Impacts of the Greenhouse Effect on Urban Transportation

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Scientists suggest that temperatures might rise 5°F to 9°F over the next 100 years, and that the sea level could rise 2 to 5 ft in response. Temperature change might reduce snow and ice control costs, slow road and bridge deterioration, and eventually reduce required pavement thickness. The uncertainty of future temperatures suggests increasing the safety factor currently designed into expansion joints on bridges and major roads, and reexamining the heat tolerances of railroad tracks. A rising sea level and the potential for more intense storms could require bridge redesign, better airport drainage, and raising of low-lying streets near tidal waters. Retrofitting could be much more costly than changes made prospectively during reconstruction. Design standards and siting criteria should be reassessed in light of likely climate changes.

Two weather models developed for the Environmental Protection Agency (EPA) (*1*) suggest that the earth could be 5°F to 9°F warmer than today by 2080, warming as much in 100 years as it did since the last glacial period 18,000 years ago. The models suggest that since the Industrial Revolution began in 1850, enough carbon dioxide and pollutants were banked in the atmosphere to cause half that temperature rise. The rest would result from projected emissions over the next century. The emissions are raising the heat-reflectivity of the atmosphere, making the earth a considerably more powerful greenhouse. With an average temperature rise of 8°F, temperatures would rise 16°F at the poles, melting much ice. Sea level could easily rise 2 to 5 ft by 2080. Other weather-related effects might include increased evapotranspiration and storm and hurricane intensity (*2*, *3*).

The heat wave of 1988, although not related to the greenhouse effect, vividly illustrates some of the potential temperature impacts. Hundred-degree weather distorted railroad tracks, forcing Amtrak to cut speeds from 125 to 80 mi/hr between Washington and Philadelphia (*4*) and possibly causing several train wrecks, most notably one that injured 160 people on a Chicago-Seattle run (*5*). Across the Midwest, record temperatures buckled highways (*6*). In the suburbs of Washington, D.C., steel expansion joints bubbled along a 13-mi stretch of I-66 (*7*). In Manhattan, extreme heat exacerbated the effects of long-standing leaks in 160 mi of concrete-sealed steam pipes that lie 11 ft below the streets, causing the asphalt to soften. As vehicles kneaded the asphalt, thousands of hummocks formed on city streets (*8*).

This article discusses the probable impacts of global climate change on urban transportation systems in Miami and Cleveland. In Miami, sea level rise could require investment of several hundred million dollars to raise streets and bridges and improve airport drainage. Costs could be similar in other low-lying cities with tidal waterfronts. In Cleveland and other inland or lake cities in cooler latitudes, the impact could be positive, with savings in snow and ice control costs, as well as in road construction and maintenance costs. The closing section of this article suggests that engineering standards related to roadway, bridge, and rail design may need revision in response to the potential for, and subsequently the reality of, global climate change.

METHODS AND PRINCIPAL LIMITATIONS

This study was based on a critical review of existing infrastructure studies in Miami and Cleveland, discussions about likely impacts with local infrastructure experts, analyses undertaken by these experts, and calculations about probable impacts by the study authors. The analyses were preliminary. They revealed which infrastructure responses to global climate change might be expensive, but were not engineering analyses of the most cost-effective responses. Because detailed analysis was restricted to two cities, the study did not identify the full range of impacts that could arise across the country.

MIAMI

Miami is a hydrologic masterwork, a densely populated area bounded by water from below and on all sides. When the city was first developed, the entire southern tip of Florida was a mangrove swamp called the Everglades that often was awash in fresh water. The initial settlement was built on local high points of the Atlantic Coastal Ridge, 10 to 23 ft above sea level, and immediately adjacent to Biscayne Bay and the Atlantic Ocean. Today, most of Greater Miami is on lower ground made habitable through drainage and reclamation (*9*).

Just a few feet below Miami's surface lies the porous rock of the Biscayne aquifer, which is one of the world's most permeable. The seaward edge of the aquifer is flooded with salt water. Maps in the Dade County Comprehensive Plan show that the height of the water table varies about 3 ft between seasons, but always exceeds sea level in most of the aquifer. In the wet season, the water table is close to the surface except along the high points of the Atlantic Ridge.

As sea level rises, the pressure of the sea water will cause the sea to rush into the aquifer below the surface and push up the fresh water. A 3-ft rise in sea level would cause roughly an equal rise in the water table.

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Streets and Highways

The City of Miami Department of Public Works reports that there are 756 mi of ground level streets within Miami. Lane miles total roughly 1,800. A typical city street consists of a 1.5-in. layer of asphalt constructed over an 8-in. limerock base. Beneath the base is a subgrade, with its top 6 in. compacted to a minimum of 95 percent of its maximum density. If the sea level and water table were to rise 2 to 5 ft, given the annual fluctuations in the water table and its proximity to the surface, the subgrade base of many city streets would be subject to a certain amount of saturation. This could cause complete structural failure if a heavy load were to pass over the surface. To prevent this, vulnerable streets would have to be raised.

The City of Miami Department of Public Works estimates that approximately 34 percent of street and highway mileage—257 mi—is 5 ft or less above the water table (D. Brenner, City of Miami Department of Public Works, personal communication, April 1988.). Raising streets by 3 ft during reconstruction, according to the Department of Public Works, would raise reconstruction cost from $150 to $175/linear ft with minimally improved transitions to adjacent properties. The cost is modest because fill can be surface-mined on public lands in the county.

The cost of reconstructing the 257 mi to adjust for a 3-ft rise in sea level would be $237 million. Omitted from this cost estimate are substantial private costs that would be incurred for better drainage, raising some yards (especially around newer buildings where the structure itself already is raised), raising lots at reconstruction, and pumping sewage from the houses to the mains in some areas.

Although the average temperature in Miami could rise from 75°F to 80°F, the increase should have negligible impact on streets and highways, because current asphalt pavement withstands substantial temperature variations, and pavement performance should improve as reconstruction incorporates technological changes.

Causeways and Bridges

The causeways running from Miami across Biscayne Bay to Miami Beach are between 5 and 10 ft above sea level and might risk structural weakening and failure. They would also be vulnerable because of the increased size of hurricane storm surges. These potential impacts could be avoided with reconstruction over the next 100 years involving design features to mitigate the effects of the sea level rise.

Except for steel drawbridges, most bridges in Miami are constructed of concrete and steel and have a life expectancy of 50 years in a saline environment. Only those near the coast have epoxy-coated reinforcing bars, a practice introduced in 1970 to fight corrosion. Without remedial action, the effects of sea level rise might include

- Pavement failure in low-elevation bridge approaches.
- Erosion beneath low-lying bridge abutments and consequent differential settlement, stresses, and strains.
- Potential lifting of corrugated steel and box culverts.
- A drop in the elevation of protective fenders on the piers over navigable waters.
- Reduced accessibility to low-lying bridges and causeways, inhibiting proper inspection and maintenance.
- Reduced underclearances on navigable waterways.
- Increased likelihood of flood backwaters, particularly for bridges over nonnavigable waters, which often have underclearances of 3 to 6 ft.
- Added slapping action of waves beneath some bridges.

Regardless of improvements over the next 100 years, bridges with piers and piles in both Biscayne Bay and in rivers would experience deeper scouring, but the decreased velocity in nonstorm conditions that results from increased water depth would mitigate the problem. Scouring would increase if storms became more frequent or severe.

The projected temperature increase should not cause bridge expansion outside design limits. Increased humidity, however, might accelerate paint deterioration on steel bridges in saline environments.

Airports

Miami International Airport is a major international hub. Located in northwest Miami, its airfields and aprons cover 7,000 a. Unlike the majority of major commercial airports, most of the surface area is asphalt pavement. The aprons are concrete. The asphalt varies in thickness from 2 to 17 in. depending on the base. Its extensive drainage system allows storm runoff to empty into ditches by the airfield, which in turn empty into the Blue Lagoon and the Tamiami Canal. The groundwater elevation ranges from 2 to 3 ft, runways 9 to 10 ft, and taxiways and aprons 8 to 9 ft. A 3-ft rise in groundwater would not flood the pavement or base, but would affect drainage retention capacity and exfiltration during a storm. If several large pumping stations were constructed to draw down the airport water table at the onset of a storm, acceptable operating conditions could be maintained. Drainage interconnections and related improvements such as pump stations, dikes and culverts might cost $30 million (R. Tripp, written communication to the Urban Institute, Howard Needles Tammen Bergendoff, 1988).

CLEVELAND

Cleveland could experience a marked change in climate over the next century. EPA's scenarios suggest that winter temperatures could increase 10°F, raising average temperatures above freezing. Summertime increases could range from 7°F to 12°F above the current 66°F average. Snowfall might be dramatically reduced, with average annual accumulations declining from 50 in. to about 8 in.

Conditions of Roads and Bridges

Like most cities, Cleveland maintains an extensive road and bridge network; it has some 1,550 mi of road and 93 bridges with a total surface area of 1.8 million ft^2 (*10*). By some measures, Cleveland's road and bridge stock is in poorer condition than is typical for U.S. cities. Among 34 cities with road condition data available for 1983, Cleveland ranked last in the percentage of road mileage rated as "good" (5.6 percent) as opposed to "fair" (91.8 percent) or "poor" (2.7 percent) (*11*).

Similarly, the city's bridges included on the federal bridge inventory are in relatively poor condition. Among 62 major U.S. metropolitan areas in 1980, the Cleveland area ranked 12th in its share of structurally deficient bridges: 23 percent of the area's 279 bridges fit this category. Among the 93 bridges for which the city has sole maintenance responsibility, 75 are structurally deficient by the FHWA definition (*11*).

The deteriorated state of the city's transportation infrastructure is the combined product of environmental and-budgetary factors (*12, 13*). Years of underfunded capital programs and deferred maintenance contributed to the need for major capital renewal. Nevertheless, engineers responsible for road and bridge design attribute a large share of the blame for poor road and pavement and bridge deck performance to environmental factors. These include moisture and temperature effects in the former case and the use of salt in deicing efforts in the latter.

Low-Temperature Effects on Pavement

The most serious low-temperature effect on flexible pavement (e.g., asphalt) performance is frost heaving, which occurs when free water in the roadbed soil collects and freezes to form ice "lenses" (*14*). The accumulation of thickness from these lenses causes localized heaving of the pavement surface during extended frozen periods. The principal variable affecting the amount of heave that occurs is the depth of frost penetration, which is directly correlated with the number of consecutive low-temperature days. The amount of heave, and hence the potential loss in serviceability, also is affected by the quality of drainage.

Currently, an average of 46 days annually have maximum temperatures below freezing. According to local highway engineers interviewed for this report, these subfreezing days, on average, produce about 5 to 6 deep freeze/thaw cycles annually. Under both climate change scenarios, the number of days below freezing, and hence the estimated number of cycles, will decline dramatically over the coming century. One scenario suggests a mean of 13 days annually with maximum temperatures below freezing, roughly a quarter of the total mean number of days currently. If the number of days below freezing are taken as a proxy of the number of freeze/thaw cycles to be expected per year, 75 percent fewer days below freezing produces an estimated 1.5 deep freeze cycles per year. City engineers estimated the current depth of frost penetration for bare pavement at 4 ft, with good drainage. Serviceability loss is estimated to be at most 0.75 psi, about 15 percent of the total index range. With increased mean temperatures, and based on a 75 percent decrease in days below freezing, a gain of 11 percent in psi (with a residual loss of 4 percent) is possible.

Frost heave is a very specific type of pavement damage attributable to climate effects. More general analyses of estimated stresses on pavement life using broad climatic regions produce similar results. The Moisture Accelerated Distress (MAD) index classifies subsoil and drainage types for geographic regions across the nation according to their potential for abetting "pavement distress" attributable to environmental factors (*15*). Pavement distress is observable in the cracking of flexible (largely asphalt) or rigid concrete pavements, frost heave of flexible pavements, or joint failure or spalling of rigid pavements.

The MAD index is based on the interaction of four factors: temperature, moisture, roadbed material, and drainage. The last two factors, as defined in the index, will be little affected by climate change. City highway engineers rate the typical subgrade in Cleveland as "moderately drained," and the granular layer as "free draining." Whatever improvement in drainage is attributable to lake level drop will not produce a shift in broad drainage categories.

The temperature and moisture changes attributable to global climate warming might produce winter conditions in Cleveland roughly akin to those prevailing today in Nashville, Tennessee (*16*). This would equate to a change in temperature zone, for purposes of calculating the MAD index, resulting in an approximate 7 percent decrease in potential for moisture-accelerated damage.

Another impact to be considered is design requirements for new or replacement road surfaces. Until 1986, The American Association of State Highway and Transportation Officials (AASHTO) defined a Regional Factor for use in the design of roadways using flexible pavements (*17*). This factor essentially was a summary measure of adverse weather conditions. It was used to weight the axle-load factor used to determine asphalt pavement thickness. This factor ranged from 0.5 in the far Southwest to a U.S. mean value of 1.7 to a maximum value of 3.5 in northern Minnesota. The Cleveland area value was 1.5. With an increase in mean temperature, and using Nashville as Cleveland's winter analogue, the value for Cleveland would drop from 1.5 to 1.0. This change suggests a 7.5 percent decline in the required thickness of asphalt overlays in roadway construction.

Maintenance Costs

Roughly estimated, the amounts to be saved in road and bridge repair costs as a result of decreased pavement and bridge deck stress are modest, but not negligible. Currently, Cleveland spends about $4.9 million per year on street repair, including filling potholes, cracks, and other surface defects. An additional $100,000 is expected on bridge deck repair (*10*). This amount is almost entirely devoted to routine pothole repair, filling of joint and other surface cracks, and other maintenance activities associated with routine treatment of ordinary surface wear and tear.

As seen in the preceding section, the change in the Present Serviceability Index attributable to frost heave is an estimated 7 percent. The estimated MAD index change, accounting for all sources of moisture-accelerated distress including frost heave, is 11 percent. If these changes are correlated with actual incidence of pavement damage, then a conservative estimate of annual savings attributable to reduced damage frequency is roughly 10 percent or $490,000.

The city performs only emergency repair on bridges. City engineers indicate that of an average annual bridge maintenance budget of about $1 million, about 10 percent is expended on the repair of bridge decks, the remainder supporting maintenance of lift bridge mechanisms (*12*). Although some deterioration of bridge decks can be attributed to the effects of temperature and moisture alone, these effects are minimal compared with the use of road salts. Because milder winters mean sharply reduced snow and ice control efforts, far less corrosive salt will need to be spread on the area's bridges. Nevertheless, the authors judge that negligible economic benefit will be credited to this development because of improved winter maintenance practices over time. Also, since 1970, widespread use of epoxy-coated reinforcing steel as a means of preventing contact between the bare steel and deicing salts should reduce corrosive impacts long before milder winters become the norm (*18*).

Capital Costs

AASHTO design guidelines, including the regional factors used in the flexible pavement design equation, are a good means of estimating changes in capital costs attributable to climate change. The expected change in winter temperatures, using an analogue of Nashville, Tennessee, means a reduction in the AASHTO Regional Factor from 1.5 to 1.0. Each unit change in the Regional Factor produces a 13 percent change in the structural number, and therefore the thickness, of flexible pavement (*17*). For roadway construction or reconstruction jobs, roughly 26 percent of total construction costs are attributable to pavement costs. Of this figure, 70 percent of costs are variable with thickness. Therefore, 18 percent of total construction costs are potentially affected by weather (26 percent × 70 percent). Thus, a change in the Regional Factor from 1.5 to 1.0 on roadway reconstruction jobs means a drop in total costs of approximately 1 percent.

Resurfacing jobs, however, contain a higher percentage of pavement costs to total job cost than do reconstruction jobs—approximately 60 percent. Using the 70 percent of costs that are variable with thickness, as before, 42 percent of total resurfacing costs can be viewed as weather influenced. If a 0.5 drop in the Regional Factor means a 7.5 percent change in structural number, then total cost reductions on resurfacing work are estimated at 3 percent.

Table 1 presents Cleveland's road resurfacing and reconstruction costs for 1983–87. Assuming that the city's capital investment levels by category change proportionately over time and that the climate-adjustment factors are approximately correct, a 5-year estimated savings of about $1 million can be expected on a total budget of $76 million.

Snow and Ice Control Costs

As in many other Northeastern cities, snow removal operations in Cleveland receive high priority from city administrators and agencies during the winter months. The Division of Streets, responsible both for roadway maintenance and snow removal, maintains four stations throughout the city during summer months. Two are manned at three shifts per day, one at two shifts, and one at one shift. These stations primarily perform street sweeping and repair. During winter months, however, six stations are activated, all manned at three shifts per day and all engaged primarily in snow and ice removal. Limited street repairs are undertaken throughout the winter months. The personnel used in city snow removal operations all are city employees and the equipment consists of Division of Streets vehicles.

Ordinarily, at the onset of snow or ice precipitation, the city will salt streets using employees and equipment assigned to their regular shifts. At this stage, some 45 units will be employed in salt spreading. If snow accumulates at ½ in./hr, or if a 2-in. accumulation is reached, the second shift will be called 4 hr early, while the first shift will be kept on 4 hr overtime. This brings total equipment on the road to 81 salt and plow units, and 15 graders. Typically, for any storm between 4 and 12 in. over a 12-hr period, the city will average 50 to 75 vehicles for the first 12 hr, and 95 to 100 over the second 12 hr. In addition to drivers, foremen and mechanics responsible for vehicle maintenance work similar shift patterns.

The annual cost of removing snow consists principally of labor costs attributable to snow removal activity, and the cost of expendable materials, such as salt, used in deicing. Table

TABLE 1 CLEVELAND ROAD RESURFACING AND RECONSTRUCTION OUTLAYS 1983–1987

Year	Reconstruction	Resurfacing	Climate-Savings
1983	$ 5,184	$1,930	$110
1984	6,233	2,179	127
1985	5,334	2,391	124
1986	26,544	2,166	330
1987	21,913	2,166[a]	284
Total	$65,208	$10,832	$977

[a] Estimated. Climate change savings are computed as 1 percent of reconstruction costs, 3 percent of resurfacing costs.

NOTE: Dollars in thousands.

SOURCE: Compiled by the Urban Institute based on unpublished material supplied by the City of Cleveland Budget Office (1987 figures) and data from the Mayor's Estimates, 1983–1986.

TABLE 2 SNOW AND ICE CONTROL COSTS

Year	Cost ($, in thousands)	Accumulation (in.)
1980	3,477	38.7
1981	4,282	60.5
1982	5,646	100.5
1983	4,069	38.0
1984	5,379	79.4
5-yr average	4,571	63.4

SOURCE: City of Cleveland Mayor's Estimates, various years; and U.S. Climatic Research Center.

2 presents Cleveland's annual snow removal budget for recent years, and the associated inches of accumulation. As the table shows, removal costs roughly track total accumulation.

The average amount of snow accumulation projected for Cleveland under each climate change scenario is about 8 in. per year, a mere 16 percent of the current annual average. The winter comparable for the Cleveland area, Nashville, Tennessee, registers average annual snow accumulation in amounts roughly equal to those projected for Cleveland. Nashville snow removal costs from 1982 to 1987 averaged about $200,000 per year. Data from other cities confirm that Nashville's approximate level of expenditure is an appropriate benchmark for accumulation of that magnitude.

These data imply that Cleveland's snow removal budget could decline from its current annual average of $4.6 million per year to about $200,000 per year. The decline of 95 percent, for an annual savings of $4.4 million, represents about 1.9 percent of the city's $235 million operating budget.

Transit

The Greater Cleveland Regional Transit Authority (RTA) operates a fleet of 1,022 vehicles carrying over 88 million passengers per year. The fleet includes 815 buses, 91 light railcars, and 116 heavy rail cars.

Analysis does not suggest any significant impact on RTA capital costs because of climate change. Neither the rail nor the bus fleets now have special equipment mandated by snow conditions that could be eliminated (and thus save costs) in subsequent replacements. All vehicles are equipped with heating systems, which still will be needed as winters become milder. All rail cars have two 7-ton air conditioning units. These should have adequate capacity to handle much longer hot weather seasons and RTA staff suggest that, if anything, a more regular use would probably improve their operation because lubricants would circulate more effectively.

None of the Cleveland buses are presently air conditioned, so equipment would probably have to be added in this category at some time over the coming century. Given an estimated average 10- to 14-year replacement cycle and considering the expected pace of temperature increases, however, there would be no justification for accelerating replacements on these grounds alone. Also, the American Public Transit Association indicates that most buses now being sold are equipped with air conditioning and that the percentage continues to increase. Price differentials for buses with and without such equipment are already small and are narrowing. Therefore, it appears that adding air conditioning for Cleveland area buses during regular bus replacement cycles over the next century would not have a noticeable effect on total capital outlays.

Similarly, although climate change will alter RTA operating costs, our interviews suggested that all effects will probably be too small to warrant quantification. On the one hand, heavy snow accumulations at present do create problems, particularly for the rail system. Snowflakes that work their way into power systems can produce "flashes" (shorts) that demobilize the equipment and yield large repair bills. RTA will be able to reduce allocations for snow clearing and other outlays for prevention/correction as snow diminishes in the future. On the other hand, some increase in fuel consumption is likely to result from more frequent use of air conditioning equipment. Rail widths also may have to be reduced slightly at replacement to reduce the chance that speeds might need to be restricted on very hot days. In relation to the overall size of RTA's $126 million expense budget for 1987, effects will be small.

IMPLICATIONS

Roads

For the most part, temperature change could reduce the cost of road construction and maintenance. Snow and ice control costs will drop dramatically. In Cleveland the costs could drop by 95 percent, almost $4.5 million per year. In cities like Washington, D.C., they might drop to zero. A decrease in deep freezes and freeze-thaw cycles also would mean fewer potholes. Warmer temperatures and the improved drainage resulting from higher evaporation rates could allow use of thinner subbases, bases and pavements in many areas, but require enhanced expansion capabilities. The savings in Cleveland are likely to be 1 percent of road reconstruction costs and 3 percent of resurfacing costs, about $200,000 per year, plus 10 percent of maintenance costs, about $500,000 per year. The reconstruction and resurfacing cost savings only will be realized if pavement standards are adjusted to reflect climatic conditions as they change.

Bridges

Sea level rise and increased storm intensity could require many bridges to be upgraded, either through retrofitting or as part of normal reconstruction, and make it harder to defer needed improvements. The range of temperature accommodated by expansion joints also might need to be increased in some areas.

Mass Transit

The impacts on transit should be modest and largely concentrated on operating costs. In the North, buses and rail cars could experience fewer snow-related delays. Conversely, slight increases in fuel costs could result from increased use of air conditioners. High-speed rail track also might need replacement to accommodate hotter temperatures.

Airports

Some airports might need enhanced drainage capacity. Air operations might face more summer disruptions because of summer fog and thunderstorms. Conversely, winter disruptions attributable to snow and ice could drop substantially.

CONCLUSIONS

The uncertain, yet potentially imminent impact of global climate change already has increased the riskiness of infrastructure investment. Application of design standards and extrapolation from historical data might not still provide reasonable assurance that expansion joints, bridge underclearances, or drainage will be adequate during a 20-, 50-, or 100-year design life. The National Flood Insurance Program's historically based maps identifying the 100-year floodplain and 500-year floodway might no longer provide a reliable basis for roadway siting. Because of increases in storm intensity that may accompany climate change, historical data might not be an adequate basis for decisions about the cost-effectiveness of wind shear radar at airports. And migration in response to climate change could radically alter the population growth projections underlying capacity decisions about highway and airport systems.

Corporate investment analysts have developed methods, including decision theory, portfolio analysis, and chance-constrained programming, to guide decision making under uncertainty. Infrastructure analysts at all levels of government might be wise to adapt these methods to their work. Especially in coastal areas, the possibility of accelerating global climate change soon may require careful decisions about how and when to adapt the infrastructure. A strong emphasis on life-cycle costing and the courage to make expensive upgrades during reconstruction in anticipation of future changes could provide large cost savings.

Growing uncertainty about future temperature, precipitation, and sea levels might dictate a reassessment of existing standards and safety factors for drainage, flood protection, facility siting, underclearances, thermal expansion capacity, and resistance to corrosion. Conversely, prompt detection of lasting changes could allow adjustment of geographically based standards—for example, on roadbed depth—and provide significant savings.

AASHTO, the American Society of Civil Engineers (ASCE), the American Society for Testing and Materials (ASTM) and the Transportation Research Board (TRB) should consider educating their committees about global climate change. The decisions of these committees on when and how to incorporate climate change into their analyses and recommendations, especially when the recommendations vary geographically, could have major cost implications. The Strategic Highway Research Program (SHRP) might be well advised to consider climate change in developing its material and performance specifications and pavement monitoring plans. As part of its needs assessment process, FHWA also might be wise to assess the potential impacts of global climate change on the Federal-Aid Highway System. Raising bridges and increasing thermal expansion capacity prospectively during reconstruction might be more cost-effective than risking sea level rise.

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