

### A MESSAGE FROM THE AUTHORS

Understanding the status of Colorado's integrated infrastructure and its important role in providing a foundation for our state's commerce and quality of life is key to building public support for infrastructure maintenance and improvement.

Infrastructure failure could reach the point where Colorado's global competitive advantage is compromised – to the point where loss of commerce and stagnant enterprise create unemployment and other negative impacts on our quality of life.

America has been blessed with leaders of vision, starting with Thomas Jefferson's 1808 vision of a national system of roads and canals to Dwight D. Eisenhower's 1956 vision of an integrated interstate highway system. Unfortunately today we lack such a vision. Even provision of resources to maintain existing infrastructure is controversial. This has resulted in today's situation where America invests only about 2% of GDP in infrastructure, compared to 5% in Europe and India, and 9% in China. Years of under funding and lack of leadership have created a national problem of deteriorating infrastructure.

Much of Colorado's infrastructure was built after World War Two and is now approximately 50 years old and wearing out. Colorado is also experiencing significant demographic and economic growth that requires expansion of existing infrastructure. Coloradoans must address the problems and issues posed by the current and future state of our infrastructure and respond with dedication and measurable results. If we choose to ignore our infrastructure we will face significant degradation of our quality of life and our state's ability to compete for business and enterprise.

The challenge to maintain infrastructure may be difficult; but if we are to remain competitive we must be willing to accept the challenge. Issues must be addressed before they become critical and we must have the foresight to prioritize the importance of maintaining the vital infrastructure that has made Colorado a place of unprecedented lifestyle and opportunity.

On behalf of an industry dedicated to problem solving and creating a superior quality of life for its community, the Colorado Section of the American Society of Engineers (ASCE) presents this document to the citizens of Colorado.

Over the last few years it has been hard to ignore the national problem of inadequately funded infrastructure. From Mississippi River levee failures to the collapse of an interstate bridge in Minneapolis, the crisis in infrastructure has made national news. Colorado has experienced failures such as the sinkhole closing I-25 in Denver caused by a water main break, and a sinkhole



closing I-70 near Vail due to erosion around a culvert. Unless a plan is prepared to maintain and improve our infrastructure, these types of events will become more common. Currently we rate Colorado's infrastructure as average and declining in condition.

At the end of the day, the question we must answer is: Is average acceptable?

If not, we all have work to do.



### **EXECUTIVE SUMMARY**

In 1997 ASCE decided to raise the awareness and understanding of the role civil engineers play in society. At the same time, ASCE wanted to raise awareness about the declining condition of the infrastructure in the U.S. To address both, ASCE developed the first infrastructure report card, which was released in 1998 and last updated in 2005. The report card reported on the condition of roads, bridges, water supplies, hazardous waste sites, solid wastes, dams, airports, and wastewater and estimated the expenditures required to bring each element into a satisfactory condition.

When the first report card was released to Congress and the public and, though the national infrastructure grade was "D+," it was an immediate success. Politicians used the document, federal and state legislators, public interest groups, associations, and many others as proof that more attention was needed to address national infrastructure deficiencies. The Colorado Section of ASCE aims to achieve the same goals regarding infrastructure in Colorado when it issued the first Colorado Infrastructure Report Card in 2003.

Twelve major sectors of infrastructure were chosen for evaluation in 2003. In most cases, the authors compiled existing data. In some cases, new data was collected through phone conversations and surveys. The data was evaluated against objective grading criteria and a grade was assigned for current conditions and those expected in 2010. The reports associated with each of the sectors of infrastructure were peer reviewed by the Colorado Section of ASCE and by a group of technical experts and administrative officials.

Five years later in 2008, the Colorado Section of ASCE decided it was time to update the 2003 report card. Important was the idea of checking in to see if the grades assigned in the 2003 report are still accurate. In was also necessary to reflect current projects and programs undertaken since 2003. And two additional sections were added, one for civil engineering educational facilities and an overview section discussing system sustainability.

It is important to point out the report card is not intended to be a commentary on, nor an evaluation of, the performance of any particular governmental department, agency, or individuals within these groups. In fact, ASCE research found that most agencies have had remarkable success in fulfilling their ever-expanding missions with less funding and fewer personnel.

A challenge in producing the report card was to maintain focus on statewide issues and avoid being overly influenced by local needs. An individual municipality or county could merit a grade significantly different than the grade given to the state as a whole. Performance of individual local communities could be measured against Colorado's infrastructure, but that would be best accomplished with a separate local evaluation. ASCE encourages the evaluation of local infrastructure, especially for multi-jurisdictional metropolitan areas.

Another difficulty posed in producing the report card was recognizing where infrastructure was under the "care" of the state, and where infrastructure was more market driven.



Examples of market driven sectors include the deregulated power industry and other utilities, such as drinking water treatment that serve a population under a user-fee structure. In these sectors, data compiled by the state on a statewide basis was not necessarily expected. In contrast, sectors that are under the "care" of the state were also graded according to the expectation of quality record keeping and data collection for that infrastructure throughout the state.

Infrastructure security has recently become an issue of heightened awareness for our nation, our state, and our communities. The full scope of this issue and the many needs and concerns that have been identified are currently under review by numerous professional groups and governmental agencies. This report card does not specifically address infrastructure security in Colorado; nevertheless, it is becoming a critical issue and will certainly impact future financial, institutional, and legislative needs.

If we delay action—if we fail to address our infrastructure problem—we are in fact going to experience a significant degradation of our quality of life. In many ways what we need to do must be markedly different from our previous actions, and that becomes an enormous challenge.



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# QUALITY OF LIFE, GROWTH, AND INFRASTRUCTURE

We could not flourish without infrastructure. Impressive as that may sound, the reality is that it is only a part of our overall quality of life. In the big picture, other facets of our built environment affect infrastructure effectiveness and each other. Where does the bus line go? Does my commute have to be so long? Is the water shortage going to affect my business or me? Why can't they connect that one section of road? Is urban sprawl sustainable? Given that the state's population is projected to grow from 4.7 million to more than seven million residents over the next two decades, how can Colorado grow in smart ways that minimize infrastructure costs and maximize quality of life?

Infrastructure is a necessary but insufficient ingredient to quality of life. In order to live healthy lives, our built environment must also be practical and well designed. It is not enough to build more infrastructure – it must also be done smartly. In fact, less may be more in terms of quality of life. Especially in larger metropolitan areas, it is entirely possible to have firstrate, well-designed infrastructure and a poor quality of life. To have excellent quality of life also takes leadership – vision, wisdom, cooperation, and integrity. Our leaders must put these pieces of the puzzle together. No one wants to live in a place where the pay is low, the commute is long, the air is dirty, the housing is expensive, access to roads is poor, or where there is a water shortage.

Governments use tools to help them put the pieces such as land use planning, zoning laws, special districts, and water rights together. All too often, however, there is insufficient cooperation between neighboring communities and no mechanism for mutual benefit. This leads to the development of communities that are physically in a metropolis but their built environment and infrastructure is discontinuous, if not incongruous. Another example is the challenge of achieving integrated planning of transportation and land development on an area-wide basis. Again, the issues of private property rights and autonomous jurisdiction clash with solutions for the "greater good" of the area. And, in the U.S., we generally do not consolidate metro area approvals of land use and transportation within a single agency such as done in some places for instance, Canada.

One of the root causes of the difficulties governments experience in putting the pieces of the puzzle together lies in the American ideal of private property and autonomous jurisdictions. For example, it is difficult to convert agricultural water for municipal use. Because of water rights, someone cannot be forced to sell their water. Nor is it easy to prevent a county or municipality from allowing a developer to build homes on the frontier of suburbia.

Our leadership in state and local government must strive for cooperative regional arrangements to provide a great quality of life in Colorado now and as the state grows.



These arrangements must have enough authority and funding to make a lasting and measurable impact on how the built environment is put together. Such planning and vision will ensure that infrastructure is put to its highest possible and most efficient use. Decisions made over the next five to ten years about infrastructure investment and maintenance will have tremendous impacts on the fiscal and physical health of communities around the state for decades to come.

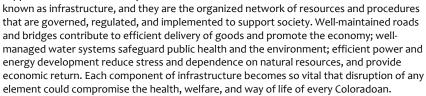


### **UNDERSTANDING INFRASTRUCTURE**

Our infrastructure allows us to make sweeping assumptions about how we live our lives, what we can get done, and how we conduct business. We hop on the road to run an errand, we flush our toilets, we turn on the tap, our trash is taken away, and we turn on the light. Anyone who has followed recent events around the world has probably noticed that, in much of the world, lack of infrastructure brings life almost to a standstill – Afghanistan, Iraq, and the levee failures in New Orleans, just to name a few.

During the years immediately following World War II, the U.S. built the greatest infrastructure in the modern world. As we move into the 21st century, however, we find that this infrastructure is deteriorating rapidly and that the need for rehabilitation and expansion to accommodate growth is urgent. The situation in Colorado is no different.

The ability of a society to progress and to flourish is a function of the systems and structures it has in place to support its activities. These systems and structures are



Unfortunately, infrastructure is, in the minds of most people, out of sight and out of mind. We are more frequently faced with crises because our infrastructure is wearing out, neglected, or simply insufficient. Moreover, crisis management is costly and, at times, extremely inconvenient. Planning, replacing, and repairing our infrastructure needs to become more routine, much like an oil change. The issue briefs provided in this guide describe 14 sectors of infrastructure that are the foundation of the quality of life and commerce in Colorado of which every citizen needs to be aware.



### REPORT RECOMMENDATIONS

Based on the overview of needs and deficiencies identified in this report a number of recommendations are made:

- The state legislature should enact a Colorado Infrastructure Improvement Act to establish a Colorado State Commission on Sustainable Infrastructure. Additionally, the legislature should establish a State Infrastructure Bank to finance identified infrastructure projects.
  - The Commission would study the present condition of the state's various infrastructure systems and report to the legislature and the people by 2010 on the capacity of our infrastructure to support our economy, the age and condition of the systems and possible methods to finance improvements. The commission's charge would be to ensure that the state's infrastructure will meet the current and future demands and that it will aid in the state's economic growth and in the preservation of the natural and human environment. The commission would be charged with developing infrastructure related legislation deemed necessary for the next 5, 25 and 50 years. A Colorado Infrastructure Bank would establish an independent entity of the state government to provide funding for qualified infrastructure projects. This effort would mirror the current European approach and a proposal currently before congress to develop a national infrastructure bank.
- 2. The governor has established a Colorado Transportation Finance and Implementation Panel to study transportation needs and trends. Implementation of their recommendations will be a critical first step in addressing overall infrastructure needs. In addition we must develop new approaches to Colorado's transportation and related land use planning or risk ending up losing out to more competitive metropolitan areas and states.
- 3. Colorado needs to support nation wide planning efforts for interstate commerce and energy. As the national government was crucial to the definition and funding of the interstate highway system in the 1950's, so today it must display leadership in rail and energy infrastructure development based on national goals.
- 4. Addressing deferred maintenance first is critical. Our first priority as a state should be to rebuild the state's crumbling infrastructure. If we do not, we risk the lives of our citizen's and the health of our economy. This is particularly a concern with water infrastructure where the problems are often out of sight under our feet.
- 5. To reverse the downward trend and improve our grade, we should strive for improvements in needs assessments, prioritization, contracting, planning and funding of infrastructure. As such, the Colorado Section of ASCE supports increasing such taxes as the gas tax and indexing it to inflation, as well as efforts to involve the private sector in planning, funding and implementation of needed infrastructure improvements.



### SUSTAINABILITY AND INFRASTRUCTURE

ASCE report cards address sustainability in terms of meeting demand, functioning well, and requiring a certain level of funding. But sustainability asks fundamental questions not only about long-term function, but also about depleting resources, far-reaching impacts, and influences on other infrastructure. In the context of infrastructure and sustainability, it is important to explore how infrastructure is built, what infrastructure is built, and should it be built. Sustainability also challenges the notion that infrastructure is categorically good and examines if "more is better."

### **ASCE Sustainability Activity**

ASCE has made a concerted effort to promote sustainability, from rural settings in undeveloped countries to the urban centers in North America. In 2005, ASCE convened a Forum of Technical Opportunities that was the beginning of integrating sustainability into ASCE policy and practice. The Committee on Sustainability was formed and is working towards a national program on Practice, Education and Research for Sustainable Infrastructure (PERSI). PERSI aims to develop the practices needed for sustainable renewal of America's infrastructure. The work of the committee and PERSI is further supported by "The Vision for Civil Engineering in 2025," published by ASCE in 2007. In that document, the civil engineers' role in a sustainable world is described as follows:

"The global civil engineering profession has increasingly recognized the reality of shrinking resources, the desire for sustainable practices and design, and the need for social equity in the consumption of resources. Civil engineers have helped raise global expectations for sustainability and for environmental stewardship. The profession has led world acceptance of green design and has been in the forefront in making environmental considerations part of life-cycle and cost-benefit analyses. Civil engineers have urged clients to use new, environmentally-friendly technologies to improve the quality of life in urban environments. Designs routinely incorporate recycling, either by using recycled materials, or by making project components recyclable at the end of their useful life. New processes, less harmful to the environment, have been implemented, and most new construction is based on green and smart-building technologies. Many new buildings actually produce more energy than they consume."

No infrastructure report card to-date has addressed sustainability head-on and this is a needed next step. In order to fulfill this need, knowledge gaps must be filled. These gaps include (as noted in the Forum report by Richard Wright, Dist. M.ASCE) performance criteria and models and measurements for sustainability of infrastructure systems that will reduce dependence on judgment to deal with important uncertainties. The Forum report also listed three system-level areas of practice that seem relevant to all infrastructure systems and projects:



- Dimensions of, Measurements of, and Systems Approaches to Sustainability including means for dealing with incommensurate environmental, social, and economic effects.
- Planning for Sustainability integrating infrastructure systems for sustainability at community, urban and regional scales.
- Geomatics for Sustainability spatial and geographical information for sustainable decisions in planning, design, construction, operation, and maintenance.

### Frameworks for Sustainability

First, it is important to note that scant literature on infrastructure exist that measure sustainability using a sustainability framework. Literature that attempts to evaluate priorities, spending, or provision between one or more sectors of infrastructure typically start with a financial framework and then identify costs and benefits of a spending decision. Other frameworks used are risk, performance (including resiliency), health, and participatory decision-making. Studies that actually use a sustainability framework include the smart growth scorecard approach (EPA 2008), pair-wise comparison of reciprocal criteria (Ziara 2002), systems-based sustainability assessment (Pearce 2003), and agent-based modeling using Fisher information (Zellner 2008). Also, although some studies recognize the need for and use a systems-based framework, they are typically targeted at a narrow set of infrastructure within an organization, enterprise, or jurisdiction.

This leads to the second important measurement aspect: scale. In the existing literature, none apparently deal with the urban/regional scale except the scorecards (EPA 2008) and ASCE report cards. Yet when urban-scale problems are tackled, they are invariably filtered through the framework of capital spending and sources of funding.

Although the scorecards and report cards employ fairly simple scoring and qualitative methods, it is exactly these that are adopted and understood most easily by the public and elected officials. Moving forward, it will be important to maintain this user-friendliness while providing defensible, qualitative and quantitative metrics of sustainability.

### A Report Card Accounting for Sustainability

What would an infrastructure report card look like if it were to take into account these sustainability aspects? It would include more than performance, capacity, and funding. It would also have to take into account existing infrastructure and potential retrofits, as well as new infrastructure. In fact, we also might question the very way we segregate our infrastructure into sectors. Let's revisit the definitions of sustainability and infrastructure.



#### Two definitions are helpful. ASCE Policy Statement 418 states that

...sustainable development is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development.

Also, Fang (2001) states that infrastructure is

...the entire set of basic and public availabilities (utilities) that support people's lives in a region, city, village or community. In general, infrastructure is immobile (locality-dependent) and has a long expected service life.

If these definitions are used as a guide, then a systems approach to evaluating and prioritizing infrastructure sustainability is needed because it encompasses the "public availabilities...that support people's lives..." So, a report card addressing infrastructure sustainability might package infrastructure into systems and these may or may not correlate with typical sectors such as roads, bridges, air quality, etc. In other words, our bridges may be sustainable, while our overall transportation system may not be. But whether or not we take a systems approach or a sector approach, sustainability must be measured and could include specific instances of the following:

- Function/performance metrics (partly addressed in existing report cards)
- Environmental impacts metrics (such as life-cycle assessment and resources depletion)
- Social equity metrics
- Economic metrics (partly addressed in existing report cards)
- Resiliency metrics
- Urban scale
- Cross-sector influences

Typical types of metrics could include weights of performance measures and benchmarking for money, energy, or a host of sector-specific quantities and qualities. For example, bridge sustainability might include qualitative *and* quantitative measures such as:

- "Does it use green materials?" or
- "Is it accessible to pedestrians and cyclists as well as cars?" or
- "What is the embodied energy of the concrete used in construction?" or



- "How much carbon dioxide will be released in the bridge's entire life-cycle/mass-flow analysis?" or
- "What is the economic benefit of the bridge in terms of commerce and reducing travel distance?"

Now, how does one reduce this information into an "A" or "B," etc. grade? As one can see, this is not a trivial exercise<sup>†</sup>. But complex or not, we must start to include the hidden costs and benefits of our infrastructure...sustainability demands it.

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To evaluate sustainability in a scientific manner, one might include value trees, network analysis, cross-correlation analysis, etc. But this has been shown to be complex, having little repeatability from one urban area to the next, and not easily grasped by the public or elected officials. However, several emerging tools and concepts could be employed that address these issues of complexity and user-friendliness: Fisher Information (a compiled metrics index), agent-based modeling, and emergy (embodied energy) within defined boundaries.



### **OVERVIEW OF GRADING SYSTEM**

Following the precedent set by the Seattle Section of ASCE, the Colorado review teams for each infrastructure sector assigned letter grades based on consideration of three general evaluation criteria: (1) condition and performance indices, (2) need versus capacity, and (3) funding versus need. Each review team had the flexibility to define specific criteria within these guidelines that was best suited to evaluating their infrastructure sector. The intent was to be able to compare grades between systems, while recognizing that the characteristics and quality of available data would be highly variable and a certain amount of subjective, but expert judgment was necessary.

**Condition and Performance.** The condition and performance indices characterize the physical condition of infrastructure in Colorado. The condition index scale below was provided as a general guideline for grading under this category.

#### Grade **Condition Index Condition Description** Α 85-100 Excellent: No noticeable defects. Some aging or wear may be visible. В 70-84 Good: Only minor deterioration or defects are evident. C 40-69 Fair: Some deterioration or defects are evident, but function is not significantly affected D 10-39 Poor: Serious deterioration in at least some portion of the structure. Function is inadequate. F 0-9 Failed: No longer functional. General failure or complete failure of a major structural component.

#### **CONDITION INDEX SCALE**

**Need versus Capacity.** For most infrastructure categories, this criterion relates to the demand on the systems, such as volume or use, versus what the systems are designed to accommodate. This is a critical evaluation criterion for Colorado because of our state's steadily increasing population and growth of communities. Some sectors were able to use a grading system based on the estimated percentage of demand that is currently met, or percentage of demand that is anticipated will be met in the future for the 2010 grade. A grading scale in 10-percent increments was suggested as a guideline, as follows: "A" = systems that can support 100% of demand, "B" = systems that can support more than 90% of demand but less than 100%, "C" = systems that can support between 80 and 90% of demand, and so on.

**Funding versus Need.** The third criterion for evaluating each infrastructure system reflects the status of funding that is dedicated to maintaining, replacing, and improving existing infrastructure, and to building new infrastructure that is needed to keep up with growth. Infrastructure systems need funding that is dedicated, indexed, steady, and long-term.



Dedicated funds such as user fees should be used only for the infrastructure systems for which these funds are raised. Indexing means that the funds need to increase as the use of the system increases. User fees and percentage taxes are examples of indexed funding. Maintenance and construction costs also need to be considered in the evaluation of funding. Steady funding provides for maintenance that extends the life of infrastructure. Long-term, multi-year funding plans should account for growth estimates so that projects can be designed and constructed in anticipation of needs, and not simply in reaction to inadequate capacity or problems caused by poor maintenance.



## INFRASTRUCTURE GRADES

Sector	2008	2010	Description
Dam Safety	В	C+	There are more than 3400 dams in Colorado, including over 300 high hazard dams. Colorado Division of Water Resources (DWR) administers dam safety, and has restricted operation of 9.6% of the state's dams (193 dams) because of deficiencies. DWR and federal dam safety programs are doing a good job of ensuring public safety through adequate inspection, review, and enforcement actions. However, public funding in the form of low-interest loans or grants is needed to facilitate owner responsiveness in repairing or upgrading to current standards their deficient and aging dams.
Water Supply	С	С	The recent drought has exposed the state's vulnerability to severe water supply shortages. By 2010, the state will have 20% more residents, while reservoir storage capacity has fallen behind since 1970 from 1.5 to below 1 acre-foot per person. Municipal conservation efforts have succeeded but only freed enough water for only a few years of growth. Due to the state's legacy of water rights, the state can have little influence on water resources planning and there is typically little coordination between water providers. Ideally, the state will continue to foster dialogue, smart storage, and provide financial incentives for resource allocation within the property and water rights structure.
Drinking Water	С	C-	Colorado's drinking water infrastructure is satisfactory condition currently, with the future dependent on continued funding and establishment and implementation of asset management plans. With a user-fee income base, this sector is more immune to budget uncertainties. Water distribution systems continue to age and deteriorate.
Wastewater Treatment	C+	С	The current treatment infrastructure is in adequate condition, while the future state of this sector is dependent on continued funding. Tracking needed maintenance and system improvements, supported by appropriate asset management practices will ensure that utilities can continue to maintain sufficient levels of service. With a user-fee income base, this sector is more immune to budget uncertainties.
Aviation	B+	В	The investment in DIA has clearly paid-off and provides Front Range communities excellent connections to the world. Funding for aviation at the federal and state level has increased in recent years and should provide sustainable funding for operations. Future access to commercial service at secondary airports appears to be waning as airlines restructure operations for financial viability.
Roads	D+	D	Colorado investments in the roadway network are not keeping up with growing demand. Over 40% of highways are rated as having poor condition. There is a significant backlog of bridges needing reconstruction or expansion. Congestion problems are well known. State and federal funding has been impacted by the current recession and increase in price of fuel. Additional funding is needed to maintain and expand the roadway system.
Environmental Cleanup	B-	C+	Cleanup of high-risk active hazardous waste sites in Colorado has historically been slow, but the pace of cleanup has quickened. Cleanup of inactive sites is good, about one-third complete. Leaking underground storage tank site cleanup is good but funding is marginal. Mind land reclamation proceeds at a steady pace, but at current projections it will require more than 25 years and \$75 million to be completed.



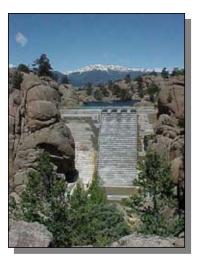
Sector	2008	2010	Description
Solid Waste	B-	B-	Land filling is the most widely used solid waste disposal method in Colorado, with 186 landfills operating statewide. The Colorado Department of Public Health and Environment (CDPHE) estimates that over 27 million cubic yards of municipal solid waste was generated in Colorado in 2002, with per capita daily waste production in the state exceeding national averages. The CDPHE estimates that there are about 50 years of life remaining in Colorado landfills. Improvements could be made in procedures for tracking current and remaining landfill volumes, and recycling efforts in the state to reduce the state's high per capita waste production.
Air Quality	C+	B-	The Colorado Air Quality Control Commission reports that billions of pounds of air pollution are generated every year across the state of Colorado from natural and man-made sources. Some of these pollutants are known to cause respiratory irritation and long-term health impacts in humans and can even cause far-reaching environmental impacts to agriculture and drinking water across the U.S. However, since 1995, despite population growth, Colorado's air quality has improved. The U.S. Environmental Protection Agency Recently tightened the air quality standard for ozone. Resulting in the creation of a front range non-attainment area.
Bridges	B-	C-	As of 2007, 17% of Colorado's bridges are structurally deficient or functionally obsolete. This number is expected to increase dramatically in the next 10 years as the bridges that were built in the 1950's during the construction of the Interstate System reach their 50-year life span.
Education	С	D+	Declining college enrollment and graduation rates are a concern. A significant number of engineers are eligible for retirement in the next ten years and will have to be replaced
Energy	C+	D	Although Colorado currently meets its electrical needs with a 15% reserve margin, existing transmission lines to other regions are limited, isolating our state from the region's power grid. With increasing growth in our state, lawmakers and the general public must eliminate their "NIMBY" (Not In My Backyard) attitudes to allow for new generation and transmission capacity that will keep up with Colorado's increasing urbanization.
Mass Transit	С	D+	Though the Regional Transportation District has made recent investments in the Denver area that have been effective and well received, much of the remainder of the state suffers an acute lack of access to transit. This primarily impacts the elderly, poor, and disabled that are not able to drive. State funding to supplement local efforts is required to provide a basic and functioning transit network.
All Sectors	C+	С	

Note: Overall Grades computed based on the following midpoint values:



### DAM SAFETY

### **Colorado Dam Safety Programs**



There are more than 3,400 dams in Colorado of which 1,800 are "Jurisdictional Size" resulting in regulatory oversight by the Colorado Dam Safety Program. Dams are a vital part of our state's infrastructure that not only ensure adequate water supply for cities and towns, but provide flood protection, irrigation water, hydropower, and recreational facilities for our citizens as well.

Over 300 of Colorado's dams are classified as "high hazard"; defined as a dam whose failure or mis-operation is likely to result in the loss of human life. Dam safety programs are a critical element to responsible stewardship of dams. Dam safety involves government regulation to ensure that periodic maintenance, inspection, emergency action planning, and other key practices are adhered to by dam owners and operators.

Trout Creek Dam

The table below shows a breakdown of the ownership of high hazard dams in Colorado in 2000. Private entities and local governments (mostly municipalities) own a large percentage of the high hazard dams in the state. The Colorado Division of Water Resources (DWR) administers dam safety for these structures, as well as state-owned and utility-owned dams. Of the 55 major federal dams in the state, the U.S. Bureau of Reclamation (BOR) owns 48, the U.S. Army Corps of Engineers (USACE) owns five, and one is operated by the U.S. Fish and Wildlife Service. These federal agencies each have their own dam safety programs, independent from the state DWR program. However, the Colorado DWR works closely with the federal agencies. This partnership is key.

HIGH HAZARD DAM OWNERS IN CO

Owner Type	Number of Dams
Federal	55
State	18
Local Government	84
Private	134
Utilities	29
Total	320

Note: From National Inventory of Dams, April 2000



### **Condition of Dams in Colorado**

About half of the high hazard dams in Colorado are over 50 years old (Colorado State Division of Water Resources). As dams get older, problems can develop, as follows:

• Long-term seepage in embankments and foundations may lead to progressive internal erosion of soil materials or dissolution of soluble minerals that could lead to unsafe pore water pressure buildup or piping failures.





Seepage Erosion Around an Outlet Pipe

Deterioration of Concrete Facing

- Sediment accumulation in reservoirs reduces the water resource and flood storage capacities and may contain contaminants from upstream basin areas.
- Increased development in areas both upstream and downstream place many dams in different land-use settings than when they were originally constructed, altering both surface runoff conditions and downstream hazards.
- Deterioration of pipes, gates, valves, and other concrete and metal structural and mechanical components.

DWR maintains a "restricted list" of dams that are not allowed to operate at full reservoir storage capacity. In 2007, there were 193 dams in all hazard categories on this list. According to DWR, 17 of Colorado's high hazard dams are considered "unsatisfactory," meaning that dam safety inspections indicated definite signs of hydrologic inadequacy or structural distress that could lead to failure of these dams if they are operated at full storage capacity. An additional, 92 high hazard dams are categorized as "conditionally satisfactory," meaning that the safety inspections revealed symptoms of structural distress, such as excessive seepage and evidence of major displacements that could lead to failure of the dam if conditions worsen.



### **Development of the Grade**

### **Grading Criteria**

A composite grade was computed using three criteria: (1) condition index, (2) need versus capacity, and (3) funding versus need. Only high hazard, or Class I, dams were considered in the condition index evaluation. By DWR definition, a Class I dam is a dam for which loss of human life is expected in the event of dam failure. Each criterion was equally weighted to compute the overall composite grade. The grading criteria definitions that were used by the Colorado Section of ASCE's Dam Safety Advisory Board in 2003 are described as follows:

**Condition Index.** The condition index criterion characterizes the *physical condition* of dams in Colorado. Condition index scales are shown in the table below. The General Scale is comprehensive, and was used for grading in other infrastructure categories. The federal agencies chose to use this scale for rating their dams. DWR used a simplified condition index scale that is more compatible with that agency's inspection criteria to rate its dams.

#### **CONDITION INDEX SCALES**

	General Scale	Colora	ado Division of Water Resources Scale		
Grade	Condition Description	Grade	Condition Description		
Α	Excellent: No noticeable defects. Some aging or wear may be visible.	Α	Satisfactory: The safety inspection indicates no conditions that appear to		
В	Good: Only minor deterioration or defects are evident.	or B	threaten the safety of the dam, and the dam is expected to perform satisfactorily under all design loading conditions.		
С	Fair: Some deterioration or defects are evident, but function is not significantly affected		Conditionally Satisfactory: The safety inspection indicates symptoms of structural distress (for example, seepage		
C-	Marginal: Moderate deterioration. Function is still adequate.	С	and evidence of major displacements) that, if conditions worsen, could lead to failure of the dam. Essential monitoring, inspection, and maintenance must be performed as a requirement for continued full storage.		
D	Poor: Serious deterioration in at least some portion of the structure. Function is inadequate.		Unsatisfactory: The safety inspection indicates definite signs of hydrologic inadequacy or structural distress (for		
D-	Very Poor: Extensive deterioration. Barely functional.	D	example, excessive seepage, cracks, slides, sinkholes, and severe deterioration) that could lead to failure of the dam if operated at full storage capacity.		
F	Failed: No longer functional. General failure or complete failure of a major structural component.				



**Need versus Capacity (Manpower and Assets).** This criterion, as defined by the advisory board, pertains to the adequacy of the *dam safety programs* that operate in Colorado. With regard to dam safety programs, the "need" is for adequate dam safety inspections, monitoring, record keeping, and emergency preparedness plans at federal, state, and local levels. The advisory board attempted to define a "grade" for the dam safety programs that considered the technical adequacy of the programs, and their current capacity in regard to manpower and assets such as number of inspectors and support staff, available tools, and possibly other considerations.

Funding versus Need for Dam Rehabilitation. The advisory board chose to define this criterion on the basis of funding needed for dam rehabilitation to renovate deficient facilities to current dam safety standards. Roughly half of the dams on DWR's restricted list have been listed for 10 years or longer. This is interpreted to reflect lack of funding to make the repairs or upgrades needed to remove the restrictions. Colorado has no state grant programs for such projects. Loans are available for local government and private projects through the Colorado Water Conservation Board Low Interest Loan Program, but these loans are underutilized because dam owners are unwilling or unable to take on even these low interest debts. The bond authority of the Colorado Water and Power Development Authority is another funding source for entities that can issue bonds. As the current, nearly unprecedented drought continues, Colorado's water supply issues have come into sharp focus. Recent news reports and articles have highlighted the need to repair and rehabilitate existing dams and reservoirs that cannot be filled to capacity because of structural flaws.

The U.S. Natural Resources Conservation Service (NRCS) built 152 flood control dams in 22 watersheds in Colorado. In 2003, NRCS estimated that 16 of those dams that were built to protect agricultural lands now have homes or other structures built in their downstream flood plain. The agency estimated that 33 of the dams it built under Colorado's Small Watershed Program will have significant and adverse environmental, economic, and social impacts if not repaired. NRCS estimated in 2003 that \$28 million was needed to rehabilitate these dams alone. Federal funding for repair of NRCS dams has been approved through PL-106-472, the Small Watershed Rehabilitation Amendment of 2000, which was enacted on November 9, 2000 and authorizes NRCS to assist local project sponsors with rehabilitation of their aging dams under a 65% federal cost-share structure. The legislation defines rehabilitation as "... the completion of all work necessary to extend the service life of the structural measure and meet applicable safety and performance standards." A dam that is rehabilitated under this program must meet all current NRCS, as well as local, state, and federal laws, and must have a designed life span of at least 50 to 100 years (NRCS Watershed Rehabilitation Information).

BOR has completed the dam safety remediation activities on all four dams at Horsetooth Reservoir near Fort Collins. The construction cost for this work was approximately \$77 million. This is an indication that adequate funding is available in at least a part of the federal sector to correct dam safety deficiencies in Colorado and other states.



#### **Data and Computation of Composite Grade**

Composite grades for high hazard dams under their jurisdiction were developed by each of three agencies: (1) DWR (this includes state, local governments, private, utilities, and some federal dam owners), (2) U.S. Department of the Interior (DOI) (this includes dams owned and operated by BOR and the U.S. Forest Service), and (3) USACE dams. Only high hazard dams were considered in the grading. The following point scale was assigned to compute the grades: "A"=4, "B"=3, "C"=2, "D"=1, and "F"=0. The table below summarizes the number of dams and the grades under each criterion in 2003.

### DAM SAFETY DATA FOR HIGH HAZARD DAMS IN COLORADO (2003)

	Criterion 1 (Condition Index)					Criterion 2 Criterion 3			
Agency	"A"	"B"	"C"	"D"	GPA	(Capacity)	(Funding)		
DWR	88	71	89	17	2.87	3.0	2.0		
DOI	42	3	2	0	3.85	4.0	4.0		
USACE	0	2	3	0	2.40	2.8	2.4		

The weighted average grade for all dams based on number of dams under each sector in the high hazard (Class I) classification was computed based on the composite grades for dams from each agency and DWR. The composite grade for each agency was computed by giving equal weight to each of the three criteria. The results are presented below.

#### COMPOSITE GRADES FOR COLORADO DAM SAFETY

	No. of High		Composite		
Agency	Hazard Dams	1	2	3	Grade
DWR	265	2.87	3.0	2.0	2.62
USDOI	47	3.85	4.0	4.0	3.95
USACE	5	2.4	2.8	2.4	2.53

The overall composite grade (G) for Colorado dam safety in 2003 was computed by weighting the composite grades for each agency according to the ratio of the number of high hazard dams under their jurisdiction to the total number of high hazard dams in the state (317) as follows:

G = 
$$[2.62 \times (265/317)] + [3.95 \times (47/317)] + [2.53 \times (5/317)]$$

$$G = [2.62 \times 83.6\%] + [3.95 \times 14.8\%] + [2.53 \times 1.6\%]$$

$$G = 2.82 = B$$

The completion of the remedial construction at the four Horsetooth Reservoir dams increases the Composite Grade for the 47 USDOI dams, bringing it from 3.95 to about 4.00. This report card update assumes the other agency dam safety grades have remained unchanged.



#### Grade for 2010

The high quality of the state and federal dam safety programs in Colorado was anticipated to remain among the best in the nation. This would help maintain the long-term grade as long as adequate funding levels for these programs are maintained. In addition, the physical condition of existing high hazard dams in Colorado is expected to continue to decline over the next several years unless funding is made available to upgrade deficient facilities. Mechanical systems such as gates, valves, and pipes) and concrete components are especially vulnerable to aging. Based on these considerations, the 2010 grade is expected to drop to a "C+."

### Recommendations

The recommendations in the 2003 report card were as follows:

- Establish a state grant program to facilitate dam rehabilitation and restoration of water storage currently prevented by restrictions.
- Support additional federal funding for the NRCS small watershed dam rehabilitation program in Colorado.
- Establish a program to facilitate the local sponsor matching funds required for NRCS program dollars to flow to Colorado; possibly a combination of grants and low interest loans. These funds would go, in large part, to sponsors (dam owners) who have the matching funds.
- 4. Support Colorado's presently successful state dam safety program with increased funding levels.

This report card update believes these four recommendations have not yet been addressed.

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### WATER SUPPLY

### Water Supply in Colorado

At the time of the 2003 report card, Colorado was in the middle of a drought from which the state has recovered to a degree, especially during the winter of 2007/08. Colorado is a semi-arid state with an average yearly precipitation of approximately 15 inches. This moisture is not distributed evenly and ranges from more than 20 inches in the mountains to less than 12 inches in areas like the San Luis Valley, Pueblo, and Grand Junction. When compared to other western states, however, Colorado is considered to have an abundance of water due to its mountain



Dillon Reservoir

snow pack. Colorado contains the headwaters for the Colorado, Rio Grande, Arkansas, North Platte, and South Platte Rivers. Colorado's rivers provide water not only to its own population but to a large part of the western U.S. as well. Today, Colorado uses about 6.1 million acre-feet (AF) of surface water while approximately 10 million AF flows out of the state on an average annual basis. Colorado continues to experience water scarcity and factors other than water quantity has become important considerations.

Remarkably, Colorado's unprecedented growth of the last decade has been achieved with limited development of new water storage, relying primarily on above average precipitation, water conservation that maximizes the yield of existing facilities, groundwater use, and the conversion of existing water rights (primarily agricultural) to new uses. Lifestyles in Colorado have seen many changes over the years from the early mining days that brought people to the state seeking gold, silver, and other riches, to a growing agricultural economy through the first half of the 1900s, to a recreational paradise that provides a wide variety of outdoor activities and supports tourism. Many of the state's newest residents fail to appreciate not only these lifestyle changes, but the source of the water supplies that sustain the lifestyles they now embrace and the changes in the landscape that have resulted from the growing communities in which they reside. Even long-time residents fail to understand the full extent of this transformation on a statewide basis, aware only of the changes that personally impact them (Colorado Water Conservation Board [CWCB] 2002a). Furthermore, as lifestyles are modified, the battle over how water is used intensifies and the challenge to provide for new uses with limited supplies increases.

#### **Compacts and Water Rights**

As noted earlier, Colorado is the source of many rivers and must meet the needs of not only its citizens but those in downstream states that rely on those rivers as well. In general, the method of allocating water throughout the western U.S. has been the Doctrine of Prior



Appropriation or "first-in-time, first-in-right." In 1922, the federal government began to negotiate contracts called "compacts" that allocated the water of various rivers (including all major river basins in Colorado) among the states. Compacts were intended to provide certainty as to how much water each state was entitled to.

In December 2007, a set of interim guidelines on how to allocate Colorado River water in the event of shortages was signed by the Secretary of the Interior. The guidelines are described as interim because they extend through 2026, and are intended to allow the system operators to gain experience with low-reservoir conditions while the effect of climate change on the Colorado River flow is further evaluated.

Colorado water rights doctrine dictates who owns the rights, and for what purpose the water may be used. The Doctrine of Prior Appropriation is used to assign water rights based on beneficial use combined with the "first-in-time, first-in-right" seniority system. During the last 40 years, most river basins in Colorado have become over-appropriated (on an average annual basis, more water rights exist than there is physical supply available). In dry years, typically only the most senior water rights holders receive their full water allotment. However, in an average water year, even most of the junior water rights holders receive some water.

#### **Planning**

Colorado does not have a state water plan per se. This is due to the fact that: (1) Colorado's Constitution provides that the right to appropriate water shall never be denied; (2) compacts are different in each major river basin; and (3) the "Doctrine of Prior Appropriation" is used to allocate water. It has been stated that the "Doctrine of Prior Appropriation" is the state water plan. Given these factors, the best statewide planning scenario possible is one that describes supply and demand by basin and encourages cooperation and partnerships among the various water providers in each basin. The Colorado Water Conservation Board (CWCB) has prepared fact sheets that depict water supply and demands in each major river basin. Water development and drought planning are currently the responsibility of each individual water provider. The state has a drought response plan (the Colorado Drought Mitigation and Response Plan), which was developed to provide an effective and systematic means to reduce impacts of water shortages over the short or long term. This plan was activated for the first time ever on April 24, 2002. This measure, however, is not proactive (it deals with lessening the impacts of drought instead of preventing the impacts of drought). The plan was not intended to address local water supply and demand management issues, which are left to the water provider.

In 2000, CWCB surveyed water providers that produce 2,000 AF or more of treated water per year to evaluate the extent and level of drought planning in Colorado. The results from 67 municipalities showed that:

- 49% had done some form of drought planning
- 53% had a master water supply plan
- 22% had a hydrology study considering drought
- 74% had a water conservation plan



In reviewing the hydrology studies, only about 4% included a robust, risk-based drought analysis. Many municipalities appeared to have designed their water systems assuming an average water year (CWCB 2000). While these percentages should increase as a result of the current drought, they reflect a need for more planning by individual water providers.

CWCB and DWR are currently developing Colorado's decision support systems (CDSS) for the state's river basins. The purpose of the CDSS water management system is to assist water users and managers to make timely, informed decisions regarding historic and future use of water. At the end of 2002, decision support systems (DSS) were complete for the entire Colorado River basin and nearly complete for the Rio Grande basin. Eventually, CWCB and DWR plan to complete DSSs for the entire state (CWCB and Colorado Division of Water Resources 2003).

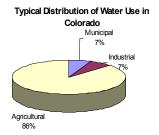
CWCB also conducted the Colorado Drought and Water Supply Assessment to evaluate how prepared Colorado has been for drought and to identify measures that will better prepare Colorado for the next drought (CWCB). CWCB also performed the Statewide Water Supply Initiative (SWSI). The overall objective of SWSI was to help Colorado maintain an adequate water supply for its citizens and the environment. The SWSI was not intended to take the place of local water planning initiatives. Rather, it was a forum to develop a common understanding of existing water supplies and future water supply needs and demands throughout Colorado, and to present possible means of meeting those needs (CWCB). Funded at \$2.7 million, SWSI was to be a comprehensive project that was completed at the end of 2004. Among SWSI's findings was the fact that estimated statewide water demand growth from 2000 to 2030 is expected to increase by 53% or about 630,000 AF of water.

#### Drought

From a hydrological perspective, the drought that peaked in 2002 was one of the worst on record. Stream flows in 2002 were typically the lowest recorded, with tree ring data suggesting the lowest flows in more than 300 years. This drought reached all of Colorado in 2002 as evidenced by water supply emergencies in Rocky Ford, Beulah, Victor, Cripple Creek, and Penrose; mandatory water restrictions by numerous municipalities; an estimated \$1.1 billion impact to agriculture, tourism, and recreation; critical or near-critical water level designations for 19 public water systems by the Colorado Department of Public Health and Environment (CDPHE); and empty irrigation reservoirs on the eastern plains in August 2002 (CWCB 2002b).

#### **Uses of Water**

Average consumptive use of water is allocated between agricultural use, municipal use, and industrial use according to the figure shown at right:





On a statewide basis, the 5% of land area in the state that is irrigated is vitally important to agricultural production. Although conversion of agricultural land to municipal use is accelerating, the contribution of Colorado's agribusiness to the state economy remains steady and comprised 2.2% of total state income in 1997, while contributing 10% to 50% of the local income in 20 agribusiness-dependent counties (CWCB 2002a). Of greater significance is the more than 90% of the state's income that is dependent on municipal and industrial supplies and recreation that relies on the waters left in the river for the benefit of downstream states pursuant to interstate compacts.

#### Supply and Demand

The 2000 census revealed that Colorado's population grew to 4.3 million people in the last decade, a 30.6% increase. This was more than twice the national average growth rate of 13.2% (U.S. Census Bureau 2000). Colorado ranked as the nation's third fastest growing state by percent. Eight of the nation's 18 fastest growing counties were in Colorado. Population projections for Colorado indicate a growth rate greater than the national average through 2010, resulting in an estimated 2010 population of 5.1 million people.

Numerous studies concerning water supply, demand, reuse, and conservation have been undertaken in the past. Typically, these have been at the regional or river basin level and have varied greatly in level of detail and scope. None have been at the state level. The broadest study was the Colorado Farm Bureau's "Colorado Water Development Study," originally issued in January 1997 and updated in 1999. Note that this study was limited in scope and water user response. The study found that annual consumptive use in Colorado is approximately 6.1 million AF in an average year. Also, seven river basins are currently near the limits of depletion or consumptive use based on in-state use or interstate compacts. The Colorado River and South Platte River basins have potential for additional development, but this may be as little as 450,000 AF, most of which is in the Colorado River basin. In contrast, the state will require an additional 1 to 1.45 million AF of water supply by the year 2100 to meet growing municipal and industrial demand (agricultural demand will be approximately the same or decrease somewhat) (Colorado Farm Bureau 1997 and 1999). This is a major concern as the water remaining to be developed pursuant to interstate compacts is likely less than this amount. Conversion of existing water rights, primarily from agriculture, will be required to meet this demand, along with additional storage to regulate seasonal flows. The Farm Bureau's study concluded that, based on dry year water yields, the state may experience a shortfall in water supply as early as 2010 (Colorado Farm Bureau 1997).

#### Storage

Because the overwhelming majority of water use is supplied by surface water, most of which occurs during snowmelt runoff, storage and other management techniques are required to meet the location and timing of the user's need. For this reason, a main factor in water supply management is reservoir storage. Colorado reservoir storage capacity grew tremendously after droughts in the 1930s and 1950s. Around 1970, active reservoir storage per capita in Colorado peaked at approximately 1.5 AF per person and has been steadily declining.



By about 1990, total statewide active reservoir storage capacity exceeded 4 million AF, but the population is growing faster than new surface water supplies and reservoirs are being developed (CWCB 2000). Current reservoir storage per capita is about 1 AF. Without any additional storage capacity, reservoir storage per capita in 2010 is projected at less than 1 AF. There are a number of major obstacles to constructing new reservoir storage that must be overcome. These include funding, political, environmental, and other issues.

### **Development of the Grade**

#### **Grading Criteria**

A composite grade was computed for 2003 and 2010 using two criteria for each year as follows: (1) need versus capacity and (2) funding versus need. A condition index was not calculated for Water Supply since the Dam Safety section already covers storage facility conditions. A general 10 percent grading system was used as shown below.

Grade	Percent of Demand Met
Α	90 to 100
В	80 to 89
С	70 to 79
D	60 to 69
F	Below 60

#### Need versus Capacity (Supply versus Demand) in 2003

While comprehensive data does exist for portions of the state, such data are not available across the state and its development is slow. Consequently, it is difficult to provide a numerical grade for need versus capacity, but the grade assigned in 2003 was a "C-," considering that:

- The broadest water supply study was completed several years ago and is limited in scope and response (SWSI is in progress but is not complete),
- The ability to develop a statewide water supply plan is limited because comprehensive water supply and demand data is not updated on a regular basis.
- Cooperation and partnerships among the various water providers could be greatly improved.
- There is a lack of planning by water providers.

#### Funding versus Need in 2003

Funding for water supply projects is primarily available through CWCB and the Colorado Water Resources and Power Development Authority (CWRPDA). Also, smaller loans with low interest



rates are available to small communities through the Colorado Department of Local Affairs and the U.S. Department of Agriculture and DOI. These agencies typically have more funding than is requested because many water providers and their rate payers (typically agricultural and small communities) are unable or unwilling to take on this debt. The maximum loan limit from these agencies is through the CWRPDA and is \$100 million per borrower per project. If a future large reservoir project is recommended by a statewide planning effort, these loan limits could impede construction. The 2003 Colorado legislature was working on bills to authorize bonds for large reservoirs that were identified through the SWSI, but none have been constructed yet.

Available funding exceeded the amount requested by water providers, but many providers were not applying for loans because they did not have a formal plan to pay them back, or would have to raise user rates to do so. In these cases, the water provider may have reduced capacity, thereby reducing a water user's supply. This may be acceptable in some cases and not in others. The grade for Funding versus Need in 2003 was a "C+."

#### Overall Grade for 2003

The overall, weighted grade for 2003 was a "C."

### Need versus Capacity (Supply versus Demand) in 2010

The state's Demography Section has projected a 2010 population of 5.2 million people, an increase of over 800,000 people when compared to the 2000 population. More than 75% of this increase will be along the Front Range. Typical water consumption is estimated at 0.25 AF per person annually. The population increase will increase Colorado's water demand by 200,000 AF in 2010 (assuming industrial and agricultural demand remains constant).

Completion of CDSS and SWSI provided valuable planning tools for water providers and should aid in meeting the future demand. Nonetheless, water planning and coordination is still the responsibility of the water providers and whether these tools are utilized remains to be seen. Consequently, the grade for need versus capacity in the year 2010 is a "C+."

#### Funding versus Need in 2010

In November 2003, Colorado voters voted down a \$2 billion bond proposal for water projects with a projected \$4 billion payback. Many water providers have not performed adequate planning and therefore have an accurate forecast of neither future needs and projects nor funding requirements. The grade for Funding versus Need in 2010 is therefore a "C-."

#### Overall Grade for 2010

The overall, weighted grade for 2010 is a "C."



### Recommendations

The state should follow the eight recommendations presented in the SWSI report.

Water providers should have a comprehensive water plan in place and update it on a regular basis. Water plans should be proactive instead of reactive (focus on providing enough water instead of how to deal with lack of water). The plans should include current and future conditions and consider the effects of various drought scenarios (that is, 10 year, 50 year, and 100 year).

Current and future water demand should be met through a combination of the following, which were addressed in the SWSI:

- Education,
- Conservation and efficiency
- Expansion or rehabilitation of existing reservoirs
- New water development projects
- Water banking/drought leasing from senior agriculture water supplies.

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### **DRINKING WATER**

### **Drinking Water in Colorado**

Colorado has 2,084 public water systems¹ in the state serving approximately 4.1 million people. When describing a drinking water system, there are conceptually two fundamental components that are involved with bringing safe drinking water to the public: (1) the cultivation, development, regulation, management, and storage of water supply to ensure that adequate water is available to a community; and (2) the treatment, conveyance, and delivery of the developed supply. Drinking water infrastructure includes all the vital components required to treat and convey safe drinking water to the public, while water supply infrastructure includes the



Another Coloradoan Enjoys Safe Drinking Water

storage aspects. The primary elements of drinking water infrastructure include four major categories: transmission and distribution, treatment, source and storage (though water supply storage infrastructure is described in further detail in the Water Supply section).

The least visible component of a public water system is the buried pipe that transmits and conveys water to the public. Transmission and distribution networks generally account for most of a system's capital value. Many water systems installed new transmission and distribution systems to keep pace with rapid population surges in the post World War II era, and Colorado is no exception. Naturally, these systems have begun to reach limitations in their design life. In general, pipes will require replacement within 50 to 75 years of their installation. Consequently, much of the pipe installed in the 1940s and 1950s may require replacement over the next 20 years.

Treatment of drinking water includes the installation or rehabilitation of infrastructure to reduce contamination through filtration, disinfection, corrosion control, and aeration. The majority of capital costs for proposed and evolving regulatory requirements are related to treatment. Treatment operations, practices, and subsequently costs are ever evolving, as new technologies, regulations, and solutions emerge.

The source aspect of drinking water infrastructure includes the construction and rehabilitation of surface water intake structures, raw water pumping facilities, drilled wells, and spring collectors. Certainly the impacts from the historic drought of 2002 have moved utilities across the western U.S. to reconsider water supply and, to the extent that supplemental supply from deep wells are available, this cost aspect is also evolving.

As defined by CDPHE, public water systems are sources of piped water for human consumption that are publicly or privately owned and have at least 15 taps or service connections, with regular service to at least 25 individuals for 60 days or more per year.



The amount of money needed for future investment in water infrastructure is a matter of some debate, and various estimates have been developed. The "needs surveys" of wastewater and drinking water systems conducted most recently in 1996 by the U.S. Environmental Protection Agency (EPA) has provided the most useful information pertaining to the nation. Water Infrastructure Network (WIN), and the American Water Works Association (AWWA) have performed other studies. The Congressional Budget Office has also analyzed future costs for water infrastructure on the basis of a probabilistic approach including high-cost and low-cost scenarios.

The federal government currently supports water system investment through the clean water state revolving fund (SRF), which receives capitalization grants through appropriation to EPA (and ultimately CDPHE); loan and grant programs of the U.S. Department of Agriculture's Rural Utilities Service; and the Community Development Block Grants administered by the U.S. Department of Housing and Urban Development. Notwithstanding those programs, the majority of the funding for drinking water services in the U.S., and Colorado, comes from local ratepayers and taxpayers.² Federal and state funding is estimated to account for less than 5% of what is typically needed, and is therefore not a sound measure of whether or not current funding levels are appropriate.

The scope of this report involved an assessment of each of these three components of drinking water infrastructure, although forecasts for treatment and source aspects proved more difficult in light of their evolving nature.

#### **Drinking Water Infrastructure Condition**

Groups such as AWWA, WIN, EPA, and the National representation of ASCE have attempted to document the condition of drinking water infrastructure across the nation. These various undertakings have yielded a wide variety of predicted needs, although a common and persistent sentiment among drinking water administrators is that a substantial increase in investment will be required over the next two decades in order to maintain high-quality drinking water systems. Replacement of pipes is likely to require the majority of future investment spending, though investment will also be needed for the maintenance of aging equipment at treatment plants and for improving water quality.

As the water distribution infrastructure ages, it becomes more and more of a challenge to assign limited capital expenditures to prioritize the repair, replacement, or rehabilitation of pipelines. There is a growing need by municipalities to find better ways to prioritize their future projects. In Colorado, some water utilities have adopted varying forms of subjective ranking systems to prioritize the rehabilitation of their pipelines. A smaller number of water utilities have done statistical analysis to predict failure of the pipelines, coupling the results with a cost-benefit analysis. The high cost of data collection to support such analyses remains one of the main reasons few water utilities have done statistical analysis to predict failures in their pipelines. Even when data are available, the daunting task of data compilation and

In 1999, federal and state grants provided just 2 percent of the revenues reported by 102 medium-sized and large wastewater systems. (Source: Association of Metropolitan Sewerage Agencies).



maintenance to support even a more subjective ranking system can be cumbersome, rigid, and not very user friendly. Implementation of computer programs written in second or third generation programming languages is usually left to a select number of analysts and engineers and results are shared through scrolls of hardcopy printouts.

Results of this analysis are indicative of the wide array of information uncovered. One of the most critical findings of the research efforts involved with this sector was in fact a lack of findings. Information available about existing water infrastructure is scarce, and where it does exist, it is limited in description. Several of the municipalities contacted in 2003 were unaware of any existing inventory with documentation of age or condition of vital infrastructure, and several of these same communities remarked that their capital spending budgets were based more on historical trends in spending rather than needs assessments or rate studies. Other communities had developed budgets that incorporated rate increases to fund complete system replacements for infrastructure older than 50 years, thereby possibly overestimating the needed investment. In summary, a grade representative of the condition of drinking water infrastructure was found to be of less value than a grade representative of the knowledge of the condition of drinking water assets. This sentiment is reflected in the following grade analysis.

# **Development of the Grade**

The approach to this report consisted of developing a composite grade using three criteria as follows: (1) condition index, (2) need versus capacity, and (3) funding versus need. However, since such a lack of knowledge pertaining to the condition of water infrastructure was revealed, the 2003 evaluation team agreed that the product of such an approach would provide little value. The condition index would have ideally served to provide the foundation for the remaining grades; however, since this foundation proved to be inadequate, basing further grading determinations upon such data would undermine the efforts of this study.

Given the dearth of any existing data documenting the current or future state of Colorado's drinking water and wastewater infrastructure, a direct outreach effort was pursued to gather pertinent data. This sort of effort was the first of its kind performed in the State of Colorado, and included public speaking at the Public Utilities Commission (PUC)<sup>3</sup>, in addition to direct opinion polling of utilities with a survey that was sent to more than 200 water and wastewater utilities<sup>4</sup>.

Water utilities serving the top 75% of the state's population were contacted in 2003. Of these, several declined to participate in the survey. Those that did participate represented 66% of the population served. The form used to conduct the survey is included at the end of this section.

The PUC affects approximately 3.4 million Colorado citizens. The PUC oversees about \$3.3 billion in annual revenue of the regulated fixed utilities. State law gives the PUC the authority to regulate the rates and services of public utilities within the state. By law, public utilities are defined as electrical, common carrier, pipeline, gas, telephone, telegraph and water corporations, which supply their services to the public.

The list of drinking water utilities included those listed in the 2001 Drinking Water Infrastructure Needs Survey report by EPA. The list of wastewater utilities included those listed in EPA's 1997 Clean Water Needs Survey.



The following table includes results from the polling effort with scored on a 1-10 scale (with 10 being the best, and 1 the worst) weighted to emphasize population served by the utility's drinking water infrastructure:

	Colorado Drinking Water Infrastructure		
	Today	2010	
Regulatory Compliance	9.32	8.95	
Funding Compared to Need	8.15	8.15	
Capacity Compared to Need	8.30	7.63	
Condition	8.22	7.67	

In addition, these utilities were asked to state whether they had an asset management plan. Of the drinking water utilities polled, utilities serving 33% of the population indicated that they had an asset management plan.

#### Grade for 2003

The grade was calculated giving equal weight to each of the five parameters (regulatory compliance, funding versus need, capacity versus need, condition, and existence of an asset management plan. Based solely on the results from this polling data, drinking water infrastructure in Colorado in 2003 was given a "C."

#### Grade for 2010

If drinking water infrastructure management continues in similar manner as it is today, and no attempts are made to develop asset management plans to accurately account for the operation, maintenance, replacement, and expansion of current infrastructure, there is a wide range of possible outcomes. For those systems which currently budgets capital needed to fund infrastructure into the future, the infrastructure will remain in fair shape, assuming that it is regularly replaced (as these budgets indicate). For those systems where current budgets are not adequate to fund the current backlog of repairs, and where system improvements will be continually demanded, it can be expected that a more severe degree of action will be required in the future. Based on the survey results and those utilities without an asset management plan will continue without one, the grade for 2010 is a "C-."

#### Limitations of the Study

The primary limitation of this study, as with opinion polls in general, is that it merely provides an estimate and is only indirectly founded upon defensible data. If ASCE had followed up with these utilities and asked them to provide data to justify the scores given, a wide range of data may have emerged. As this effort is the first of its kind to document the infrastructure's condition, such follow up did not occur in 2003, although it is recommended for future analysis.



Furthermore, though the asset management results were collected, they were not included as part of the grade. Asset management is a method to take care of the infrastructure, not an indicator of the state of the infrastructure itself. Results are also limited in that, while nearly all of the utilities were surveyed in 2003, many smaller utilities simply did not have the data.

### Recommendations

- Appropriate capital expenditures toward the development of comprehensive asset management programs, and develop inventory databases to evaluate asset conditions. In the short term, these expenditures will be significant and demand comprehensive reconnaissance efforts and data processing work. Long-term savings will surely be realized as capital investments will be made efficiently and based on needs. Furthermore, short-term expenditures spent on unexpected collapsing of infrastructure are much more costly than maintenance and replacement costs spent ahead of time. Endeavors such as the Pipe Evaluation System (PIPES)<sup>5</sup>, by the Seattle Public Utilities Department are prime examples of how asset management is performed most effectively. With the tremendous growth of geographic information system (GIS) implementations comes the demand to realize the benefits of such expenditures. The power of a GIS implementation to perform spatial analysis and ability to store vast amounts of data related to spatial features makes it an ideal tool to support the evaluation of pipelines.
- Water providers, municipalities, and utilities need to work with the public to promote
  the need for additional research, increase awareness of future challenges, to
  evaluate local rate structures, and adjust rates where necessary.
- Encourage state funding of inventory projects.
- Reassess needs upon gathering better knowledge.

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# WASTEWATER TREATMENT

### **Wastewater Treatment in Colorado**

Wastewater treatment is composed of the collection system, treatment works, and discharge system. The treatment works include the various physical, biological, and chemical processes that make the wastewater suitable for a wide range of uses. The majority of treated wastewater is released downstream in strict fulfillment of downstream water rights and interstate river compacts. A comparatively small amount of wastewater may be reused to extinction. This water is typically treated to a higher degree.



Typical Wastewater Treatment Plant

The majority of wastewater systems are small. For example, 58% of our nation's community wastewater systems serve 500 people or fewer, and 85% serve less than 3,300 people. In addition, there are many privately owned septic units serving households that are excluded from statistics on publicly owned treatment works.

In contrast, the greatest population served is through large, centralized wastewater treatment systems. Nationally, just 7% of community water systems serve more than 10,000 people each, but they provide 81% of those served by such systems. "Very large" systems, defined by EPA as those serving more than 100,000 customers, represent 1% of systems but 44% of all people served. Similarly, the largest 3% of wastewater plants handled 68% of the total flow processed by all such plants nationwide. In Colorado, the top 9% of wastewater plants handled 75% of the total flow processed.

In 1992, and then again in 1996, EPA conducted a needs assessment, accomplished through CDPHE, with respect to the nation's wastewater infrastructure. This assessment was performed on a state-by-state level to generate an accurate understanding of the condition of the infrastructure, and to facilitate the development of federal budget appropriations.

# Wastewater Treatment Infrastructure Condition

The federal government currently supports wastewater system investment through the clean water SRF, which receives capitalization grants through appropriation to EPA and CDPHE. Also included in the SRF are loan and grant programs of the Department of Agriculture's Rural Utilities Service and Community Development Block Grants administered by the



Department of Housing and Urban Development, Notwithstanding those programs, the majority of the funding for wastewater services in the U.S. and Colorado comes from local ratepayers and taxpayers. 6 Federal and state funding is estimated to account for less than 5% of what is typically needed, and is therefore not a sound measure of whether or not current funding levels are appropriate.

One of the most critical findings uncovered by the research efforts involved with this sector was a lack of findings. Information available about existing water infrastructure is scarce, and where it does exist, it is limited in description. Several of the municipalities contacted were unaware of any existing inventory with documentation of age or condition of vital infrastructure. A number of these same communities remarked that their capital spending budgets were based more on historical trends in spending rather than needs assessments or rate studies. Other communities had developed budgets that incorporated rate increases to fund complete system replacements for infrastructure more than 50 years old, thereby possibly overestimating the needed investment.

# **Development of the Grade**

Given the dearth of any existing data documenting the current or future state of Colorado's drinking water and wastewater infrastructure, a direct outreach effort was pursued to gather pertinent data. This sort of effort was the first of its kind performed in the State of Colorado, and included public speaking at the Public Utilities Commission, in addition to direct opinion polling of utilities with a survey that was sent to more than 200 water and wastewater utilities<sup>7</sup>.

Wastewater utilities serving the top 75% of the state's population were contacted. Of these, several declined to participate in the survey. Those that did participate represented 55% of the population served. The form used to conduct the survey is included at the end of this section. The following table presents summarized results from the polling effort with scored on a 1-10 scale (with 10 being the best, and 1 the worst) weighted to emphasize population served by the utility's wastewater infrastructure:

	Colorado Wastewater Infrastructure		
	Today	2010	
Regulatory Compliance	8.84	7.41	
Funding Compared to Need	8.02	7.00	
Capacity Compared to Need	8.59	7.77	
Condition	8.51	7.25	

In 1999, federal and state grants provided just 2 percent of the revenues reported by 102 medium-sized and large wastewater systems. (Source: Association of Metropolitan Sewerage Agencies).

The list of drinking water utilities included those listed in the 2001 Drinking Water Infrastructure Needs Survey report by EPA. The list of wastewater utilities included those listed in EPA's 1997 Clean Water Needs Survey.



In addition, these utilities were asked to state whether they had an asset management plan. Of the wastewater utilities polled, those serving 55% of the population indicated that they had an asset management plan.

#### Grade for 2003

The grade for 2003 was calculated giving equal weight to each of the five parameters (regulatory compliance, funding versus need, capacity versus need, condition, and existence of an asset management plan. Based solely on the results from this polling data, wastewater infrastructure in Colorado in 2003 was given a "C+."

#### Grade for 2010

If wastewater infrastructure management continues in similar manner as it is today, and no attempts are made to develop asset management plans to accurately account for the operation, maintenance, replacement, and expansion of current infrastructure, there is a wide range of possible outcomes. For those systems where current budgets overestimate the capital needed to fund infrastructure into the future, the infrastructure will remain in fair shape, assuming that it is regularly replaced (as these budgets indicate). For those systems where current budgets are not adequate to fund the current backlog of repairs, and where system improvements will be continually demanded, a more severe degree of action will be required in the future. Based on the survey results in 2003 and the assumption that those utilities without an asset management plan will continue without one, the grade for 2010 is a "C."

#### Limitations of the Study

The primary limitation of this study, as with opinion polls in general, is that it merely provides an estimate and is only indirectly founded upon defensible data. If ASCE had followed up with these utilities and asked them to provide data to justify the assigned scores, a wide range of data may have emerged. As this effort is the first of its kind to document the infrastructure's condition, such follow up did not occur, although it is recommended for future analysis.

Furthermore, though the asset management results were collected, they were not included as part of the grade. Asset management is a method to take care of the infrastructure, not an indicator of the state of the infrastructure itself. The results are also limited by the fact that, although nearly all of the utilities were surveyed, many smaller utilities simply did not have the data.



### Recommendations

- Appropriate capital expenditures toward the development of comprehensive asset management programs, and develop inventory databases to evaluate asset conditions. In the short-term, these expenditures will be significant and demand comprehensive reconnaissance efforts and data processing work. In the long-term, however, savings will surely be realized as capital investments will be made efficiently and based on needs. Furthermore, short-term expenditures spent on unexpected repairs to infrastructure are much more costly than maintenance and replacement ahead of time. Endeavors such as PIPES<sup>8</sup>, by the Seattle Public Utilities Department are prime examples of how asset management is performed most effectively. With the tremendous growth of GIS implementations comes the demand to realize the benefits of such expenditures. The power of a GIS implementation to perform spatial analysis and its inherent function to store vast amounts of data related to spatial features makes it an ideal tool to support the evaluation of pipelines.
- Water providers, municipalities, and utilities, need to work with the public to promote the need for additional research, increase awareness of challenges ahead, assess local rate structures, and adjust rates where necessary.
- Encourage state funding of inventory projects.
- Reassess needs upon gathering better knowledge.

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### AVIATION

### **Aviation In Colorado**

The aviation infrastructure of Colorado consists of 77 public use airports. These range in size from Denver International Airport (DIA) to small general aviation airports serving rural communities such as Sterling and Nucla. The Colorado mountainous topography increases the benefits of in-state travel. The Colorado aviation system allows efficient access to all regions of the state keeping Colorado competitive in today's global economy.

DIA remains the predominant aviation gateway for travelers flying into and out of Colorado to the rest of the world with approximately 619,000 operations and 49.8 million passengers in 2007. Over the



Denver International Airport

past five years operations have increased an average of 4% per year while passenger enplanements have grown an average of 7% per year. The completion of the 6th, and longest, runway at DIA has allowed the airport to grow at an average of over 23% per year over the past five years in international passenger traffic. DIA is one of the fastest growing large hub airports in the nation with 18 passenger airlines serving more than 140 destinations worldwide and nearly 1700 daily operations. The start and subsequent rapid increase of service at DIA by Southwest Airlines has added new opportunities and lower fares for passengers in the region. DIA's current footprint can accommodate 50 million passengers —which was almost reached in 2007. In preparation for anticipated growth, the airport has initiated work in the next phase of its master plan, which will plan for additional airside and landside space as well as a rail link to the downtown city core. The airport has immediate plans to add 10 gates on Concourse C as well as build an on-airport hotel.

Colorado has 13 scheduled commercial airports that serve the rest of the state besides. These airports include Colorado Springs Municipal Airport, Pueblo Memorial Airport, Durango – La Plata County Airport, Aspen – Pitkin County Airport, Eagle County Regional Airport, Yampa Valley Regional Airport, Alamosa-San Luis Valley Regional Airport, Cortez/Montezuma County Airport, Gunnison County Airport, Montrose Regional Airport, Telluride Regional Airport, Grand Junction Regional Airport and the Fort Collins/Loveland Airport. The airports serve to not only bring tourists to enjoy the reasons we live in Colorado, but to relieve congestion on surface transportation system and allow for air express mail and air ambulance services as well.

The general aviation airfields in Colorado provide limited passenger service and are intended for private aircraft operators, business aircraft operations and limited aviation services providers such as crop dusting, air ambulances, aerial photography, and recreational flying,



gliding, and parachuting. Centennial Airport located in Arapahoe County and Rocky Mountain Metropolitan Airport located in Jefferson County are two very busy general aviation airports serving the business needs of the Denver Tech Center and the Interlockin Business Park.

Airspace improvements are currently underway to increase capacity and safety throughout the mountains of Colorado in areas where there is a lack of radar surveillance. The project is a joint effort between FAA, CDOT, and local governments and is part of the FAA's National Next Generation Air Transportation System program. This first of its kind surveillance system will increase aircraft arrival rates in poor weather conditions from 4 arrivals per hour to 16-20 per hour. This will make the Colorado Aviation System a more viable transportation solution for tourist from around the world.

# **Development of the Grade**

The state of Colorado airport facilities and civil infrastructure is generally good. The massive investment to create DIA is generally viewed as a nucleus to the economic growth that Colorado has experienced in the past decade. Similar investments, if not of similar size, in the Colorado Springs Municipal Airport has resulted in a facility capable of becoming a significant regional airport.

The general condition of the airfield pavements at Colorado airports, a primary measure of the ability of airports to provide a high level of service, is generally good. From statistics provided by the Federal Aviation Administration (FAA), the overall condition rating is 86 out of a possible 100 for secondary Colorado airfields (not including DIA and Colorado Springs Municipal Airport) that receive FAA grants. This compares to Utah and Wyoming airports that have overall pavement conditions of 74 and 79 out of 100, respectively.

A large reason for the overall general favorable condition of Colorado airports is attributable to the Colorado Aeronautics Board, which provides airport grants from the Colorado Aviation Fund. This fund comes from an excise tax on aviation fuel and provides an average of \$6.5 million in grants for airport infrastructure maintenance and construction, which help leverage larger FAA funds for Colorado Airports. Colorado was the last state to create an Aeronautics Board and the results of doing so are beginning to show.

There are still unmet needs at Colorado airports that are beyond the current level of funding available from federal and state sources. The 2035 state transportation plan identifies \$8 billion in airport and aviation system needs over the 2035-planning horizon. Only \$6 billion is available to meet these needs in this period.

**Physical Condition.** The physical condition of airports in Colorado appears generally good, and adequate funding is available to maintain this situation. A grade of "A" appears appropriate.



**Need versus Capacity.** The construction of DIA and its current plans for expansion should be adequate to handle demand for the Denver area through 2010. A Master Plan update is underway which will focus on near-term needs for 2015 and reserve space to accommodate needs to 2030 and beyond. The Denver Regional Transportation District is planning to extend a commuter rail line to DIA from downtown Denver and be operational by 2015.

The needs of the rural areas for affordable and convenient commercial flights can only be met by the private sector and do not seem to be constrained by lack of physical infrastructure. Overall a grade of "B" is assigned.

**Funding versus Need.** With the exception of the lack of an adequate number of flights to smaller communities, public funding should be adequate to meet need. As such a grade of "B" is assigned to funding.

Overall a grade of "A-" is assigned to the current situation and "B+" to the 2010 situation. A slightly lower grade is assigned to the 2010 infrastructure as much of the recent investment in Denver and Colorado Springs will be 15 years old and some replacement needs will be evident.

### Recommendations

- Concerted efforts to ensure sustainable funding through federal legislation and state fuel taxation are required to maintain Colorado aviation infrastructure in good condition.
- Coordination between other infrastructure sectors such as roads and mass transit are
  vital to fulfilling federal expectations of multi-modal transportation efforts and
  improving all transportation sectors in Colorado.

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### ROADS

### **Road Conditions in Colorado**

Roadway mobility and accessibility rate high in the concerns of Colorado residents. Urban roadways are congested during the peak travel periods. Over 40% of the highways throughout the state are rated as having poor pavement condition. Moreover, there is a significant backlog of roadway bridge structures that need to be reconstructed, replaced, or expanded. See the "Bridges" section of this report.

Problems with congestion are well known to the Front Range commuter. Passenger and commercial travel on Colorado highways has increased dramatically in the



One of Colorado's Less Congested Roads

past 15 years in correlation to the rapid growth in population from 3.3 million in 1990 to 4.7 million in 2005. This addition of 1.4 million people represented about a 42% increase over the 15-year period. Some investments to respond to the growth have concentrated on adding capacity to limited stretches of strategic highway corridors such as I-25.

Additional problems on the West Slope are evident caused by the energy boom. Heavy trucks and work related traffic generated by drilling operations are impacting both state and local roadways and bridges.

Road surface conditions of Colorado interstate highways, regional roads, and local streets are deteriorated from increased traffic loading and Colorado's harsh pavement weathering conditions, and they were further exacerbated by the unusually harsh 2006-07 winter blizzards.

The Colorado Department of Transportation (CDOT) maintenance budget fluctuates from year to year in their attempt to meet the goal of maintaining 60% of the state's roads in good or fair condition. In the years 2004-2006, they slightly exceeded their goal, however, in 2007 the rating dropped to 59%, just missing their goal. This indicates that 41% of the state's roads are in poor condition.

CDOT projects a steady degradation of road conditions in the years ahead, and coupled with rapidly escalating construction costs, they will be unable to meet their stated goal without a substantial increase in annual maintenance funding.



Legislation at the federal level, through the enactment of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), and the state level, through Referendum C, has had a positive impact in advancing limited roadway projects. The improvements are readily apparent along I-25, the primary lifeline of the Colorado Front Range, as attested by the T-REX project in Denver, and the COSMIX project in Colorado Springs. These projects and other significant investments made by local communities and private developers have helped Colorado roads to handle the influx of additional drivers that came with the jump in population.

Included are significant tolled highway projects in the Denver Metro area. Most of the effort on these was to complete a beltway around the metro area. E-470, the eastern half of a beltway from I-25 south of the Denver Technological Center, past I-70 and Peña Boulevard to DIA to north I-25 near 160th was competed in stages from mid 1991 to early 2003. The Northwest Parkway (NWP) continued the beltway on to US 36 opening in late 2003. These tollway projects were funded through bonds sold on the private market. Tolls pay off the bonds and fund operations and maintenance.

These toll roads are part of a nationwide trend toward direct user pay financing as gas tax revenues have not been increased to even match inflation and the Highway Trust Fund seems headed for total depletion. CDOT embraced the tolling concept by forming the Colorado Tolling Enterprise (CTE). Its first tolled facility effort was to convert the I-25 North HOV lanes to also accommodate High Occupancy Toll (HOT) lanes with variable pricing. This allows single occupant vehicles to use the lanes paying a variable toll that is highest in peak periods. Vehicles with two or more occupants (HOV 2+) still can use the facility free. This project has generated revenues beyond original expectations. CTE has also been examining tolled improvements in other locations including continuing of the 470 Beltway to close the gap between the NWP and C-470. This latter effort has now been turned over to a new toll Authority, the Jefferson Parkway Authority to attempt completion.

It appears certain that tolled highways will be a part of Colorado's transportation picture for the foreseeable future.

# **Development of the Grade**

A composite grade was computed using the typical report card grading criteria as follows: (1) condition index, (2) need versus capacity, and (3) funding versus need. Each criterion was assigned equal weight to compute the overall composite grade.

#### **Condition Index**

CDOT has set a pavement goal of 60% good or fair, and 40% poor and has nearly met this goal (59% in 2007). As such, a grade of "C" seems appropriate. Given the projected continued deterioration of the system, a grade of "C-" was assigned for 2010.



#### **Need versus Capacity**

Congestion on Colorado's roads is increasing. The number of miles driven on state highways increased 60% between 1990 and 2006. Capacity improvements are not keeping pace with this growth in vehicle miles traveled, which continues to increase faster than the population growth. Recent improvements to I-25 in Denver and Colorado Springs have temporarily improved travel on these isolated sections, but statewide the problem of congestion is increasing. A grade of "D+" for the current status and a "D-" for 2010 appears reasonable.

#### **Funding versus Need**

The Governor established a "Colorado Transportation Finance and Implementation Panel" to look at the funding and needs of the state's transportation systems, and make recommendations for the future. This panel submitted their report to the Governor in January, 2008. Several scenarios for increasing transportation funding were evaluated, and the recommendations were to increase the funding \$1.5 billion per year to improve the current conditions. An increase of \$500 million per year was the minimum increase needed to maintain the current roadway network.

It was hoped that the passage of Referendum C in 2005 would have added transportation funds for 5 years. Unfortunately this has not proven true, as short-term trends are negative. Increases in gasoline and diesel costs have lead to cutbacks in use. This in turn has lead to declining revenues at both the federal and state levels. The state legislature did not pass any bills in the 2007 session that would have increased transportation funds. Due to the less than expected revenue from Referendum C, and the lack of any new funding bills from the state legislature, a Grade of "D-" was assigned for the current status. Given the continuing increase in miles traveled, combined with no identifiable increase in the future funding, a Grade of "D-" was continued until 2010.

	Summary Grade		
	Current	2010	
Condition	С	C-	
Needs versus capacity	D+	D-	
Funding versus need	D-	D-	
Average grade	D+	D	

# Recommendations

Solutions to ease the increasing demands on Colorado's transportation system and improve highway conditions, capacity and safety, are available.



- On personal level, people could choose to move closer to their work locations, telework, or use alternative transportation methods. Colorado communities have made determined efforts to improve their sidewalks and bikeways.
- Changes in land development patterns could help to reduce the growth in travel demand.
- Local governments continue to bear the brunt of the increased population growth.
   Local bond measures may help, but without state and federal funds to assist, limited improvement will occur.
- The Colorado Transportation Finance and Implementation Panel's "A Report to Colorado" evaluates the current status of transportation issues, and makes recommendations for the future. It is recommended that future legislative action be taken to fully implement the solutions presented in the report.
- The \$1.6 billion plus required for the T-REX project has primarily been borrowed against future federal highway grants. This means that, in the years following the completion of the T-REX project, federal funds available for Colorado will be used in part to repay incurred debt. Congress through SAFETEA-LU appropriates the current funding for national transportation. CDOT, local governments and Colorado residents should continue to push for additional Federal funding. This includes the need to increase the state and federal gas tax to generate needed revenues. Direct user pay (tolled) alternatives also need to be considered.
- Coordination between other infrastructure sectors such as aviation and mass transit are vital to fulfilling federal expectations of multi-modal transportation efforts and improving all transportation sectors in Colorado.

Colorado has made steps in transportation funding to help address the growth in demand. This effort now needs to be built upon to provide a sustainable funding stream to improve and maintain our roadway network.

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# **ENVIRONMENTAL CLEANUP**

# **Remediation Activities in Colorado**

Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) in 1980 to clean up highly contaminated hazardous waste sites across the country. To receive monies from the fund, a site must be included on the National Priorities List (NPL), which includes those sites that present the highest risk to public health, safety and the environment. Colorado has 21 sites on the NPL.



Rocky Mountain Arsenal

Active hazardous waste sites in Colorado are addressed by the Colorado Hazardous Waste Program, which is administered by the Colorado Department of Public Health and Environment (CDPHE), Hazardous Materials and Waste Management Division (HMWMD). The State of Colorado is authorized to administer its Hazardous Waste Program under the federal Resource Conservation and Recovery Act (RCRA), administered by the U.S. Environmental Protection Agency (EPA). Approximately 1500 RCRA sites that may need cleanup have been identified in Colorado.

Leaks from underground storage tanks (UST) cause damage to the environment and risks to public health and safety. In Colorado the UST and leaking UST (LUST) programs are administered by the Division of Oil and Public Safety of the Colorado Department of Labor and Employment. Thousands of LUST sites have been recorded in Colorado. LUST sites undergo remediation in accordance with Colorado's Storage Tank Regulations; USTs are permitted, constructed, operated, monitored, and financially warranted in accordance with the same regulations.

The Colorado mining industry has been governed by laws, rules and regulations which emphasize mine land reclamation since the mid-1970s. Colorado is, however, an historic mining state, starting with the 1859 Colorado Gold Rush. More than 23,000 "pre-law" abandoned mines have been counted. Since 1980, Colorado has had an active abandoned mine land reclamation program, funded annually by the federal Office of Surface Mining Reclamation and Enforcement. To date, on the order of 7,000 abandoned mines have been reclaimed. More are reclaimed each year, in pace with the funding received. There is some uncertainty that the long term funding will be adequate to cover the projected need/cost of reclaiming all of Colorado's abandoned mine lands.

The sum of sites in each of these four primary areas is considered the universe of hazardous waste sites in Colorado for purposes of this study and report. They form the basis of the report of environmental cleanup for the infrastructure report card. Each area is discussed, summarized and given a separate grade in the following sections.



# **Development of the Grade**

#### Colorado CERCLA (Superfund) Sites

Colorado has 21 Superfund sites authorized for cleanup under the federal Superfund program. The program comprises several steps—site designation, characterization, decisions regarding cleanup, design of the remedy, and finally construction of remedy. After cleanup is completed and cleanup goals are achieved, sites can be "de-listed" and removed from the NPL. Cleanup is funded through a combination of the responsible parties, EPA, and the state.

Significant progress has been made in cleanup of the 21 sites. Eight are complete, one is nearly complete, 10 are active NPL sites, and two are classified as Natural Resources Damage Sites. Some of the NPL sites, such as Summitville, will require additional construction, operation, and maintenance for the foreseeable future (beyond 2010). One proposed site, the Nelson Tunnel/Commodore Waste Rock site near Creede, is likely to add to Colorado's NPL. Though the overall status of CERCLA sites is good, recent funding cuts at the federal and state levels may undermine this good standing; there is also uncertainty over operational budgets needed to maintain these sites.

Based on these considerations, the grade given to the CERCLA Superfund hazardous waste cleanup component is a "B" for 2008 and a "B" for 2010.

#### **RCRA Regulated Hazardous Waste Cleanup Sites**

RCRA regulated hazardous waste sites requiring cleanup at the end of fiscal year 2001 approached 1500 (including high-, medium- and low-ranking facilities). Of the 1500 sites, 942 were considered high ranking. Investigation at all sites had been started or completed, and corrective action had been concluded at a total of 87 sites--just 9% of the overall total of those ranked "high."

Since then, Colorado has made steady and significant progress in its Hazardous Waste Program. CDPHE participates with the EPA Region 8 in the Colorado Environmental Performance Partnership Agreement (CEPPA) which identifies key environmental priorities and goals, defines the working agreement between CDPHE and EPA, and provides for federal funding through Performance Partnership Grants. Federal and state funding for the HMWMD Hazardous Waste Control Program has been stable since 2000, and showed marked increases beginning in 2006. Federal and state funding of Colorado's Hazardous Waste Program has been, or will be about \$1.4 million per year for fiscal years 2007 through 2009. About 27 % of the total comes from the state.

HMWMD's program has exceeded national targets for having operating permits and post-closure permits in place. Colorado regularly meets or exceeds national environmental indicators for human exposure and groundwater releases.

Acknowledging HMWMD's well-organized and measurably successful program and the stable, but not ambitious funding (funding isn't keeping pace with rising construction costs and inflation), the RCRA hazardous waste cleanup grades are C for 2008 and C- for 2010.



#### **UST/LUST Programs**

There are an estimated 9,000 active and closed LUST sites in Colorado; more than an estimated 6,000 of the sites have been or are in the process of being cleaned up. USTs used to store petroleum and other regulated substances are subject to the "Storage Tank Regulations," 7 C.C.R. 1101-14, effective April 30, 2006. These regulations supersede prior rules and amendments, dating from December 1989. The UST/LUST regulations are administered, managed, and enforced by the Colorado Department of Labor and Employment, Division of Oil and Public Safety. These regulations bring Colorado current with industry standards and applicable federal rules.

The rules are all encompassing; they apply to the design, installation, registration, operation, monitoring and decommissioning of USTs. The rules include the financial responsibility requirements for the owners/operators of petroleum storage tanks, to be met by fees and sureties. The rules also provide for owner/operator participation in the "Petroleum Storage Fund," which reimburses eligible applicants for allowable cleanup costs. The Fund is supported by a sliding scale surcharge on petroleum products. When there is \$12 million in the Fund, the surcharge is zero; when the Fund revenues are less than \$3 million, the surcharge is \$100 per tank truckload. The surcharge has been \$100 since July 2005.

Colorado's UST/LUST program is an effective cooperation between government and industry. It is evidently a dynamic program, keeping up with the occurrences of LUSTs, but running with a limited financial reserve in the Fund.

Based on these considerations, the UST/LUST cleanup component is given a "B for 2008, and a "B-" for 2010.

#### **Abandoned Mines**

Colorado has a rich and colorful mining history. The great surge in mining came in 1859 with the Colorado Gold Rush. Colorado continues as an important mining state, generating over \$2.6 billion in sales annually and currently producing significant amounts of coal, gold, silver, gypsum, limestone, molybdenum, soda ash, sodium bicarbonate, as well as aggregates/sand and gravel. In 2006, for example, Colorado mines produced 36 million tons of coal, 350,000 ounces of gold and 100 million pounds of molybdenum.

The Colorado legislature first enacted modern laws, rules and regulations for mining and mined land reclamation by passing the Colorado Surface Coal Mining Reclamation Act in 1973. Revisions and amendments occurred through April 1995 in response to changing conditions for public safety, environmental protection, and mining/milling methods. Emphasis on reclamation performance standards, performance warrantees, and financial warranties has been paramount in this legal/regulatory evolution. The 1973 Act created the Colorado Mined Land Reclamation Board (Board) which grants and oversees the administration and enforcement of mine reclamation rules and regulations to the Colorado Department of Natural Resources, Division of Reclamation, Mining and Safety (DRMS). Other mining and mined land reclamation rules and regulations effected by the Board include the "Mineral Rules and Regulations for Hard Rock, Metal and Designated Mining Operations," May 1977,



with amendments through August 2006; "Regulations of the Colorado Mined Land Reclamation Board for Coal Mining," August 1980, with amendments through March 2001; and the "Mineral Rules and Regulations for the Extraction of Construction Materials," October 1995, with amendments through August 2006.

As a result of these state mining laws, mined land reclamation has been on going and steadily improving since, at least, the late 1970's. However, there was an absence of mine clean up or reclamation at many thousands of mine sites that were closed and abandoned before that time. The status of these abandoned mines is the focus of this Infrastructure Report Card section.

In 1977, the U.S. Congress passed, and the President signed into law, the Surface Mine Control and Reclamation Act (SMCRA), which created the federal Office of Surface Mining Reclamation and Enforcement (OSM). OSM was empowered to promulgate federal rules and regulations for surface mining and transfer primacy to states that developed comparable, or more stringent, programs. SMCRA also provided for the enablement and entitlement of the Abandoned Mine Land program (AML) for OSM to fund and oversee for primacy states, and implement for non-primacy states.

AML program funding comes from severance taxes on producing surface and underground coalmines. The taxes are collected by the federal government. OSM returns some fraction of the annual severance tax revenues to each coal producing state in proportion to the tax revenues received from mine operators in the state. The funds are used primarily for reclaiming coal mine sites that were abandoned prior to the enactment of the 1977 SMCRA. Sites are selected for reclamation in accordance with a system of priorities devised by OSM. Abandoned non-coal sites can become eligible for reclamation depending on their level of risk to public safety and/or the environment, and following the reclamation of high priority abandoned coal mine sites.

With the enactment of SMCRA, many mining states began immediately to inventory their abandoned mine land sites and develop plans to achieve primacy. Colorado became a primacy state for its mine land reclamation and the AML program in 1980. SMCRA has been reauthorized a number of times since 1977. The latest reauthorization occurred in December 2006; it extends the collection and allocation of mined coal severance tax revenues through September 2021.

Since Colorado is a coal producing state, its AML program is entitled to the annual funding authorized by Congress and administered by OSM. This funding is, by and large, the only financial resource available to the Colorado AML program for reclamation of abandoned mine lands.

OSM and the primacy states have collaborated to improve and regularly update the state inventories through a data collection and management system named the Abandoned Mine Land Inventory System (AMLIS). AMLIS is maintained and operated by OSM. It is a reliable system for measuring the progress on reclaiming abandoned mine lands.



Since the start of the Colorado AML program, more than 23,000 abandoned mine sites (1,495 coal sites and 21,939 non-coal sites) have been inventoried. As of June 2004, 6,681 AML sites (942 coal sites and 5,739 non-coal sites) have been reclaimed, about 29% of the total inventory.

The annual AML reclamation revenues that are available to Colorado vary according to Congress' appropriations and allocations, and the state's coal production. Currently, the annual AML grants to Colorado amount to about \$3 million; about two-thirds of that amount goes to the AML reclamation projects. Current AMLIS statistics/estimates indicate that the estimated total cost for Colorado AML reclamation is about \$125.5 million. About \$42 million has been spent on completed projects since 1980. Additional projects have been funded in the amount of about \$4.5 million, and there is an estimated amount of about \$79 million yet to be funded.

Annual allocations to Colorado versus coal severance tax receipts to the federal government are compromised by Congress' penchant to hold payments to the states in abeyance, in favor of the General Fund. If the current rate of program funding is sustained through 2021, Colorado may be on the order of \$50 million, or 40%, short of the estimated amount needed to complete its AML program. Considering these uncertainties in funding and what prospects there may be for reauthorization in 2021, a report card grade can be conjectured based on current funding levels and the fact that the Colorado DRMS has been diligent at implementing its AML program since its onset. The Infrastructure Report Card grade for abandoned mine land reclamation is a "C" because, although Colorado has an effective AML reclamation program, there may not be enough revenue returned from the federal AML program to complete the reclamation of all state abandoned mine land sites. The "C" grade is given for 2010, as well as 2008.

#### **Summary Grade for Environmental Cleanup**

A summary grade compiled as a simple average of the four areas studied corresponds to a grade of "B-" for 2008 and a grade of "C+" for 2010.

### Recommendations

**Superfund Sites** – Much progress has been made regarding cleanup of Colorado Superfund sites and cooperation between Colorado (CDPHE) and the federal government (EPA). However, some EPA policies and procedures, as well as program funding, makes for slow progress and results in conflict among the public, the state and the EPA. It is recommended that Colorado representatives to the U. S. Congress (1) work to amend CERCLA so there is less risk to and greater opportunity for private sector involvement in Superfund site remediation, and (2) work more closely with CDPHE to define and stand firm on the funding and timetables for cleanup of Colorado's Superfund sites.

**RCRA Hazardous Waste Sites** – Colorado, in cooperation with EPA Region 8, has a well-organized hazardous Waste Control Program in place. The issue is the level of state and federal funding. It is recommended that CDPHE impress upon the Colorado assembly



and Colorado's representatives to the U.S. Congress that current levels of Program funding from the federal government and the state is not even adequate to keep pace with rising construction costs and inflation.

**UST/LUST Programs** – Colorado's UST/LUST programs are well-managed and effective. There is a good level of cooperation between the state and UST owners/operators. However, the Petroleum Storage Fund appears to be running with a limited financial reserve. It is recommended that the Executive Committee, formed by the Storage Tank Regulations and inclusive of government and industry, consider increases in Fund surcharges and/or other means of Fund income so as to raise the reserve.

**Abandoned Mines** – Colorado's abandoned mine land reclamation program is well-established and efficiently operated. Funding for the program is derived only from the federal AML program, based on severance taxes from the state's coal production. This source of revenue may not continue past 2021. Appropriations and allocations are at the discretion of the U. S. Congress. The return to Colorado is consistently too little to accomplish the state's AML reclamation goals. It is recommended that Colorado's representatives to the U. S. Congress lobby diligently and steadily for the revenues due to Colorado for its AML reclamation program.

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# SOLID WASTE

# General Principals of Solid Waste Management

Solid waste in Colorado is managed in a variety of ways. The EPA has ranked the most environmentally sound strategies for municipal solid waste as follows:

- 1. Source Reduction and Reuse Landfill
- 2. Recycling
- 3. Composting
- 4. Disposal in Landfills or Combustion Facilities



Shredded Tires at a Colorado Landfill

Source reduction (including reuse) is the most preferred method, followed by recycling and composting, and, lastly, disposal in combustion facilities and landfills. Currently, in the U.S., 32.5% of waste is recovered and recycled or composted, 12.5% is burned at combustion facilities, and the remaining 55% is disposed of in landfills<sup>9</sup>. While EPA's hierarchy of solid waste management alternatives still applies to Colorado, land filling is by far the most common method for managing solid waste in the state. Note that the percentage of waste recovered and recycled or composted has increased from 28% to 32.5% in the last seven years.

#### Source Reduction (Waste Prevention)

Source reduction can be a successful method of reducing waste generation. Practices such as grass recycling, backyard composting, two-sided copying of paper, and transport packaging reduction by industry have substantially reduced solid waste volumes. Source reduction has many environmental benefits. It prevents emissions of many greenhouse gases, reduces pollutants, saves energy, conserves resources, and reduces the need for new landfills and incinerators.

#### Recycling

Recycling, including composting, diverted 82 million tons of material away from landfills and incinerators in 2006, up from 15 million tons in 1980<sup>10</sup>.

<sup>9</sup> www.epa.gove/epaoswer/non-hw/muncpl/facts.htm

http://www.epa.gov/epaoswer/non-hw/muncpl/facts.htm



Typical materials that are recycled include batteries, recycled at a rate of 99%, paper and paperboard at 51.6%, and yard trimmings at 62%. These materials and others may be recycled through curbside programs, drop-off centers, buy-back programs, and deposit systems.

Recycling prevents the emission of many greenhouse gases and water pollutants, saves energy, supplies valuable raw materials to industry, creates jobs, stimulates the development of environmentally friendly technologies, conserves resources for the future, and reduces the need for new landfills and incinerators. In 1996, recycling of solid waste in the U.S. prevented the release of 33 million tons of carbon into the air—roughly the amount emitted annually by 25 million cars.

Recycling in Colorado is growing but, because there is no requirement mandating a recycling percentage, there is no central source for data pertaining to recycling volumes. Individual recyclers would have to be contacted to determine the recycling volumes in various communities. These include the Denver Recycles Program, the Colorado Association for Recycling, EcoCycle, and a myriad of other public and private recycling programs across the state. Paper, cardboard, glass, aluminum, steel, and yard wastes are generally assumed to be part of most recycling programs. Additional materials such as coal ash, construction debris, asphalt, meat processing byproducts, and electronic components should be also considered in determining a grade for Colorado.

#### Combustion/Incineration

Burning municipal solid waste can generate energy while reducing the amount of waste by up to 90% in volume and 75% in weight. EPA's Office of Air and Radiation is primarily responsible for regulating incinerators because air emissions from combustion pose the greatest environmental concern. In 1999, in the U.S., there were 102 incinerators with energy recovery capabilities; their combined capacity was 96,000 tons of municipal solid waste per day<sup>11</sup>.

#### Landfills

Under RCRA, landfills that accept municipal solid waste are primarily regulated by state, tribal, and local governments. EPA, however, has established national standards these landfills must meet in order to stay open. Municipal landfills can accept household hazardous waste. The number of landfills in the U.S. is steadily decreasing—from 8,000 in 1988 to 1,754 in 2006<sup>1</sup>. Landfill capacity, however, has remained relatively constant as newer landfills are much larger than in the past.

<sup>11</sup> www.epa.gov/epaoswer/non-hw/muncpl/disposal.htm#combust



Land filling is by far the most widely used solid waste management alternative in Colorado. Currently there are 186 solid waste facilities in the state<sup>12</sup>. Municipal solid waste is measured by volume rather then by weight in Colorado. The database of active landfills in the state available from CDPHE's Solid Waste Department on the web<sup>13</sup>. Additionally, participation in the Hazardous Substance Response Fund requires each landfill, whether owned and operated privately or publicly, to submit information on a quarterly basis noting volumes of materials disposed of in that landfill. Each landfill owner/operator is required to submit payment based on the disposal volumes with the data. The forms that are completed are available through the state and may include information regarding the type of vehicle at the fill (commercial versus non commercial) and the volumes of liquid sludge disposed of as well (if the facility is approved to take those wastes).

Statistics are available from the CDPHE web site regarding the total volume of waste generated <sup>14</sup>. For example, CDPHE estimates that more than 27 million cubic yards of municipal solid waste was generated in Colorado in 2006. In 2005 the estimated volume of municipal solid waste generated was about 28 million cubic yards. The population in Colorado in 2005 was approximately 4.7 million. After correcting for the estimated amount of waste that is generated by construction and demolition, Coloradoans are estimated to generate about 6.5 pounds per person per day of municipal solid waste. According to the EPA, the national average in 2002 was about 4.6 pounds per person per day<sup>15</sup>. In addition, the amount of solid waste generated in Colorado increased by an estimated 30% between 2000 and 2005, while the population of increased only 9% over that same period. This represents a 21% increase in municipal solid waste generated per person.

There is no single source for determining total and remaining landfill capacity at each facility. All operating plans (permit applications) are required to have landfill capacity information. However, the information can only be obtained through a file review in state offices or by contacting the owner/operator. Some capacity information may be available through the Title V Air Quality program because in some cases, capacity reports are required to determine whether the landfill must have a Title V Operating Permit. In discussions with the CDPHE the estimated life of the major Colorado landfills is approximately 50 years.

It is worth noting that the number of landfills in the state is decreasing because of the increasing regulatory costs associated with permitting and operating such facilities. This trend reflects the influence federal solid waste regulations (RCRA Subtitle D) have had on solid waste management in the state. Additionally, many more landfills are now using engineered containment structures and leachate management systems, a reflection of the influence of environmental regulation. With the decreasing number of landfills, more facilities are proposing capacity expansions. These capacity expansions are generally more desirable than new permits because of the political atmosphere for permitting as well as the costs associated with permitting new versus expanded facilities.

<sup>&</sup>lt;sup>12</sup> Colorado Active Solid Waste Facilities (http://www.cdphe.state.co.us/hm/sw/swfacinfo.htm)

<sup>13</sup> http://www.cdphe.state.co.us/hm/sw/swfacinfo.htm

<sup>14</sup> http://www.cdphe.state.co.us/hm/swreport/swreport.htm

<sup>15</sup> http://www.epa.gov/epaoswer/non-hw/muncpl/facts-text.htm



#### **Transfer Stations**

Transfer stations and drop boxes are being increasingly used as landfills close and other landfills expand capacity. Data regarding the number of transfer stations in the state is available from the CDPHE but volumes of solid waste through the transfer stations is only available from the operators.

#### Composting

Composting is not widely used in Colorado, though a number of facilities compost certain various materials. No data is currently centrally available for compost volumes. The state has recently promulgated regulations pertaining to compost operations.

#### **Data Collection and Analysis Concerning Solid Waste**

There has been a significant lack of data collected on the condition of solid waste in Colorado. The CDPHE collects basic information on the amount of solid waste generated and the user fees collected. However, there is little data collected on landfill capacities, remaining life of landfills, categorization of waste disposed, and status of remediation efforts. To address the deficiency in data collection and evaluation of solid waste in Colorado, the CDPHE has recently hired two full time staff personnel to collect data, conduct comparisons with other states, and identify areas of improvement to the way solid waste is handled in Colorado. It is anticipated that this proactive step taken by CDPHE will help Colorado to better understand the issues with solid waste and provide specific guidance for improvement.

# **Development of the Grade**

Each criterion was assigned equal weight to compute the overall composite grade. The grading criteria were discussed and defined by the solid waste advisory board as follows:

**Condition Index.** The advisory board considered the general condition index rating as shown on the following table in making a judgment as to the condition of solid waste management in Colorado. The "condition" of landfills was interpreted in relation to two elements: (1) their status in light of modern standards of practice for engineering of these facilities, and (2) remediation efforts.

**Need versus Capacity.** The advisory board interpreted this criterion as relating to existing and future landfill volumetric capacity versus anticipated capacity needs.

**Funding versus Need.** This criterion was interpreted relative to private funding and state-assisted funding. Again the advisory board recommended splitting this criterion into two elements: (1) funding for new disposal capacity, and (2) funding for remediation.

**Rationale and Computation of Composite Grade.** Because actual data on landfill capacity, recycling, and other methods for solid waste management in Colorado are not available in a format that facilitates detailed numerical computation, the solid waste management advisory board assigned grades under each of the grading criteria based on judgment and experience.



The results are summarized as follows:

#### **COLORADO SOLID WASTE GRADES BY CRITERION**

Criterion	Description	Subcategory	Letter Grade	Composite Grade
1	Condition Index	Engineering status	B-	2.5
		Remediation	C+	
2	Need vs. Capacity	NA	В	3.0
3	Funding vs. Need	NA	В	3.0

The composite grade (G) is based upon a 4.0 scale and was computed by giving equal weight to each of the three criterion as follows:

$$G = [2.5 + 3.0 + 3.0]/3$$
  
 $G = 2.83 = B-$ 

Because of the subjective nature of their development, a brief discussion of the rationale considered in deducing these grades by the advisory board is provided in the following paragraphs.

Condition Index: The regulations in Colorado do have requirements for engineered containment structures, but there is also the exemption for small landfills (i.e. those that generate less than 20 tons of MSW daily) and the ability to justify less than the prescriptive composite liner system of 2 feet of recompacted soil with a maximum hydraulic conductivity of 10<sup>-7</sup> centimeters per second, overlain by a flexible membrane. Additionally, if a vertical expansion is proposed over an unlined cell, no liner will be constructed, as is the case in Larimer County. Most landfills currently being permitted in Colorado as new facilities or lateral expansions of existing facilities are being required to have some type of liner system coupled with a leachate collection and removal system. The advent of new liner components has also allowed new landfill designs that do not incorporate the prescriptive RCRA Subtitle D system. Many landfills are making use of geocomposite liners as a component of the overall liner system. Liner system installation is being made a requirement not only of the larger private facilities but also for small to medium municipal facilities as well. For this portion of the grade for Criterion 1, the advisory board recommended a grade of "B-" for 2008.

Remediation of landfills in the state is a slower process. The advisory board was aware of one or two facilities moving forward with the typical remedial plans and a few more that are in the assessment monitoring stage. There may be many more that have problems but are not in the remediation program so far, and many with no information available since they have never been monitored and were closed or exempted from monitoring. As of July 1, 2001 the state has implemented an Environmental Covenants Policy which allows the CDPHE to place land use restrictions on a site that has not meet the requirements for remediation of a contaminated site. The CDPHE has published a list of sites on its website that have environmental covenants.



For these reasons, the advisory board recommended a grade of "C+" for 2008 for this portion of the criterion because the state is really only beginning to get this effort underway.

**Need versus Capacity:** Generally, there seems to be adequate landfill capacity in the state although there may be pockets where capacity is less than optimal. In the Front Range (Denver, Colorado Springs, Fort Collins, Pueblo), there are a number of expansion projects moving forward. That is not to say that these have all been approved, but it is anticipated that most will be approved. Fort Collins is looking to expand the Larimer County Landfill to offer capacity for another 15 to 20 years. Denver Regional Landfill probably has less than 5 years remaining. Colorado Springs has three large landfills with substantial capacity remaining. Pueblo has two large landfills with an adequate amount of capacity.

In the mountains and Western Slope, some of the landfills have been or are in the process of being expanded to adequately handle the needs. Grand County is in the process of expanding their facility and Summit County had an expansion approved some years ago.

The board recommended a grade of "B" for 2008 for capacity, as it seems that both the private operators and the municipal operators are planning for needs and addressing them.

**Funding versus Need:** Funding on the private side is less of an issue than it is for the smaller landfills in the state. In has been the experience of members of the advisory board that most of the larger and medium size landfills are complying with the RCRA Subtitle D and State regulations for designing and constructing landfills. As a result of RCRA Subtitle D, many of the smaller, rural facilities are also being required to design and construct using newer liner technology and to follow construction quality control procedures as they submit new permits or expand existing facilities. These smaller facilities are constrained in terms of available funding, but are generally finding the funds to meet the design requirements. Many of the smaller landfills do fall "beneath the radar" of the state because they are not submitting new permit requests. These facilities do not always have the funding to upgrade their facilities to meet RCRA Subtitle D requirements.

The State of Colorado has realized a shortfall in funding to promote recycling and waste reduction. House Bill 07-1288 was signed by the Governor on May 23, 2007. This bill created a Sustainable Resource Economic Opportunity Commission. The commission collects a landfill facility fee and tipping fee. The fees collected are used to fund grants that promote the recycling industry and to create markets for recycled goods. The funds are also used to assist the CDPHE in collecting data on solid waste/recycling to be used for forecasting areas of need and focus regulatory efforts<sup>16</sup>.

The board agreed that there is little motivation to discover problems at existing, unlined landfills and even less at closed unlined landfills. Funding to clean up old landfills and existing landfills is hard to procure. The state is beginning to enforce some remedial action regulations but it is a slow process.

<sup>&</sup>lt;sup>16</sup> 2007 Colorado General Assembly: Legislative Summary (see www.leg.state.co.us). Current as of May 23, 2007



The board considered the grade in light of funding available for new disposal capacity and funding for remediation. Funding for new capacity in 2008 may merit a "B-" overall with an "A" at the newer, larger facilities (private and public) and a C at the smaller rural facilities. Remediation funding is more a function of the enforcement. If the state has determined that a facility has a problem, generally the funding is found to address the problem albeit at a more controlled pace. There are not many enforcement actions for remediation and owners are not proactively looking for problems. Consequently, the board concluded that remediation funding could not be given a meaningful grade.

#### Grade for 2010

In general, solid waste systems in Colorado are expected to meet projected demand over the short term. The overall grade of "B-" is expected to be valid through the 2010 time frame.

### Recommendations

It is difficult under the current record-keeping system to evaluate current and remaining landfill capacity. The state regulatory agency could establish a more user-friendly database with current landfill capacity and status of permitted volumes.

Funding is lacking for remediation of old landfills and is hard to obtain especially for the smaller facilities. An effort should be made to make funds available for cleaning up landfills and provide motivation for remediation instead of reliance strictly upon enforcement actions and EPA superfund programs.

Further efforts should be supported to encourage the general public to reduce solid waste and to increase the level of recycling.

# Sources

Please see footnotes.



# AIR QUALITY

# Air Quality in Colorado

Outdoor air quality was selected as subject matter for the report card because of its correlation with transportation, energy, business, and population growth. According to the American Lung Association, "scientists have estimated that the number of deaths in the U.S. associated with air pollution ranges from 50,000 to 100,000 per year." Without question, long-term exposure to high levels of air pollution (whether naturally occurring or man made) is associated with numerous human health effects. In addition, high levels of air pollution directly impact agricultural production (for example, in the form of acid rain) and can even be a source of pollution for water bodies.



The Denver Basin's Infamous "Brown Cloud"

The EPA designated some Colorado areas as nonattainment during the 1970s and 1980s. However, in August of 2002, acting administrator of EPA, Christine Whitman, announced that the Denver area was the first major metropolitan area in the U.S. to fully comply with federal air quality standards. For the previous 3 years, Colorado maintained complete compliance with all federal health-based air pollution standards. To put this in perspective, in 1995, Colorado had 12 areas with non-attainment air quality designations within the state.

According to the Colorado Air Quality Control Commission, street sanding and sweeping controls, wood burning restrictions and controls, and new vehicle technologies continue to reduce air pollution within Colorado.

Through the implementation of state implementation plans (SIP), the 17 Colorado communities that violated federal clean air standards in the past and were designated as nonattainment areas by EPA, continue to focus on maintaining attainment status. In addition to SIPS, summer ozone season alerts have been issued as required, but the ozone standard was not violated from 2000 through 2002 in the Denver Metro area. A High Pollution Advisory Program is also in effect during the winter months and issues advisories to create awareness about high pollution days. For example, red advisories trigger wood burning bans and encourage people to limit driving. No violations of air quality standards occurred during the 2000 through 2002 winter high pollution season. In fact, the 2003 Denver Metro areas wintertime high pollution season was the most "clean" on record.



This good news has been tempered by EPA's issuance of a more stringent air quality standard for summertime ozone pollution. The Front Range region (stretching from Douglas and Jefferson Counties to the south through to Larimer and Weld Counties to the north), were designated as nonattainment by EPA in November 2007. Though air quality has actually improved when compared to 1980's and 1990's levels, the more stringent EPA standard has resulted in the region violating the 8-hour ozone standard during the 2001-2003 and 2005-2007 periods. A process is now underway to develop a revised air quality plan that brings the region back into attainment.

At this time, based on the meteorological conditions in Colorado, acid rain is not a problem and a trend in a reduction for automobile emissions has been documented. This reduction in emissions has proven to have a direct impact on improved air quality. An emerging issue is the deposition of nitrogen compounds in the high elevation regions of Rocky Mountain National Park. Nitrogen deposition threatens alpine ecosystems in the Park, and a plan has been developed that seeks emission reductions from industrial, mobile, commercial and agricultural sources.

# **Air Quality Standards**

EPA, to protect public health and welfare, established the National Ambient Air Quality Standards (NAAQS). Six criteria air "pollutants," including carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO $_2$ ), ozone (O $_3$ ), particulate matter (PM $_{10}$ /PM $_{2.5}$ ), and sulfur dioxide (SO $_2$ ), are monitored by the EPA across the country. EPA based on their ability to directly impact the public health and welfare selected these constituents. In general, when any of these federal air quality standards are violated for more than one day a year, the EPA can place a state in nonattainment for exceeding NAAQS.

#### Air Quality Management, Programs and Data Sources in Colorado

Colorado's state and local governments, regional agencies, and citizen groups have taken an active role in attempting to improve air quality. Many programs exist to monitor, report, and respond to air quality issues across the state, and the state performs all air quality measurement activities.

The Colorado Air Quality Control Commission is the state designated authority that is chartered to develop a regulatory program to protect and improve air quality in Colorado. The Air Pollution Control Division is the specific agency responsible for the implementation of the air quality management programs that have been adopted by the Air Quality Control Commission. To date, several different programs are administered by the Air Pollution Control Division to address specific needs within air quality management, as follows:

- Mobile Sources Program
  - Focuses on automobile inspection, alternative fuels, a clean screen program (remote sensing of emissions), diesel emissions, and oxygenated gasoline programs.



- Planning and Policy Program
  - Provides public education and outreach and implements a variety of air quality planning and policy initiatives.
- Stationary Sources Program
  - Evaluates, issues permits and inspects stationary sources, such as those for industrial applications, mining operations, and construction projects.
     This program also controls open burning and implements a wood stove burning program.
- Technical Services Program
  - This program is responsible for the collection, analysis, and modeling of ambient air quality data.

The Air Pollution Control Division is also responsible for administering air quality management plans or SIPs, as specifically developed to address areas of nonattainment or to maintain compliance with the NAAQS. The SIPs summarize the problem and probable cause, and identify a course of action to reduce the pollutants to within air quality standards. Historically, plans have been developed for carbon monoxide, particulate matter, and ozone.

Regional air quality planning groups have also been created by the Governor to support the directives of the Air Pollution Control Division in Denver, Greeley/Fort Collins, and Colorado Springs. Colorado has been separated into six regions (based on the specific air quality conditions and challenges for each region) and is supported by local health departments and regional air quality planning entities. These regions are sized according to geographic and population densities and include the West Slope, Northern Front Range, Central Front Range, Pikes Peak, South Central and Eastern High Planes regions. Each region provides a yearly report that summarizes various items such as air pollution sources, air pollution control measures, city and county programs, air quality indexes and a listing of independent services provided (for example, inspections). Through these reports, additional programs, studies, and support can be developed to address the specific needs of each region.

# **Development of the Grade**

A composite grade was computed using the typical report card grading criteria as follows: (1) condition index, (2) need versus capacity, and (3) funding versus need. Each criterion was assigned equal weight to compute the overall composite grade.

**Condition Index.** The "condition" of air quality in Colorado was based primarily on EPA air quality violations and focused on: (1) current attainment status and number of standards in nonattainment, and (2) how frequently does Colorado nearly exceed any of the federal air quality standards year-over-year.



#### CONDITION INDEX SCALE

Grade	Condition Description	
Α	Excellent: Attainment for 3 years.	
В	Good: Currently within attainment and seldom pushing standards.	
С	Fair: Currently within attainment but frequently pushing standards.	
D	Poor: Currently within nonattainment for one standard.	
F	Failed: Currently within nonattainment for more than one standard.	

**Need versus Capacity.** This criterion was more subjective and is based on the air quality trends within the state. It specifically considers the current and forecasted challenges for the year and looks at the ability of the state to naturally, or through volunteer or state/federal mandated restrictions, adapt to these challenges.

**Funding versus Need.** This criterion focused on two areas: (1) the ability to obtain federal and state funding dollars when a problem is identified, and (2) the ability to effectively utilize those funding dollars.

#### Rationale and Computation of Composite Grade

Based on both the challenges that the state of Colorado has met in reaching full attainment and in the development and execution of SIPs, the following grades were assigned to air quality.

#### 2008 COLORADO AIR QUALITY GRADES BY CRITERIA

Criterion	Description	Subcategory	Letter Grade	GPA
1 Co	Condition Index	Attainment	В	2.0
	Condition index	Pushing Standards	D	
2	Need vs. Capacity		В	3.0
3	Funding vs. Need		B+	3.5

The composite grade was computed by giving equal weight to each of the three criterion as follows:

G = 
$$[2.0 + 3.0 + 3.5]/3$$
  
G =  $2.83$  = C+



Because of the subjective nature of the grade development, a brief discussion of the rationale considered in deducing these grades by the advisory board is provided in the following paragraphs.

**Condition Index:** As federal regulations change, Colorado must be prepared to adapt to the changes. Future regulations may require that existing areas of focus (and possibly success) be balanced with the future needs to meet a standard. For example, the Denver Metro area was challenged in the summer of 2003 with higher ozone levels and exceeded the 8-hour standard for ozone. These high values, coupled with high values during the 2005-2007 period, has resulted in the Front Range region being designated as nonattainment.

**Need versus Capacity:** Current summary reporting appears to have a disproportional focus on the previous year's efforts versus what the needs and direct challenges may be in the future. The amount of data collected to properly model future air quality appears to be inadequate and warrants further investigation. It also seems that trending data is not in place to correlate the improved or declining areas with the specific cause for this change.

One major challenge was demonstrated in the summer of 2003 and during the 2005-2007 period. Despite continuing to meet the 1-hour ozone standard, Metro Denver failed to meet the new 8-hour standard several times. In fact, ozone levels increased for many locations on the East Slope as a direct result of emissions and meteorological conditions. The Early Action Compact was initiated based on this possibility, but causal relationships for the increase in ozone levels have not been identified. A new planning process to reduce emissions and bring the region back into attainment status is now underway

**Funding versus Need:** It appears that both the funding mechanisms and dollars are in place to effectively support air quality programs within the state of Colorado. CDOT, for example, is providing generous support for 2008 ozone planning efforts needed to bring the region back into attainment status. However, the method by which the spending priorities are determined is unclear. Published accountability for these expenditures was not available for review.

#### Grade for 2010

In general, air quality in Colorado should be consistent for the next decade. However, several factors may have a negative influence on the future state of air quality in Colorado, as follows:

- Changing regulatory standards may be more restrictive and difficult to meet. For
  example, EPA has a new tougher 8-hour ozone standard that will lower the allowable
  ozone level and average it over 8 hours versus the current 1hour.
- Competition for funding among all of the infrastructure categories and other statewide initiatives.
- Population growth, which can lead to additional construction and increased motor vehicle miles, may have an unpredictable impact on air quality.



- Continued unpredictability in controlling air quality based on lack of "cause and effect data."
- Difficulty in quantifying spending efforts and program effectiveness in improving air quality, which may not allow for the money to be appropriated to the proper programs.
- Continued meteorological changes (for example, droughts) that can directly impact ozone levels.

Positive factors that could offset air quality challenges include:

- Continued automobile emission controls and improvements (state and federal).
- Early identification of the air quality challenges prior to 2010.
- Effective air quality control programs.

Considering these factors, a grade of "B-" is anticipated for 2010.

# Recommendations

Colorado has made significant progress in meeting EPA's established air quality standards while millions of people continue to live in counties throughout the U.S. that do not meet these standards that protect public health and the environment. It is imperative, however, that Colorado redirect its focus on the cause and effects of the state's air quality challenges. It is also recommended that Colorado:

- Continue to institute wood burning controls and similar "behavioral" programs as needed.
- Develop effective public education and awareness programs that allow the public to see the value in supporting programs and initiatives, both behaviorally and fiscally.
- Develop a long-range strategy to address future air quality risks, pollution sources, and the potential impacts of population growth.
- Develop quantitative criteria and measurements to justify the effectiveness of each
  existing air quality program to improve air quality within the state. For example,
  federally mandated emission controls on newer automobiles may be playing a much
  larger role than local public education efforts.
- Institute new programs based on technical relevance versus public or political perceptions that will have the best "return on investment."
- Be proactive versus reactive in its approach to addressing air quality.



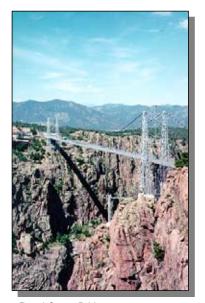
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# **BRIDGES**

# **Bridges in Colorado**



Royal Gorge Bridge

All major classified public bridges (bridges with a clear span of 20 feet or more) are inspected every 2 years in accordance with the National Bridge Inspection Standards (NBIS) and Pontis element inspections. (Pontis is described in the Recommendations section below.) From these inspections, bridges are assigned sufficiency ratings on a 100-point scale. A structurally deficient bridge is one with components rated in poor condition. While not necessarily unsafe, these bridges may have limits for speed and weight. A functionally obsolete bridge has older design features and while it is not unsafe for all vehicles, it cannot safely accommodate current traffic volumes, and vehicle sizes and weights.

The number of aging bridges is increasing rapidly. Of the 3,775 bridges on state and federal highways (on-system bridges) in Colorado:

- 66 were built before 1930 9
- 160 were built between 1930 and 1949 9
- 545 were built between 1950 and 19599
- 1,186 were built between 1960 and 19759
- 1,387 were built between 1976 and 2007<sup>9</sup>

The dramatic growth of Colorado's population places an increased burden on the state's transportation system, expediting the deterioration of our bridges. Travel on Colorado's roads and highways increased by 60% from 1990 to 2006.

While there are over 3,500 bridges on all federal and state highways in the state, this report card evaluates the 8,366 bridges on all roads in the state, on- and off-system that are inspected under federal, state, and local entities.



# **Development of the Grade**

#### Performance Criteria 17

The sufficiency rating formula is a method of evaluating data by calculating four separate factors to obtain a numeric value that is indicative of a bridge's sufficiency to remain in service. The result of this method is a percentage in which 100% would represent an entirely sufficient bridge and zero would represent an entirely insufficient or deficient bridge. The sufficiency rating shall not be less than 0% nor greater than 100%.

The factors considered in determining a sufficiency rating are: S1 - Structural Adequacy and Safety (55% maximum), S2 - Serviceability and Functional Obsolescence (30% maximum), S3 - Essentiality for Public Use (15% maximum), and S4 - Special Reductions (detour length, traffic safety features, and structure type - 13% maximum).

Sufficiency Rating = S1 + S2 + S3 - S4.

Bridges are broken down into 3 categories.

- POOR: Bridges that have a sufficiency rating of less than 50 and are structurally deficient or functionally obsolete.
- <u>FAIR</u>: Bridges that have a sufficiency rating of less than 80 and more than 50 and are structurally deficient or functionally obsolete.
- GOOD: All other bridges.

### **Evaluation for 2007**

In 2007, the Federal Highway Administration (FHWA) rated  $17\%^{18}$  of the state's bridges structurally deficient or functionally obsolete. The good news is that this percentage has remained fairly constant for the past 5 years. Ongoing bridge maintenance has prevented the percentage of deficient bridges from significantly increasing.

The fact that the status of Colorado's bridges has remained steady can be attributed to a variety of reasons. Recently, there has been a concerted effort to improve the condition of the off-system (local city and county) bridges. Since 1985 for example, about 20% of the off-system bridges were replaced, greatly improving the overall off-system bridge condition. Colorado currently ranks 4<sup>th</sup> in the nation in the condition of its off-system bridges. 19

<sup>&</sup>lt;sup>17</sup> Colorado Department of Transportation Guidelines for Selecting Off-System Bridges for Rehabilitation or Replacement, May 16, 2001

Bureau of Transportation Statistics, Table 1-7,2007

<sup>&</sup>lt;sup>19</sup> Department of Transportation Bridge Program Performance Audit, September 1999



This was primarily the result of a concerted effort by the Colorado legislature to provide state funds in addition to federal funds allocated strictly for rehabilitation or replacement of structurally deficient or functionally obsolete bridges. Unfortunately, this state program was discontinued 11 years ago. This decreased the allocated dollars for bridge rehabilitation or replacement by 50%. The following table shows Colorado's on-system bridge condition statistics since 1994:

	Data from Past CDOT Bridge Branch Annual Reports			Historical Data				
Year	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07
Statewide	3697	3707	3694	3702	3733	3754	3757	3775
Good <sup>1</sup>	3139	3110	3110	3132	3153	3265	3271	3280
Fair	447	479	470	452	465	383	375	379
Poor	111	118	124	118	115	106	111	116

Notes: Data for approximately 4,500 off-system bridges not shown.

Good = Bridges not on FHWA Select List.

Fair = Bridges on FHWA Select List that rate from 50 to 80 and are Structurally Deficient and/or Functionally Obsolete.

Poor = Bridges on FHWA Select List that rate below 50 and are Structurally Deficient and/or Functionally Obsolete.

Bridges on FHWA Select List must meet FHWA Criteria to be Structurally Deficient or Functionally Obsolete.

Based on Pontis, the current estimated cost of replacing and rehabilitating structures on the state highway system requires \$638 million or approximately \$31.9 million per year without adjustments for inflation<sup>20</sup>. It should be noted that this amount is low because it only reflects the cost of replacing the current bridge. When one includes the costs of roadway work and engineering services along with the fact that most replacement bridges will be larger, the annual funds needed would increase to approximately \$141.3 million.<sup>21</sup>

Despite the need for increased bridge repair and replacement funding, it does not seem that current allocated funding levels will satisfy the demands. If the anticipated funding levels (current funding projections) remain what they are today, 40% of the bridges will be rated poor by 2035. The percentage of good, fair, and poor bridges is calculated by dividing the total average daily traffic (ADT) of the bridges in each category by the total ADT of all the bridges in the system.

The percentage of good bridges serves as the base letter grade given in the report card. Since 17% of Colorado's bridges are structurally deficient or functionally obsolete, the base grade would be 100%-17%=83% or a "B-."

<sup>20</sup> Colorado Department of Transportation Proposed Budget Fiscal Year 2002-2003, Governor Bill Owens, November 16, 2001

<sup>21</sup> Interview with Jeff Anderson, Colorado DOT Bridge Maintenance Engineer, August 1, 2002.



#### **Evaluation for 2010**

While the condition of the state's bridges has remained steady, significant deterioration of the bridge system is expected in the next 10 years. Maintenance data has shown that bridges in Colorado will not require major repair work or replacement until they are 50 years old. Until recently, the number of bridges 50 years old or older has been a small percentage but this will increase dramatically within the decade. The 1950's were a "baby boom" of sorts for bridges. The bridges built in the 1950's during the construction of the Interstate System will turn 50 in the next 10 years and Colorado will be hit with a wave of bridges requiring rehabilitation or replacement. Recent problems such as the I-70 bridge viaduct in Denver is a prime example of what happens when bridges come of age when there is insufficient funding.

The future condition grade was more subjective since bridge condition data for the future is not yet available. Nevertheless, current data shows general trends and it is predicted that there will be a significant increase in the deterioration of Colorado's bridges in the next 10 years.

Based on these considerations, the grade for bridges for 2010is projected to be a "C-."

# Recommendations

One solution to prevent Colorado's bridges from deteriorating is to increase funding allocated to CDOT. Of the money a vehicle owner pays for the gas tax, license plate, and car sales tax, only 25% goes to the statewide transportation system. The remaining 75% goes to local government general funds to be used for any purpose. In addition to increased funding, there are other things that should be done to insure a safe and efficient bridge system.

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# **EDUCATION**

# **Education in Colorado**

In Colorado, as well as throughout this country, education is vying for the same funding sources and revenue as other portions of the Infrastructure.

The two components of education, K through 12 and higher education, have similar needs to continue to meet their obligation to the community and citizens of Colorado. These needs include maintaining or replacing buildings that have become outdated, updating curriculum, retaining quality staff, retaining students, and securing funding. Several studies are underway, and legislation is proposed to address some of the changes needed to meet the needs of the diverse and changing population of students and to encourage students to stay in school and to pursue college educations upon completion of high school. Andrew Romanoff and Peter Groff state in their May 11, 2008 Denver Post editorial that "Deep cuts in recent years have left Colorado near last place in public support for higher education."

On April 20, 2008 front page of the Denver Post, Allison Sherry stated:

"If nothing changes, children getting ready for preschool today will start – and finish – college at an even lower rate than now, Already, the six-year graduation rate is well below 50 percent at more than half of the public four-year colleges and universities in the state. College enrollment has dropped every year since 2004.

The above prediction is indeed a dire prediction. Directly related to meeting the needs of infrastructure maintenance and construction is the education of young civil engineers. It is these young engineers who will step forward as our leaders and custodians of our infrastructure as the "baby boomer" generation retires.

#### Introduction

In the past, education funding was separate from other infrastructure components and relatively secure, although limited. In recent years, however, education has been vying for the same funds being sought for transportation and other infrastructure needs. School buildings that are 30, 50, or more years old need a significant amount of funding to remain adequate, safe and serviceable for the needs of an often increasing student population. Curriculum needs to be updated and enhanced to meet the rapidly changing technology and resources of the age of the Internet. As other employer's demands for a qualified workforce increase, it has become increasingly difficult to attract and maintain qualified teachers at the typical teacher's salaries. The traditional revenue stream from the state general fund and property taxes is not meeting all of these needs. Recent revenue bonds have included components dedicated to education. Legislation has placed restriction on reduction of education funding in the event of budget shortfalls.



All of these issues have placed education infrastructure on par with other traditional infrastructure components such as highways and water resources. Education, including K-12 and higher education, is such a complex issue that is deserving of a 'Report Card' of its own.

For the purposes of updating Colorado's Infrastructure Report Card, evaluation shall be primarily limited to education with respect to preparing young engineers to meet the needs of designing and maintaining the state's infrastructure. Currently there are 6 colleges and universities in Colorado that offer civil engineering programs or degrees in civil engineering. To form a baseline for this report card update, each program was evaluated regarding trends in student enrollment and graduation.

## **Survey Methodology and Results**

Education was not included as an infrastructure area in the 2003 Report Card; therefore there is no data available for a benchmark. A brief survey was with six questions was sent to the Civil Engineering student advisors at each college with a Civil Engineering program. The survey was intended to gage trends at each college and not for a numerical comparison between the schools. There was a 50% response to the questionnaire.

The first two questions asked about the trend for enrollment compared to previous years and the trend for graduation after normal attrition. Two of the three responses were "about the same" and the third was "increased."

ASCE advocates "raising the bar" for professional licensure of engineers. The second two survey questions were to assess how the students are preparing for registration. The three respondents indicated that over 80% and up to 95% of the graduates have passed the Fundamentals of Engineering Exam (FE Exam) prior to graduation. Unfortunately, information regarding the number of graduates entering a graduate or post-graduate program was either not available or the numbers were very small.

In her book, <u>The 21</u>st Century Engineer, Dr. Patricia D. Galloway outlines a suggested skill set to help engineers to be competitive in the global marketplace. The last two survey questions were to determine if the current curriculum offer the necessary courses and if the current course work meets employer expectations. Foreign language though available is not always required in the basic curriculum. One respondent indicated that some employers looked for CAD experience in AutoCAD 3D. The other respondents had not had special requests from employers regarding course content or curriculum.

# **Development of the Grade**

In the three areas evaluated for engineering education, a grade of "C" is reasonable. The current trend in Colorado is declining college enrollment. Although the trend for engineering enrollment has been steady; declining enrollment could result in this grade going down in the future. Ideally, an increase in both enrollment and graduation rate should be seen to meet the projected need for engineers. A significant number of engineers are eligible to retire within the next 10 years. This means that the number of engineers produced by our colleges and universities will have to increase to fill these vacancies, or this grade will decline.



In 2005, the ASCE Report Card for America's Infrastructure graded the nation's schools at "D." This is reflected in the condition of schools throughout the state where many rural schools were constructed prior to the 1930s.

There is great disparity in available funding for school construction and upgrades. The bonding capacity in some districts is in the billions of dollars, while other districts with an equal or greater student population have less than \$1 million in bonding capacity. Because funding has fallen short of planned levels, over the past few years, and the trend appears to be continuing, the funding potential should also be graded "D."

	Colorado Education Infrastructure		
	Today	2010	
K-12 Completion and Retention	С	C+	
Post-Secondary Retention and Completion	С	D	
Funding Compared to Need	D	D	
Condition	D	D	
Average Grade	С	D+	

# Recommendations

For K through 12 students, 5 pieces of legislation signed by Gov. Bill Ritter<sup>8</sup> will go toward improving the completion and retention rate for students and maintain the status quo within the next few years. The outlook for post secondary education is not as optimistic and concerted efforts to encourage students to pursue college educations as well as efforts to increase the percentage of graduates is required. ASCE can be an advocate of accessible and affordable college education.

Because our state has found itself in the position of different portions of the infrastructure vying for the same sources of funding, it is important that, as we work with clients, that we council them not to divert funds designated for education to other purposes if there will be a negative impact on the education program. It will be difficult to balance priorities, and there is not a uniform or consistent source of funding for schools. In many cases, the schools with the greatest need are dependent on state grants because the school district tax base is so low. When working with school districts, engineers should maximize the opportunities to acquire alternate funding such as grants.

Also every effort should be made to assure that new construction and renovations are energy efficient, and sustainable. Consideration should be given to incorporating renewable energy and alternate energy sources in new construction and renovations. Poudre Valley School District has been leading the way in incorporating energy saving measures and sustainable construction in their schools. Life cycle costs should be part of the decision making process.



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# **ENERGY**

# **Energy Production and Conveyance in Colorado**

#### Introduction

Colorado's electricity needs are met by a combination of independently owned utilities and public power agencies and co-ops. Siting and permitting requirements are somewhat different for these two entities. Reporting requirements are also different for each type of entity.

In the past few years, there has been a substantial public debate about the best methods to meet the growing needs for Colorado's energy. The general population



A Substation in Golden

of the state has grown dramatically with a large influx of migration from other states. The recreation opportunities abundant in Colorado have been a major factor in this migration. However, the increasing amounts of traffic and noticeable air pollution in the Denver metropolitan area have been a cause for concern. There have also been concerns about the increased use of the natural resources and recreation facilities and the impact on the wildlife and other resources caused by the greater population. This backdrop of concern, coupled with the nationwide increase in fuel and energy prices, as well as the unmistakable linkage between the War on Terrorism and imported oil, have given rise to a new realization about the need for more options in energy production and delivery.

In 2006, a report was prepared pursuant to House Bill 06-1325. This report was the culmination of an effort by a broad spectrum of energy industry professionals to evaluate the reliability of the state's electricity infrastructure. The commission, appointed by the legislature and the governor, consisted of 15 individuals. Their task was to, "engage affected stakeholders to develop a comprehensive plan that addresses the state's future electric infrastructure needs for the benefit of Colorado and its citizens." The report, titled "Report of the Task Force on Reliable Electricity Infrastructure," was finalized on November 1, 2006. The report contains four primary recommendations and one additional observation. These are:

- Transmission Cost Recovery Rider
- Identify Renewable Generation Resource Development Areas



- Governmental involvement with organizations like the Colorado Coordinated Planning Group
- Appropriate adequate funding for the Public Utilities Commission (PUC) to actively
  participate in regional electricity transmission planning, reliability and regulatory
  forums

The Task Force identified a critical shortage in the electric utility industry of specialized and highly trained workers

The 31-page report was an ambitious undertaking. The Task Force not only assembled a large amount of data and analyzed it, but it also summarized four public input meetings from around the state. All of those involved, and those who supported them, are to be commended for a job well done.

More recently, Governor Ritter has announced a goal of reducing greenhouse-gas emissions by 20% by 2020. The industry has responded to this challenge with plans for new solar and wind powered generating facilities, as well as a re-examination of other sources such as hydroelectric facilities. In a recent article, the top Colorado executive of Xcel energy discussed their plans to add about 800 megawatts of wind power and 250 megawatts of solar power, effectively doubling its use of renewable resources by 2015. Xcel provides power to about 70% of Colorado residents. The utility has also invested large sums to upgrade basic infrastructure, amounting to about \$100 million between 2005 and 2007 in cable, transformers and infrastructure. And the completion of the Rockies Express pipeline for natural gas has started to impact the market price for this important resource.

The 2007 Colorado Resource Plan, an integral part of Xcel's recent application for filing with the Colorado PUC, indicates that Xcel intends to perform the following:

- Install 800 MW of wind power in stages coming on-line between 2010 and 2015
- Install 25 MW of Solar Power to be installed by 2011
- Replace two coal units at Cameo Station and two coal units at Arapahoe Station with a single combined cycle natural gas unit at Arapahoe Station
- A possible additional 1000 MW of additional capacity, possibly including a "set aside" for 200 MW of additional Solar Power for the years 2013 through 2015.
- Under separate filing, request permission for a new 345kV transmission facility between Smoky Hill and Pawnee



The Task Force Report contains many references to external documents. These documents and their significant content follow:

The Colorado Energy Forum (CEF) recently published its study titled, "Colorado's Energy Future" which concludes that an additional 4,900 MW of new supply, possibly including conservation measures, will be required by 2025. In a November 2007 report, the CEF investigated the effect of the passage of Colorado's expanded Renewable Energy Standard (RES) on the state's energy and generation capacity needs. The CEF estimated, based on reasonable assumptions, more than 3,300 MW of wind generation and nearly 200 MW of solar generation must be deployed in order to meet Colorado's RES. However, when taking into account the intermittent nature of wind and solar resources, we estimated that the reliable capacity credit for these renewable resources range between 330 MW and 1,122 MW. This means that even after the legal mandates of Colorado's RES are met, significant amounts of new electric generating capacity still will be required to meet the state's needs. Based on the assumptions and data in this study, Colorado will need to address additional resource needs in the range of 3,700 MW to 4,500 MW by 2025.

There are real consequences of failure to meet the identified resource need. If the state's utilities are not able to meet the expected growth in future demand, reliability will be decreased and more outages will occur. Future electric outages could have a huge financial cost to Colorado. In addition, the failure to meet anticipated electricity needs may lead to higher Colorado electricity rates, making the Colorado economy less competitive and reducing the growth of future Colorado employment and income. If utilities are able to meet the future demand at lower costs through good planning, these negative economic impacts may be avoided.

The Western Resources Advocates (WRA) published a report titled, "A Balanced Energy Plan for the Interior West." This report demonstrates how energy efficiency, renewable energy and combined heat and power resources can be integrated into the existing system to meet needs, reduce risk and save money while reducing pollution.

A report titled, "Colorado Long Range Transmission Planning Study 2005-2015" (CLRTP) was prepared jointly by Aquila Networks, Colorado Springs Utilities, Platte River Power Authority, Xcel Energy, Tri-State Generation and Transmission, and the Western Area Power Administration. The plan concludes that an additional 4,000 MW of additional generating capacity is needed, as well as an overall investment of approximately \$2.0 billion over the next 10 years. This study was associated with a voluntary organization formed in 1992 called Colorado Coordinated Planning Group (CCPG). The study included an inventory of transmission infrastructure as well as options to meet pressing needs for both Xcel Energy and Tri-State.

The Task Force also received individual testimony from representatives of each member of the CCPG, as well as members of the public and the PUC staff.

In a separate presentation, the Senior Team Lead for Xcel Energy's Siting and Land Rights Department described that the process required to obtain the decisions needed to define a new transmission line route can extend from 19 to 36 months.



Funding of transmission infrastructure received abundant attention with presentations by numerous groups representing both individual suppliers and industry representatives, as well as PUC staff. Of utmost clarity is the need for transmission facilities to serve new renewable resource-based generation sites, normally located remotely from load centers.

Of important note, all major suppliers and transmission owners in Colorado testified individually that their facilities meet all published technical criteria for transmission safety and reliability including the loss of one major "link in the chain" that would prevent service or induce a "cascade" effect.

Nuclear power is a technology worth considering, due to its obvious lack of impact on greenhouse gases. Cost control has been a concern in the past, along with the safety of the overall system. In the years since a project has been pursued earnestly, the safety aspects have been improved. However, we need a long term program for nuclear waste disposal. A viable on-site solution might be an option to the current proposed national site in Nevada, even though it would be reasonably close to us in Colorado. The issues of safety during transport to the Nevada site are tough to solve. However, one of the biggest issues in Colorado for nuclear power is the source of water needed for cooling. With all of the debate on this issue, and its high profile statewide, it is hard to envision a scenario where adequate sources of single pass cooling water would be available for use in a nuclear facility of adequate size to be commercially viable. Of course, with other renewable sources of energy being considered, our historic price fixation is apparently drifting toward a higher price realization, which may bring some form of nuclear power within the realm of cost-effective solutions.

# **Development of the Grade**

In the development of a grade for the current system of energy generation and transmission for Colorado, we were mindful of past grades, as well as changes that have recently occurred, both with respect to capacity developed, as well as increases in load. While some additional facilities have been built, the overall system is still subject to transmission bottlenecks, as well as a lack of movement toward significant added generation capacity. The current focus on renewable sources of electricity ignores the unpredictable nature of these sources. However, current load is being handled, so a grade of "C+" seems warranted.

With respect to future needs, we are deeply concerned that no significant plants are currently being planned to address the projected demands. The popular fixation on renewable sources completely ignores the unpredictable nature of wind and solar sources, and to some extent hydroelectric sources as well. Geothermal and nuclear sources provide much more stability, but lack the ability to quickly ramp up production to meet peak hour demands. These considerations starkly demonstrate that all forms of energy production must be "in the mix" to satisfy the need for reliability, the single most important aspect of power supply. Finally, power is one of the few commodities that must be consumed immediately, with very little storage available. So considering all of the above, we grade the planning and future supply of energy a grade of "D."



# **Sources**

Colorado's Renewable Energy Standard, A Report by The Colorado Energy Forum, November 2007.

Report of the Task Force on Reliable Electricity Infrastructure, November 1, 2006.

Application of Public Service Company of Colorado for Approval of 2007 Colorado Resource Plan and Petition for Waiver of Competitive Procurement Rules to Replace Cameo and Arapahoe Coal Units with a Natural Gas Combined Cycle Plant at Arapahoe Station, November 15, 2007.

The Denver Post, article updated January 27, 2008, "Xcel wired about renewable initiative."



# MASS TRANSIT

# Mass Transit in Colorado

Transit service in Colorado has been improving over the last 10 years. The highest levels of service are provided where local financial support is available to supplement federal funding. The citizens of the Denver region and in the mountain resort communities have made the largest investments. More limited service is available in the remainder of the state. Much of this service is oriented toward the needs of the elderly and disabled. Colorado's elderly population is projected to increase from approximately one-half million currently to an estimated 1.3 million in 2035. The state's total



A Light Rail Station

population is projected to grow from about five million today to 7.8 million by 2035. With most of the growth to occur in the Front Range, the need for urban and interurban transit will become more acute. In addition, rural residents have little or no bus service available to fulfill basic needs of even transit dependents such as the elderly and disabled. Currently an estimated 45% of the transit need is met statewide. By 2035, only about 30% of the total transit need is projected to be met as transit services fail to keep up with growing trip needs.

In November of 2004, the Denver Metro Area approved funding of the FasTracks program that includes construction of six light rail or commuter rail corridors and extension of two existing light rail lines. The entire built-out program will add 122 miles of new light rail and commuter rail, 18 miles of Bus Rapid Transit (BRT) service, rehabilitate union station to be Denver's rail transit hub and 57 new transit stations to the system. FasTracks is programmed to be completed by 2017. However, in its early years, cost escalation issues have arisen as the original estimate of \$4.7 billion has increased to \$7.9 billion. RTD is currently holding public meetings in an effort to determine how to proceed from this point.

The completed Southwest Corridor light rail extension has provided improved commuting opportunities for some suburban commuters and ridership has exceeded expectations. The Central Valley light rail spur provides access to the sports venues. The completed T-REX project provides 19 miles of a light rail line from Broadway to Lincoln Avenue in Douglas County and the spur up the median of I-225 from I-25 to Parker Road. Fort Collins and Colorado Springs provide limited fixed-route local bus service; both also fund long distance van services.



For the remainder of Colorado, the availability of transit is more limited. While most areas have some form of on-demand transit operations such as vans for the elderly and disabled, these services are often inadequately funded and some rely on volunteer operators.

Some of the mountain communities have made significant investments in transit for purposes of relieving congestion and to provide access to ski resorts. These include the Roaring Fork Transportation Authority, Vail, Steamboat Springs, and Summit County. In addition Mesa County and Grand Junction have established Grand Valley Transit, which is providing demand-responsive services.

In the San Luis valley, four counties have no transit operations at all to provide even a basic level of mobility for the poor and elderly in those areas.

The majority of funds spent each year to operate statewide public transportation services are generated from local revenues. Federal Transit Administration programs and human services programs provide additional funding. Funding for capital and equipment is provided through federal, state, and local funding. Colorado's commitment to public transportation has grown through funding from Senate Bill 97-1 which, for the first time, designates a portion of state general fund revenues to pay for strategic transit capital or planning projects.

Transit providers in Colorado identified approximately \$57 billion worth of transit project needs over the next 28 years. Current revenue streams will not be sufficient to fund all of the identified transit projects through 2035. Anticipated \$27 billion in constrained revenue over the 2008-2035 period, will result in a funding shortfall of \$30 billion.

# **Development of the Grade**

#### **Condition Index**

Additional financial support from the federal government for both Denver and other state projects has resulted in a generally good physical infrastructure supporting existing service. A grade of "B" appears appropriate for both today and the future.

### **Need versus Capacity**

Currently with only 45% of the transit need met statewide, and by 2035, only about 30% of the total transit need is projected to be met. A current grade of "D+" and a future grade of "D-" appears appropriate.

### **Funding**

Current funding sources appear to be adequate to maintain but not improve current service levels. As such a grade of "C" for today seems appropriate. With a funding shortfall of \$30 billion by 2035 a grade of "D-" for the future are assigned.



#### **Overall Grades**

The overall grades for mass transit in Colorado are as follows:

	Summary Grade			
	Current	2010		
Condition	В	В		
Needs versus capacity	D+	D-		
Funding versus need	С	D-		
Overall grade	С	D+		

# Recommendations

- Securing additional transit funding to address the growing need for transit through SB-1, but it is difficult to predict the amount that will be available each year as this is dependent upon the economy and legislative actions.
- Advocacy of additional federal transit funds for Colorado communities as part of the reauthorization of the federal transportation bill is crucial.
- Coordination between other infrastructure sectors such as roads and aviation are vital to fulfilling federal expectations of multi-modal transportation efforts and improving all transportation sectors in Colorado.

# **Sources**

Colorado Department of Transportation (CDOT). 2008. "2035 Statewide Transportation Plan."



# WHAT YOU CAN DO

You can turn on your tap just about anywhere in the U.S. and get clean water. This is a wonderful thing, but it has created an "out of site, out of mind" mentality. Some say this has led to improvement only when infrastructure failure becomes the catalyst. Colorado's deteriorating infrastructure is presently being handled on a crisis-management basis and this approach is exacerbating the problem.

One of the best things you can do, then, is to bring infrastructure to the front of your mind and promote infrastructure awareness among your elected officials and fellow citizens. Some of the more practical ways to do this are to:

#### Be an Informed Citizen:

Learn about your community's infrastructure needs. Get to know your legislative representatives and discuss your concerns with them. Bring awareness not only to state officials, but to municipal and county representatives as well. Special districts and school districts are making many infrastructure decisions so it is important to work with the different local governments that represent you.

### • Demand Continuous Maintenance:

If roads, bridges, and other infrastructure facilities are not kept in sound condition, they cannot support the level of services they are designed to handle. Regular maintenance prolongs life and minimizes the need for more costly repairs over the long term.

# • Think Long Term:

Renewing the State's infrastructure is an ambitious goal and cannot be accomplished overnight. Furthermore, the facilities built today must last for decades to come. Comprehensive planning and long-term investment are key to sound decision-making.

### • Recognize Non-Monetary Solutions:

In addition to more money, institutional, managerial, and legislative deficiencies exist and should be addressed to speed the project development process and improve the prioritization process.

### • Recognize Growth Patterns:

Monitor the infrastructure investments that shape growth patterns in your community. Many infrastructure issues are directly related to growth and impact growth patterns. Get involved in the planning decisions being made about land use, transportation, housing, economic development, water and other growth related issues in your community.



Excellent resources exist to identify your elected officials, current legislative initiatives, civic affairs, and growth and infrastructure issues. These include your state and local government web sites and the following websites:

#### International Websites

www.wfeo.org World Federation of Engineering Organizations

www.ceequal.com Institution of Civil Engineers The Civil

Engineering Environmental Quality Assessment

& Awards Scheme

**National Websites** 

www.vote-smart.org www.smartgrowthamerica.org

www.smartgrowth.org www.sustainable.doe.gov

www.lgc.org www.planning.org

www.transact.org

www.lincolninst.edu

www.uli.org www.brookings.edu www.placematters.com

www.usgs.gov

www.nrel.gov

www.sustainabilityforum.com

www.eiolca.net

www.usgbc.org www.persi.us

www.asce-susdev.org

Project Vote Smart

Smart Growth America FPA site on Smart Growth

U.S. Department of Energy

Local Government Commission American Planning Association

Surface Transportation Policy Project

Lincoln Institute for Land Policy

Urban Land Institute Brookings Institute

Place Matters

U.S. Geological Survey

National Renewable Energy Laboratory

Sustainability Forum

Carnegie-Mellon Economic Input-Output Life

Cycle Assessment

U.S. Green Building Council

Practice, Education and Research for

Sustainable Infrastructure

ASCE Committee on Sustainability

**Colorado-based Websites** 

www.colorado.gov State of Colorado

www.dola.state.co.us Department of Local Affairs www.cml.org Colorado Municipal League

www.ccionline.org Colorado Counties www.apacolorado.org APA Colorado Chapter

www.livablecenter.org Livable Communities Support Center www.icastusa.org | Links International Center for Appropriate &

Sustainable Technology

www.rmi.org Rocky Mountain Institute
www.10xe.org Factor 10 Engineering



# **GLOSSARY**

#### Aeration

To supply with air.

#### Ambient

Existing or present all around.

#### Capitalization

The act or process of supplying net worth or value.

#### Combustion

An act or instance of burning.

#### Composting

A process to develop decayed organic matter.

### Corrosion

The act or process of wearing away or weakening gradually.

### Disinfection

The process of removing a disease-producing substance or agent.

#### Downstream

In the direction of or nearer to the mouth of a stream.

#### **Enplanements**

Number airplane boardings.

#### Filtration

The process to separate out matter in suspension from a gas or liquid.

### Floodplain

An area of land submerged by floodwaters.

#### GIS

**Geographic Information System** 

#### **Greenhouse Gases**

Gases contributing to the warming of the surface and lower atmosphere of Earth.

### Hydrology

The science dealing with the properties, distribution and circulation of water on and below the earth's surface and in the atmosphere.

#### Hydropower

The production of electricity by waterpower, also known as hydroelectric power.

### Incineration

The process of burning to ashes.

#### Infrastructure

The system of public works serving a city, state or region, including roads, bridges, water supply systems, waste sites, wastewater systems, dams, airports, mass transit, and energy delivery systems.

### Leachate

A solution or product obtained by the action of a percolating liquid.

### **Piping**

Infrastructure used to convey any fluid.

#### Qualitative

Analysis that is non-numeric in nature.

#### **Raw Water**

Untreated water not fit for human consumption.

### Remediation

The act or process of correcting a problem.



#### Sediment

Earthen material deposited by water, wind or glaciers.

#### Sinkhole

A hollow place or depression where water collects.

### Transmission

The process of conveyance or movement.

### Topography

The configuration of an earthen surface and the natural and man made features of an area or region.

### Upstream

In the direction opposite to the flow of a stream.

#### Watershed

A region or area draining ultimately to a particular water course or body of water.

### Weighting

A numerical coefficient assigned to an item to express its relative importance.



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