Water Quality and Ecosystems

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General Environmental Responsibilities of the Federal Highway Administration

The mission of the Federal Highway Administration (FHWA) is to continually improve the quality of our Nation's highway system and intermodal connections. As one of its strategic goals, the FHWA includes the need to carry out its mission in a manner that protects and enhances the natural environment and communities affected by transportation. This goal requires that principles of environmental stewardship be incorporated in all of the FHWA's policies, procedures, and decisions. Therefore in concert with the State transportation agencies, the FHWA must responsibly consider and evaluate all aspects of the environment throughout the highway planning, design, and development processes. The FHWA also must provide training and technical assistance to its State and Federal partners to help minimize the potential adverse environmental impacts of Federal-aid and Federal Lands projects. Training and other assistance enhances FHWA's ability to implement ecosystem and habitat conservation, and showcase existing exemplary initiatives.

The possibility for global climate change draws the attention of organizations whose responsibilities not only shape current activities, but also respond to projected future trends concerning the status of the environment. Although the existence, magnitude, direction and potential affects of global climate change are in constant debate, the FHWA should consider and develop contingencies for possible effects of climate change on surface transportation systems and the surrounding environment.

Therefore, this paper generally examines transportation responsibilities and outcomes in light of changes in climatic conditions that could occur based on possible trends in global warming. The paper specifically addresses trends that may influence how FHWA and its partners fulfill responsibilities to protect water quality and ecosystem integrity relative to the nation's highway program. Its purpose is to stimulate thought on these potentially important issues by pointing out possible consequences of warming trends on these resources. The paper does not draw conclusions on the likelihood of such consequences nor attempt to estimate their severity.

Transportation Development – The Federal Partnership with the States

Area-wide transportation planning is a pivotal strategy in the cooperative approach for financing needed improvements in the nation's transportation infrastructure. The approach is a federal-aid program wherein State and local governments finance needed transportation improvements with the use of Federal funds made available from taxes collected primarily through the sale of gasoline. Under this funding arrangement, the State Departments of Transportation (DOTs) and the Metropolitan Planning Organizations, must plan highway and transit improvements through the use of an integrated process that results in long-term programs of projects needed to support the current and future movement of people and goods. These programs address needs over several frames of reference. Although mobility improvements are the focus, the planning process also includes participation by the public and private sectors in order to support other quality of life objectives. The process incorporates a variety of elements, including environmental protection and enhancement coupled with accessibility to, and equity in, the provision of transportation services. Collectively, these and other elements of the planning process can fit together as a Federal-State partnership to help meet a variety of local needs and national priorities.

FHWA's Environmental Obligations and Commitments

Transportation agencies and planning organizations acting through the Federal-State partnership, must comply with numerous Federal and State environmental statutes, implementing regulations, and Executive Orders. The most significant of these in terms of both time and money expended to address potential effects of transportation projects on water quality and ecosystems are the National Environmental Policy Act of 1969 (NEPA), the Clean Water Act of 1977 [in particular Sections 404 (permits for the discharge of dredged and fill material), 402 (Stormwater permits for Phase I & Phase II), 401, and 303 (TMDLs)], Coastal Zone Act Reauthorization Amendments (CZARA) of 1990, Executive Order 11990: Protection of Wetlands, and the Endangered Species Act of 1973.

Actual costs for implementing programs and strategies to avoid, minimize, and mitigate potential impacts to water quality, wetlands, and endangered species are difficult to distinguish and measure. Current baseline examples are necessary if DOTs are to plan for changes in time and costs that may be needed for compliance and environmental stewardship in a future with an uncertain and changing climate. Lack of available data makes the planning for future outcomes problematic. There could be scenarios where resource commitments must increase as transportation programs adjust to more numerous and varied effects of climate. Conversely, the importance of environmental features may diminish over time due to climate changes, thereby reducing the relative effects of transportation on the environment and lowering current expenditures for impact mitigation. Given projected warming trends, conclusions of how continued compliance may change expenditures in the future are discussed in the sections that follow.

Stormwater Programs and the Clean Water Act

The Clean Water Act is addressed by individual DOTs through the implementation of Best Management Practices for the mitigation of potential water quality impacts from roadway stormwater runoff, construction activities, maintenance and other highway-related activities. The costs of these measures can be expressed through various means – permit application requirements, construction of detention ponds, design, monitoring and maintenance programs, and other requirements.

The most common contaminants in highway runoff are heavy metals, inorganic salts, aromatic hydrocarbons, and suspended solids. The major sources of these pollutants are vehicles, maintenance activities, and wet and dry atmospheric deposition. Vehicles are both a direct source of pollutants and an indirect source. Vehicles contribute directly to the pollutant load through normal operation, corrosion, tire wear, leakage of lubricants and fuels, cargo spills, and accidents. They indirectly contribute pollutants by picking up solid materials, which they later deposit on the road through precipitation wash-off, the scouring action of wind, and gravity. Highway maintenance activities, such as sanding, deicing and the application of herbicides also contribute materials to the runoff pollutant loadings from highways. Atmospheric fallout, or dustfall, accumulates on paved surfaces during dry periods and can contribute significantly to the runoff mix during wet periods. Dry and wet deposition can be characterized by a variety of substances most often reflecting land use sources adjacent to the highway.

Roadways and highways are designed to quickly convey stormwater away from the travel path of vehicles. This is done for safety reasons and also to ensure that the physical integrity of the road surface is maintained. These impervious surfaces affect the potential concentration of pollutants by intercepting and diverting the stormwater flow. Retention and detention basins, among other management practices, can be highly effective means for controlling pollutant release to the environment and have been used extensively for many years.

But by far, the most prevalent highway drainage design has been unintentionally treating stormwater runoff effectively since the time of the first paved roads. These are the common features of vegetated swales and ditches along roadsides. Simple measures such as these collect runoff pollutants directly from the pavement, trapping them through soil adsorption and filtering through the vegetation. These simple drainage features can be very effective when considering only physical mechanisms to remove pollutants from stormwater, but they also provide important chemical and biological abatement as well.

Where vegetated drainage features are not practicable, such as urban and suburban areas with curb and gutter draining into storm sewer systems, highway runoff may have adverse effects if no specifically designed measures are taken for the removal of excessive contaminants before the runoff reaches receiving waters. In these cases, adverse effects of highway runoff water quality can be minimized through structural and non-structural best management practices or through a combination of both.

Structural best management practices consist of infiltration technologies, detention, retention, filtering systems, low impact development features, and in limited applications, porous pavements. Structural best management practices operate by physically trapping runoff until contaminants settle out or are filtered through underlying soils or other artificial media. They work through the process of gravity settling of constituents, or through the infiltration of soluble nutrients through soil or filters, or through constructed biological and chemical processes.

Non-structural best management practices deal mainly with source controls, such as low impact development land use planning and management (which also use structural methods), street sweeping, or improved maintenance programs. These methods help reduce the initial concentration and accumulation of contaminants in the stormwater runoff. Non-structural controls can reduce the need for generally more costly structural controls.

Climate Changes and Highway-related Stormwater Quality

Water quality is a direct result of the chemical inputs received from air and the surrounding land and the biogeochemical processes that transform those inputs. Direct chemical contributions come from point source discharges, such as from sewage treatment plants. Indirect contributions come from atmospheric deposition and surface waters that flow in watersheds through vegetation, soils, and aquifers, each of which contributes to water chemistry. Global climate changes have the potential to significantly alter stormwater runoff quality and quantity by changing water temperature, flows, runoff rates and timing, and the ability of watersheds to assimilate wastes and pollutants.

Climatic changes leading to higher intensity storms may increase flows from highway facilities over and above what is now calculated during the design of typical drainage systems. This may mean increasing erosion of receiving stream channels, leading to higher sediment, chemical, and nutrient loads. On the other hand, lower flows associated with drought conditions could reduce dissolved oxygen concentrations, reduce the dilution of pollutants, increase zones with higher water temperatures, and increase flushing times.

Increased rates of oxygen depletion in already eutrophied waters in U.S. may occur if global warming trends continue as some predict.

Warming could increase the rate of biological production and decomposition by increasing the rates of metabolism, the duration of the growing season, and the volume of waters that are biologically active. Increased water temperatures enhance the toxicity of metals in aquatic ecosystems and increased lengths of biological activity could lead to increased accumulation of toxics in organisms. If changes in terrestrial ecosystems occur because of warming, nutrient cycling rates and the delivery of nutrients to surface waters may be altered. Nitrification rates in soils are temperature dependent and in some regions, mean annual nitrate concentrations in streams are highly correlated with average annual air temperature. Extended droughts in some regions may increase the risk of acidification of streams due to the oxidation of pools of organic sulfur in soils.

The net effect on water quality for rivers, lakes and groundwater in the future depends in part on how climate conditions might change. This may require that DOTs expend greater funds to adjust stormwater drainage designs to compensate for the potential of additional adverse impacts.

Wetlands

There is an overall national policy for Federal agencies to protect and enhance the nation's wetlands. The policy is to reverse the trend in habitat loss by achieving a net gain in wetland acreage resulting from Federal actions. Provisions of the Clean Water Act support it, most specifically by the Section 404 program that regulates the discharge of fill material into waters, including wetlands. In 1994, FHWA issued an agency Environmental Policy Statement. Among the commitments made by the FHWA in the statement was a call for the protection and enhancement of all natural resources, including wetlands. In subsequent strategic plans and performance agreements, the FHWA established an agency policy of no-net-loss of wetlands impacted on a program-wide basis for Federal-aid highway projects.

In 1996, the FHWA revised its no-net-loss policy upward to a net gain goal. The agency's 1996 performance plan and all subsequent plans indicated this change by establishing a performance measure for wetland acreage replacement ratio of 1.5:1. The current FHWA Performance Plan states that the agency will: "*On a program-wide basis, replace at least an average of 1.5 acres of wetlands for every 1 acre directly affected by Federal–aid highway projects where impacts are unavoidable*" The FHWA achieves its wetland conservation and enhancement goal by working with the DOTs to encourage the use of the flexibility under authorizing legislation to finance wetland mitigation and restoration projects.

As a measure of performance under the FHWA's net gain policy, the agency gathers annual wetland loss and gain under the Federal-aid highway program nationwide. Data gathering from the State DOTs began in fiscal year 1996. Data collected over the last 6 years indicate that nationwide, the Federal-aid highway program has achieved a 130 percent gain in wetland acreage (2.3:1 gain/loss ratio). In terms of acres, the Federal-aid highway program produced a total reported net gain of more than 16, 958 acres of wetlands nationwide 1996-2001.

Once a DOT has clearly established the need for a highway that will require the taking of wetlands (after exploring avoidance alternatives), the DOT must develop plans to mitigate for wetland losses. The FHWA has developed a tool to collect and analyze wetland mitigation information from each of the DOTs. The estimate for average cost per acre of compensatory wetland mitigation is approximately $35,000, nationwide. This figure was $16,000 per acre in 1995. This results in an estimated cost from 1996-1999 for the entire federally funded highway program of approximately 50-80 million dollars per year for replacement wetlands (in pre-1995 dollars). Comparing these figures with the average total national obligation of Federal funds from categories that could be used for wetland mitigation during those years of about $11 billion, the cost of mitigation is approximately 0.7% of the total annual expenditure.

Likely climate change impacts on wetlands can be expected because changes in temperature and precipitation can alter wetland hydrology, biogeochemistry, plant species composition, and biomass accumulation. Because of the fragmentation impacts resulting from past human activities, wetland plants often cannot migrate in response to temperature and water-level changes and hence are vulnerable to complete elimination. Existing roads, as well as future road projects may inhibit migration rates in a changing climate and therefore require an increase in the number of acres that must be mitigated, thus leading to higher cost to the highway program.

Small shifts in the balance between precipitation and evapotranspiration can alter the groundwater level and affect groundwater discharge and streamflows, which may significantly reduce the size of wetlands and changes in wetland types. Loss of remnant plant and animal species from alpine wetlands seems likely since there is little opportunity to migrate. Mid-continental wetlands that depend on precipitation as a primary water source may be especially vulnerable to climate variation and change. Some climate scenarios for the Northern Great Plains region suggest that increased temperatures over the next 50 years could result in a 40% or more reduction in the number of prairie potholes and a resulting decline in waterfowl populations.

Although wetland species are sensitive to changes in seasonality of precipitation, there are some practical options for protecting wetlands as a whole from changes in precipitation and other factors, such as rising sea level. Future wetland mitigation may require greater emphasis on linking fragmented ecosystems to provide plant and animal migration routes. It could also mean development in coastal and estuarine areas would have to be rethought to maintain viable wetland resources because sea level rise would tend to "re-establish" wetlands further inland. All these potential occurrences could have dramatic effects on how transportation systems are planned and implemented, particularly the costs associated with the mitigation of impacts to a wetland resource otherwise threatened or redefined by climate changes.

Endangered Species and Ecosystems in General

The Federal Highway Administration and State Highway Agencies have broad responsibility for ensuring the planning, construction and operation of an environmentally sound, effective, and safe national transportation system. These responsibilities encompass almost all ecosystems where any human development has occurred. Transportation projects often have important direct and indirect impacts on natural ecosystems, and connect adjacent or distant ecosystems through travel corridors and right-of-way management practices. Highways affect ecosystems by altering and replacing existing biological communities, by creating barriers between different habitats, by introducing new species and activities, by providing new access for socio-economic development and construction, by altering drainage patterns, and by changing the basic geochemistry of a region (for example, water and air quality). Many of these impacts are long-term, even those which we often consider to be temporary. An example is erosion and sedimentation. While the source of erosion might be temporary, the effects of the sediment are long lasting once it has entered the aquatic system. Other impacts, such as those generated by access, can be both long term and progressive, depending on local land use and development planning.

Whenever a proposed transportation improvement has the potential to affect a species listed, or proposed to be listed as either Threatened or Endangered under the Endangered Species Act of 1973, certain actions are required. This may involve studies to determine the actual presence of such species in the project area, and consultation with the agencies having jurisdiction over the species, either the U.S. Fish and Wildlife Service or the National Marine Fisheries Service. The result of these actions may mean project modification and special measures to remove the potential for impact to the species.

There are currently 1,261 species listed as either endangered or threatened on the Threatened and Endangered Species List in the U.S. The FHWA tracks the cost of Endangered Species involvement on Federal-aid highway projects on a yearly basis. The most recent data indicate that in 1998, $6,933,700 was spent on items such as land acquisition, habitat enhancement, and monitoring.

Previous assessments have established a wide range of possible direct effects, including changes in lake and stream temperatures, lake levels, mixing regimes, water residence times, water clarity, thermocline depth and productivity, invasions of exotic species, fire frequency, permafrost melting, altered nutrient exchanges, food web structure, and more. These impacts could lead to a wide range of serious adverse impacts on ecosystems, with changes in vegetation patterns, possible extinction of endemic fish species already close to their thermal limits, declining area of wetlands precipitating reductions in waterfowl populations, concerns about stream health, and major habitat loss.

In the southeastern U.S., for example, the projected impacts of higher temperature are: reduction in habitat for cool-water species, such as brook trout and many aquatic insects, which are near the southern extent of their ranges; greater summer drying of wetland soils resulting in greater fire threat; and the northward expansion of subtropical species, some of which are nuisance exotics. Indirect effects mediated through food web interactions are also likely in an altered climate.

Species have differing environmental needs in their ecosystems. A change that can be devastating to one species is likely to encourage the expansion of another to fill that niche in the system. Extreme conditions such as floods, droughts and fire are critical to sustaining certain ecosystems, and changes in the frequency of these events are likely. The natural ecosystems of the Arctic, Great Lakes, Great Basin, Southeast, and prairie potholes of the Great Plains appear highly vulnerable to the projected changes in climate.

The health and dynamics of ecosystems are fundamentally dependent on a wide range of climate-sensitive factors, including the timing of water availability, overall water quantity, quality, and temperature. A changing climate may intensify current threats to ecosystems and species in peril in many ways, such as by accelerating the spread of exotic species and further fragmenting populations. The number of species that are currently listed as threatened or endangered is likely to increase in the future due in part to climate changes. Therefore in the future, there will likely be an increase in money and time spent researching, consulting on, and implementing compensatory measures for endangered species potentially impacted by transportation projects.

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