons of cargo) can be estimated for various time periods and conditions:

- A peak day with twelve hours of operation
- A peak summer month with twelve hours operation, seven days/week
- A year, with operations ceasing during the winter and during major storms.

The canal's capacity will be a function of the characteristics of the canal, the boats, and the operating characteristics. The maximum capacity of the lock is the inverse of the function of the cycle time for the lock. If the cycle time is a half hour per boat, then the maximum capacity is two boats per hour. The operating capacity, expressed in boats per day, will be limited by the hours of operation. If the lock operates twelve hours per day, then the operating capacity would be 24 boats per day. The sustainable monthly capacity would be further reduced to allow time for maintenance, to allow for periods of slower or interrupted operations during bad weather, and to allow for smooth functioning of the canal despite the normal variations in traffic and the routine delays that might occur. For example, the lock might be closed for one day per month for routine maintenance, heavy rains or winds might reduce capacity by 50% for several days per month, and miscellaneous delays might amount to an hour or so each day. This would reduce sustainable monthly capacity as follows:

- Days per month: 30
- Days required for maintenance: 1
- Expected days of operating at 50% capacity: 3-4 days, which is equivalent to 1-2 days of lost operation
- Miscellaneous delays: about 1 hour per day or 30 hours per month, which is equivalent to about 4 days per month

- Net days available for normal operation per month: 30 – 1 – 2 – 4 = 23 days

Thus the sustainable capacity would be no more than 75% of the operating capacity. A further reduction in sustainable capacity might be necessary based upon traffic patterns and service requirements. For example, traffic volumes might be much higher during the middle of the day and much lower on weekends, and users of the canal might expect at most modest delays during normal operations (i.e. delays related to maintenance or bad weather may be acceptable, but extensive delays related to congestion may be viewed as unacceptable). These considerations would reduce sustainable monthly capacity to less than 70% of operating capacity:

- Weekend days per month: 8-10 days, with perhaps traffic at 50% of normal volume, which is equivalent to 4-5 days of normal operation or about 15% of monthly capacity.
- Peak patterns of traffic: the lock must be functioning reasonably well during these peak periods, so there will be unused capacity the rest of the day. If peak period totals only 6 hours per day, then there will be idle capacity the rest of the day. If the off-peak volume is 50% of the peak volume, then the maximum daily capacity under normal operations and normal service levels will be only 75% of the operating capacity (100% for 6 hours and 50% for 6 hours produces an average utilization of 75% for the entire 12 hours).

If you consider these two factors along together, there will be a further reduction in capacity:

- Operating Capacity: 24 boats per day through the lock
- Sustainable capacity, without considering traffic patterns: 70% of operating capacity
- Adjustment for traffic patterns:
  - Weekends: 15% reduction
  - Weekday peaks: 25% reduction
- Sustainable capacity, taking into account traffic patterns: if these factors are considered to be independent, the sustainable capacity will drop to less than half of the operating capacity: (0.70)(0.85)(0.75) = 45% of operating capacity, or 11 boats per day.

However, there is certainly some overlap among these various factors. Storms may occur on weekends, and if they do, then they will not disrupt operations as much as if they occur on weekdays. Providing capacity for acceptable service during peak periods may also make it easier to schedule routine maintenance during slow periods of the day or the weekends. Miscellaneous delays that occur during off-peak times will not seriously affect capacity. The estimate of sustainable capacity is therefore perhaps 50-60% of the operating capacity or 12-15 boats per day or 360 to 450 boats per month.

Is this an acceptable estimate? Do we really believe all of these assumptions? Wasn't that just hand waving and magical thinking when the sustainable capacity was increased from the calculated 45% to a rather broad range of 50-60% of the operating capacity? The answer to all of these questions may be "maybe"! We could study canals in much greater detail in order to refine the assumptions, and we could develop simulation models to look much more closely at the effects of traffic patterns on service levels. However, rather than spending a lot of effort trying to answer these questions about methodology, let's look at several more aspects of capacity, namely the loads carried on each canal boat, the ability to operate throughout the year and the ability to adjust operations as needed to keep up with demand. Perhaps the estimate of sustainable capacity is acceptable as it is.

First of all, the size of the average load is very important. The maximum capacity measured in tons/day could be based upon the size of the largest boat that could use the canal. So, if the canal could be used by boats that carry 15 tons, then the maximum capacity would be 24 boats/day x 15 tons/boat = 360 tons/day. If the largest boat could carry 50 tons/day, then the maximum capacity would be 1200 tons/day. In either case, the average load – and therefore the operational capacity - would be considerably less than the maximum load, especially if some of the boats only carry loads in one direction. If the average load were estimated to be 11-12 tons/boat, that would be a reduction of 20-25% in capacity measured in terms of tons/day – and another reason for being somewhat imprecise in our measure of capacity.

Weather is an even larger factor. Canals are unusable when the water levels are too high or too low or when they are frozen over. Depending upon the climate, periods of inoperability could last for months or half the year, and these periods could vary greatly from one year to the next. If weather shuts down the canal for three months, then annual capacity would be reduced by 25%; if weather shuts down the canal for four months, then annual capacity would be reduced by 33%. There could easily be a 5-10% variation in annual capacity depending upon the weather.

Finally, the users and operator perhaps have considerable options regarding operating and pricing policies. All of the above estimates assumed operations of twelve hours per day. Is this a credible constraint? Would it not be possible to add some extra hours of operation during the peak season? And couldn't some of the off-peak capacity be utilized by reducing lock fees for these periods in order to promote somewhat different usage patterns?

Hold on! These are too many questions for this stage of the analysis! What can we conclude with some certainty? We think that the locks on the canal can probably handle close to 24 boats/day when things are going well, but that they may not be able to handle even half that much on a sustainable basis because of a variety of potential problems. We also think that the canal will be able to operate for about eight months of the year. If we take ten boats per day as the sustainable capacity, that would be 150 tons/day and 36,000 tons in eight months. We know this is a rather fuzzy number, but perhaps it will be sufficient. Now let's turn to costs and competition. Will there be a market for the canal?

Canal Competitiveness

When canals competed with horse-drawn wagons, they had a marked advantage in cost, as illustrated by the immediate success of the Middlesex Canal when it opened for operations between New Hampshire and Boston in 1803:

> *"The advantages of canal travel over wagon transport were obvious at once. One horse, for example, could easily draw 25 tons of coal on the canal. On land the same horse could pull only 1 ton. One team of oxen could pull 100 tons, an amount that would take eighty teams on land. In the first eight months of the canal's operation, 9,405 tons were carried at a cost of $13,371. The cost for such a shipment by land would have been $53,484."*
>
> Daniel L. Schodek, "Landmarks in American Civil Engineering",
> MIT Press, p. 12

These estimates of operating cost for this 27-mile canal can easily be converted to the cost/ton-mile of transporting freight by canal boat or by wagon. Expressing cost as the cost per ton-mile is useful because that allows a normalized comparison among different modes of transportation, different lengths of haul, and different time periods. Assuming that all of the 9,405 tons were transported the entire length of the canal, the cost per ton-mile of using the canal was $13,371/(27 miles x 9,405 tons) = $0.056 per ton-mile. If the distance by road was also 27 miles, then the cost of using a wagon was four time as large: $53,484/(27 miles x 9,405 tons) = $0.21 per ton-mile. These numbers are very interesting because they are considerably larger than the costs of transporting freight along the inland waterways and highways in the 21st century! Transporting coal on the inland waterways or on railroads now costs less than $0.02 per ton-mile, while the cost of truck transportation is well under $0.10 per ton-mile (and a penny in 1803 was worth a whole lot more than a penny is now worth 200 years later!)

Engineering-Based Cost Model for a Canal

Knowing the cost/ton-mile is interesting historically, and it is a useful indicator that customers or managers might use. Being able to estimate the cost/ton-mile as a function of design factors and operating conditions is essential to planning and evaluating a transportation project. It is mildly interesting to know that the Middlesex Canal cut costs by 75% relative to horse-drawn wagons, but a canal designer and his financial supporters will want to understand the potential costs and benefits related to constructing a specific canal that would attract traffic from wagons. Given assumptions about unit costs and productivity, it is possible to create an engineering-based cost model for a canal. Let's assume that the operating costs and productivity parameters for a canal are based upon typical values for the early 19th century:

- Cost for the two-person boat crew ($1/day each, for ten working hours)
- Cost for the teamster and the horse ($1/day each or $2/day total)
- Cost for the boat ($2/day for a boat with a capacity of 15-tons)
- Cost for lock operations ($2/day for an operator and routine maintenance)
- Cost for canal and embankment maintenance ($40/year per mile)
- Average speed (three miles per hour along the tow path)
- Average time per lock (12 minutes for a 15-ton boat)
- Annual operations: 225 days per year
- Annual tonnage along the canal: 10,000 tons

Using these assumptions, we can estimate the variable costs of operation for a canal of any length and with any number of locks. For example, let's calculate the variable cost/ton-mile for a trip by a 15-ton canal boat along a 30-mile canal that has 10 locks. First we need to know how long the trip will take:

- Travel time along the canal: 30 miles/3 mph = 10 hours
- Time in the locks: 10 locks x 0.2 hours per lock = 12 hours

The boat operates 10 hours per day, so the trip will take 1.2 days. Perhaps the crew finishes unloading in morning at one end of the canal and hopes to reach the other end in time to start unloading the following afternoon. We will assume that the cost of the trip will include 1.2 days for the crew, the boat, the teamster and the horse:

- Boat Crew: 2 people x $1/day x 1.2 days = $2.40
- Teamster and horse: one team x $2/day x 1.2 days = $2.40
- Boat cost: $2 per day x 1.2 days = $2.40
- Total variable cost = $7.20
- Total ton-miles = 15 tons x 30 miles = 450 ton-miles
- Variable cost per ton-mile = $7.20/450 = $0.016/ton-mile
- Variable cost per ton = $7.20/15 = $0.48/ton

The fixed costs include the cost for the lock operators (who are assumed to be available whether or not there is any traffic) and the cost for canal maintenance.

- Lock operations: ($2/lock per day) x (10 locks) x (225 days per year) = $4,500 per year
- Maintenance: $40/mile/year x 30 miles = $1,200 per year
- Total fixed cost: $5,700 per year
- Total fixed cost per ton: ($5,700/year)/(10,000 tons/year) = $0.57/ton
- Total fixed cost per 15-ton load: $8.55

The total, fully allocated cost for the trip will be the sum of the variable cost and the allocated portion of the fixed cost: $7.20 + $8.55 = $15.75. The total, fully allocated cost per ton-mile will be $15.75 per trip/450 ton-miles/trip = $0.035. This cost is well below the estimated cost of $0.21 per ton-mile of using a horse and wagon, so it is likely that the canal could attract traffic and earn profits for the investors.

If these cost and capacity calculations used in this example were incorporated within a spreadsheet, it would be possible to explore how costs and capacity would vary with differing assumptions concerning the structure of the canal, the size of the canal boats, the operating parameters, and the unit costs. Such a model could also be used to see how costs/ton-mile would vary with the annual tonnage on the canal and the size of the boats.

Evaluating the Canal Project

From the designer's perspective, critical questions would concern the size of the canal: should they build it only to accommodate 15-ton boats, or should they build it to handle larger boats? To handle larger boats, the canal would have to be a little wider and deeper, and the locks would have to be larger, so the costs of construction would rise. On the other hand, with larger boats, the variable costs/ton-mile would be expected to decline, since the same crew could handle a larger boat.

From the owner's perspective (or the perspective of the banks and investors who were providing the funds for the project), the key question would be whether or not they could charge tolls sufficiently large to cover their fixed costs of $5,700 per year plus sufficient profit to justify their investment. To figure out how much they would need to charge for a toll, we need an estimate of what it would cost to build the canal. Canal costs were on the order of $20,000 per mile in the early 19th century, so that a 30-mile canal would have cost about $600,000 to construct. This money would have to be raised from investors who would expect (or at least hope) to receive a substantial annual dividend. A 10% dividend would amount to $60,000 per year, so the total amount of money raised by the toll would have to be $65,700 per year. If this were to be raised by a toll based upon tonnage, the average toll would have to be $6.57 for the expected 10,000 tons/year.

Is this a realistic toll? To answer this, we need to consider the perspective of the user. By using the canal rather than a horse and wagon, the user transports freight at a variable cost of $0.48 per ton. The toll would raise this cost to more than $7/ton or $0.25/ton-mile for the 28-mile canal– which is more than the cost of using a horse and wagon, which was estimated above to be $0.21/ton-mile! With such a large toll, the canal would have difficulty attracting any traffic at all.

Upon hearing this sad news, the investors would have several options. They could cancel the project as unprofitable. They could settle for a smaller return on their investment; cutting the toll to $3.57 per ton would provide a 5% return, and it would keep the cost per ton-mile well below the cost of the competition. They might also conduct a more careful study of demand, including an assessment regarding the potential for growth in canal traffic over a 10- to 20-year horizon. They could also consider building the canal for larger boats, a strategy that would further reduce operating costs for users, possibly for a fairly modest increase in construction costs.

Notice how the degree of precision has softened as we have progressed through this example. We started with some concern over the many assumptions that we were making concerning capacity and operating costs. By the time we got to the end, however, we discovered that the largest cost by far would be the return on investment that would be required to attract investors. Given the cost of the canal, the required toll would be an order of magnitude larger than the users' operating costs, and the major problem with the project appears to be that there is not enough traffic to justify the investment.

To reach this conclusion, it doesn't matter much if at all whether the canal boats move along at 2 or at 3 mph, and it doesn't matter whether the locks take 12 minutes or 15 minutes. It also doesn't matter whether the capacity of the canal if 50% more or less than our preliminary estimate of 36,000 tons per year. Why? Because our projected demand is barely 25% of that amount; adequate capacity seems to be assured. The lack of precise estimates of operating costs and capacity doesn't matter nearly as much as what we have discovered to be much more important considerations:

- How much traffic will use the canal – when it first opens and over the next ten to twenty years? Perhaps the investors can defer dividends for a few years in order to secure very attractive profits in the future.
- What will it really cost to build the canal and how great a return on their investment will investors require?
- Should the canal be redesigned to handle larger boats that might attract more traffic?

Examples of Canals

China constructed its Grand Canal more than 1300 years ago[1]. Linking Beijing with the country's major river systems and ultimately the coast, this canal provided a means of transporting a steady supply of grain from the south to the north of the country. During the 7th century, 300,000 tons of grain were transported per year along this route. The canal was an enormous undertaking: 5.5 million laborers worked six years on one 1,500-mile stretch of the canal (20 person-years per mile).

England's industrial revolution was given a strong push when canals were constructed that provided cheap transportation for coal, agricultural products, and everything else[2]. The Bridgwater Canal, built in 1761 to link Manchester with coal mines, halved the price of coal in Manchester and helped Manchester become England's leading industrial center. By the 1840s, the country had a network of 5,000 miles of canals and navigable rivers, and nearly every city or town was within 15 miles of a canal. As the country prospered, canals were built to be straighter, wider, and deeper; aqueducts were constructed to allow canals to cross rivers.

The Potowmack Canal was the first extensive system of river navigation in the US[3]. Championed by none other than George Washington, the canal was designed to open up the area west of the Appalachian Mountains by providing a water roué to the Potomac River (which flows toward what is now Washington D.C.). The canal allowed boats with a 16-20 ton payload to make the 185-mile trip in three days at half the cost of transporting the same freight by horse and wagon. The canal ran into problems because of recessions, lack of skilled workers, and bad weather. The route was navigable only for three months of the year, the canal tended to fill up with sediments, and the wooden locks decayed. The canal did help spur investment in and development of the western region, but it was a financial failure. After an investment of $750,000 between 1785 and 1802, the canal company was $175,000 in debt by 1816.

The Middlesex Canal was a similar project that was aimed at providing a better link between Boston, Massachusetts and the farms and forests of New Hampshire[4]. The 27-mile canal required the construction of 50 bridges, 8 aqueducts, and 27 locks. The investment of $528,000 ($20,000 per mile) was, for the time, an enormous amount equal to 3% of the assessed value of all property in Boston. The canal suffered because the freight – what little there was - was mostly southbound. Despite the small volume of freight, there were political disputes, as people in New Hampshire did not appreciate a company chartered by Massachusetts diverting freight from New Hampshire's major port.

The Erie Canal was the most ambitious canal project undertaken in the US during the 19th century[5]. The project was first proposed in 1724, and it was widely discussed for nearly 100 years as a means of linking New York City and the Hudson River with the Great Lakes at a point to upstream of Niagara Falls. Because of the geography of the eastern US, the Erie Canal route was the easiest way to get from Atlantic ports across the Appalachian Mountains. Thomas Jefferson called the Erie Canal "a splendid project – for the 20th century!"

Gaining support for the construction of the canal required a major political effort, and not only because of the difficulty in financing such a large project. There was uncertainty about the route; an inland route would be expensive, but it would avoid exposing trade to attacks from Canada if the route used Lake Ontario. Merchants who used ground transport were against the project, because it would expose them to competition. There was also a lack of skilled engineers for carrying out the project – and the project therefore led to the creation of civil engineering schools at Rensselaer Polytechnic Institute and Union College.

DeWitt Clinton was a member of the commission formed in 1810 to consider the construction of the canal. As a former mayor of New York City, a US senator, and eventually as governor of New York, Clinton was the foremost champion of the project, and it was finally approved by the state legislature. The 363-mile canal, with 83 locks and

---

[1] E.L.Newhouse, Ed., "The Builders", National Geographic Society, Washington DC, 1992, p. 29

[2] E.L.Newhouse, Ed., "The Builders", National Geographic Society, Washington DC, 1992, p. 30

[3] Schodek, "Landmarks in American Civil Engineering", MIT Press, Cambridge, MA pp. 3-6

[4] Schodek, op. cit., pp. 5-12

[5] Schodek, op. cit., pp. 13-19

18 major aqueducts between Albany and Buffalo, was constructed between 1817 and 1825 at a cost of $8 million plus the loss of 1000 lives from malaria and pneumonia.

In order to limit costs of construction, the canal was built just wide enough (40 feet) and deep enough (four feet) to handle medium-sized boats. When the canal opened, demand and revenue exceeded all expectations, and it was possible to finance projects that increased the canal to a width of 70 feet and a depth of seven feet.

The long-term impact of the canal was immense. According to Schodek, opening up Lake Erie was the "decisive impetus" for commerce in the eastern US to move east-west rather than north-south. Rochester and Buffalo became boom towns, and population in New York increased all along the route of the canal. The success of the Erie Canal sparked development of a system of canals in Ohio, as population and economic development in the country pushed further westward.

Epilogue: Canals vs. Railroads

Table 1 summarizes the costs and operating characteristics for the main transport options in the early 19th century. Turnpikes provided a way to achieve substantial improvements over rough roads, and they could easily be financed by tolls. Canals cost two to four times as much to construct, but they cut freight transport costs to a third of the costs of using turnpikes. Canals enjoyed only a brief period of supremacy in the United States, as they were restricted by topography and their service was much slower that what was possible once railroads were introduced. Railroads were similar to canals in terms of construction cost and operating cost, but they were much faster and therefore much more attractive for passengers and for most kinds of freight.

Table 1 Comparison of transportation Costs, first half of the 19th century

Rough Road $1-2,000/mile to construct	1 ton/wagon 12 miles/day 12 tm/day/vehicle	$0.20 to $0.40/tm for freight rates
Turnpike $5-10,000/mile	1.5 tons/wagon 18 miles/day 27 tm/d/v	$0.15 to $0.20/tm
Canal >$20,000/mile	10-100 tons/boat 20-30 miles/day 200-3000 tm/d/v	$0.05/tm
Railroad $15-50,000/mile	500 tons/train 200 miles/day 100,000 tm/d/v	<$0.05/tm

Lessons for Other Infrastructure Projects

This brief review of a few of the major canal projects in the US provides some useful lessons regarding projects:

- Ideas and concepts for major infrastructure projects may abound long before the means to build the infrastructure are available.
- Important public figures may become champions for particular projects.
- Major projects can, like the Erie Canal, be decisive in directing development and population growth, but it is also possible to spend major resources on projects like the Potowmack and Middlesex Canals that have only modest potential.
- Changes in technology can kill projects (railroads quickly put these canals out of business by the mid-19th century).

- Financing is a major concern.

The discussion of canals also offers some insight to the different perspectives of the various participants in evaluating projects. If potential users' costs are lower, they will use the facility. In deciding whether to use a new canal, potential users had to ask whether it would be possible to lower freight costs by using canals rather than horse and wagon or by using large canal boats rather than smaller boats. Potential users therefore would compare their costs for equipment and operations for their current and newly available options.

Owners or entrepreneurs have a different question: should they build the facility? They have to compare annual revenues to annual costs, taking into account the costs of construction and the continuing costs of operating and maintenance. If they are going to borrow money, they have to be able to pay back the interest. If they are going to charge tolls, they have to compare the amount of the toll to what users would actually save by using their facility. Set the toll too high and nobody will use the facility.

Potential investors have a simpler and more direct question: if they put their money into the project, would they be able to recover their investment plus a reasonable return? They should be worried about the feasibility of the project, the time it could take to complete the project, and the ability of the project to actually generate revenue. They would not necessarily have any interest in the details of the construction or the operation, and they would be comparing this project with completely different options for making money.

Contractors may not care at all about what the project ultimately accomplishes, as long as they are able to complete their portion of the project on time, safely, and on budget. They will be very interested in trying to predict construction costs, choosing the most effective technologies and materials, and in planning and managing the process. They must determine whether the potential profits from the project are worth the risks that they perceive to be associated with the project.

Resource: Project Evaluation: Essays and Case Studies
Carl D. Martland