The Tennessee Valley's Energy and Water Resources in the 21st Century

Good afternoon. I want to begin by thanking Dr. Furbish for the invitation to speak to you today. TVA values its relationship with Vanderbilt, and I am always happy to speak to students.

I was excited when Dr. Furbish told me about the interdisciplinary nature of this class. I am a strong believer in the benefits of interdisciplinary approaches to issues. That's one of the reasons I did my graduate work at Carnegie Mellon University and also one of the reasons that I enjoy working at the Tennessee Valley Authority.

For over 70 years, TVA has used an integrated, interdisciplinary approach to achieving its three-part mission of providing low-cost reliable power, environmental stewardship, and economic development. Chemical, civil, electrical, environmental, mechanical, and nuclear engineers work with archaeologists, biologists, botanists, chemists, ecologists, ichthyologists, entomologists, limnologists, and zoologists to plan, maintain, and operate TVA's integrated power and river system – all for the purpose of providing multiple benefits to the people of this region.

When I read the background information on this class, I saw many similarities between the issues you are studying and the issues we deal with at TVA. My responsibilities include management of the Tennessee River system and its associated public lands, corporate environmental policy, and research and development. Renewable versus non-renewable resources, understanding and managing risk, fossil fuels and the environment, nuclear power, electric utility restructuring, global climate change, water supply - these are things we deal with on almost a daily basis.

Today, I want to begin by telling you a little about TVA's history, because, in many ways, it is the history of energy development and use in this region. Then I'll talk about some issues related to the future of electricity production. I'll end my presentation by addressing regional water quality and quantity issues. I plan to leave plenty of time for discussion.

First, a little history about TVA.

- I want to begin by reminding us all what life in the Tennessee Valley was like in the 1930's (the era of the Great Depression).
- Per capita annual income was only $169—about 49 percent of the national average.
- The economy of the Valley region depended almost entirely on agriculture consisting mostly of subsistence farms of less than 100 acres.
- Very little industry existed.
- Land was marked by decades of mistreatment from mining and over cutting of woodlands.
- Generations of farming had worn out the soil, causing devastating erosion and nutrient depletion.
- Crop yields were very low.
- Weather patterns in the valley brought annual flooding that devastated towns and farms.
- And navigation was undependable due to dramatic variations in the river's depth.
- Only three farmers in a hundred had electricity, while even fewer had running water.
- Housing was substandard and illiteracy was twice the national average.
- Three out of five people in North Alabama had malaria.

TVA was created by an act of Congress in 1933 - one of the government initiatives designed to pull people and the US economy out of the Great Depression.

Key attributes of the TVA Act included:

- A flexible mission
- A broad mandate - TVA was "charged with the broadest duty for the proper use … conservation… and development of the natural resources of the Tennessee

River drainage basin…and its adjoining territory… for the general social and economic welfare of the nation."

- The idea was to develop a region – in its entirety – and provide an enduring infrastructure that could support growth and development far into the future.

As a regional development agency, TVA had a multipurpose mission – producing reliable, low-cost power, managing the Tennessee River system, and supporting sustainable economic development in the 7-state TVA region.

Nashville is actually outside the Tennessee River watershed – however Nashville is within the TVA power service area. If you live in Nashville you get TVA-supplied power through your local distributor NES. If you live in one of the surrounding communities your TVA power is delivered through your local cooperative.

The TVA Act told us to provide a navigable waterway from Knoxville, Tennessee to Paducah, Kentucky. We were to reduce flooding. We were to produce power and bring the benefits of electrification to a region that was too poor to be of interest to for-profit utility companies. And we were to help farmers control erosion and improve the productivity of their land.

Less than three months after its creation in 1933, TVA began construction of its multipurpose dam system. High dams were built on tributary rivers to hold back rainwater and runoff in the mountains of Virginia, North Carolina, Georgia, and East Tennessee. Low dams were built on the Tennessee and Clinch Rivers to support navigation. Hydropower generation equipment was installed at most of these dams to meet the Valley's electricity needs.

In the early 1940's a massive construction effort was undertaken to build 10 hydroelectric dams to provide electricity needed for the war effort. Electricity was needed to make aluminum for warplanes and by the Manhattan Project in Oak Ridge. But even ten new dams were not enough to meet the growing electricity demand, so in 1942, TVA began construction of its first coal-fired power plant, Watts Bar, near Spring City in east Tennessee. TVA continued building fossil plants through 1973, when it completed its largest coal-fired plant, Cumberland, located northwest of Nashville. TVA's last hydroelectric dam, Tims Ford, was completed in 1972.

TVA sited its generating plants throughout the Valley and constructed a high-voltage transmission system to deliver electricity to power distributors and large industries. The transmission system was designed to increase reliability within the TVA service area by connecting all of TVA's generating plants and providing multiple connections to customer delivery points. It also provided limited interconnections with surrounding utilities so they could help each other out in times of trouble and to allow the sale and purchase of surplus power to further improve reliability.

As early as the 1950's, nuclear power was seen as the logical replacement for fossil fuels. You have all probably heard the now-infamous quote from Lewis Strauss, Chairman of the Atomic Energy Commission in 1954 that, "It is not too much to expect that our children will enjoy in their homes electricity too cheap to meter."

In the late 1960's, projections called for electricity demand to continue to increase at seven percent each year. TVA began an aggressive program to build 17 nuclear units at seven plants located across the Valley. Unfortunately, the promise of "power too cheap to meter" was soon replaced with the reality of high nuclear plant costs caused by safety-related design and construction changes. The early 1970's was a time of increasing coal prices and labor costs. Utilities were also having to invest in emissions reduction equipment. All of these factors resulted in nation-wide increases in energy costs.

In response to these higher energy prices, people and businesses significantly reduced their consumption, which reduced the need for new capacity. The first of three units at Brown's Ferry, TVA's first nuclear plant, began commercial operation in 1974. Two additional plants, Sequoyah and Watts Bar, began operation in 1981 and 1996. TVA cancelled or deferred construction of the other 11 of its planned nuclear units.

One of the things that makes the electricity industry unique is that there are few cost-effective ways to store large quantities of electricity. One way is to store it as potential energy in the form of water. When low-cost electricity is available off-peak, at night, you can use it to pump water to the top of a mountain. When power demand is high, you can let that water flow back down from the mountaintop reservoir to spin turbines that generate hydropower. TVA's Raccoon Mountain pumped storage plant, located near Chattanooga, was completed in 1979. It can generate over 1,500 MW to help meet peak demand. Pumped storage plants are net energy users – it takes about 3 megawatt hours of input for each 2 megawatt hours of electricity generated. However, the price differential between off-peak and on-peak power is great enough to make pumped storage plants valuable assets. Unfortunately, there aren't many places where you can build them.

In the 1970's TVA began testing alternative energy sources including solar, wind, and biomass. At that time, the economics were unfavorable for wind and solar in this region. By the end of the 1990's improvements in technology had reduced the price disadvantage of wind-powered generation.

In 2000, TVA created Green Power Switch, a program where environmentally-conscious individuals and businesses voluntarily pay a premium for electricity from solar, wind, and landfill gas generation sources. TVA built three wind-powered generators on Buffalo Mountain, located about six miles northwest of Oak Ridge. This was the first commercial-scale use of wind power to generate electricity in the southeastern United States. The first three turbines on Buffalo Mountain provided about two megawatts of capacity. In 2004, TVA signed a 20-year power purchase agreement for the addition of 15 larger wind turbines, bringing the wind park's capacity to 29 MW. These 18 turbines generate enough electricity to power over 3,700 homes.

Let me give you a brief overview of TVA today. We are the largest public power producer in the Nation with over 33,000 MW of generating capacity. TVA is a power generator and wholesaler – we provide power to 158 public power distributors and 62 direct served customers over our 17,000 miles of transmission lines. These distributors meet the electricity needs of 8.5 million Valley residents.

We have a diverse generation portfolio – coal, nuclear, hydro, pumped storage, natural gas, and renewables, which include wind, solar, and landfill gas. About 60 percent of our generation comes from coal, 29 percent from nuclear, and 10 percent from hydro, with natural gas and renewables making up the remainder. TVA's power rates are among the lowest in the country.

But TVA is more than just a power company. We manage the nation's fifth-largest river system for the public purposes of navigation, flood control, water supply, and recreation – as well as the production of power. TVA dams and reservoirs have prevented over $5.7 billion in flood damages – on average, about $220 million per year, and the navigation system saves shippers – and the ultimate consumers of the goods shipped – about $1 billion per year compared to the next least costly form of transportation for bulk commodities. We manage 293,000 acres of public lands and 11,000 miles of shoreline. Our reservoirs and recreational facilities support millions of recreation user-days each year.

The TVA power system is self-financed; we get no appropriations from Congress. Even the federal functions of navigation, flood damage reduction, and public lands management - that are funded by tax dollars in all other parts of the country - are paid for by Valley residents and businesses through their electricity rates. Over 8.5 million Valley residents are the direct beneficiaries of TVA's efforts. Other parts of the country also receive benefits from TVA through reduced flood damage along the Ohio and Mississippi Rivers and access to over 800 miles of navigable waterway through TVA's system of dams and locks.

Now I'd like to talk about two issues that may have major impacts on the future of electricity generation in the Valley and the nation: industry restructuring and environmental regulation. One of the main things these two issues have in common is that they increase uncertainty, and uncertainty is a bad thing in an industry where investments are large and lumpy and assets have long service lives.

Utility industry restructuring used to be called deregulation. But after the problems in California and the collapse of Enron, even the most rabid proponents of electricity markets have been forced to acknowledge that you can't completely deregulate an industry that provides a product as critical as electricity – especially when that product has to be provided in real-time, 24 hours a day, 365 days a year. The northeast power blackout of August 2003 provided an example of some of the problems that must be addressed when you try to separate the responsibilities for power system control from ownership and operation of generation and transmission systems. It also highlighted the need to have strong regulations to ensure that asset owners meet their responsibilities for things like right-of way clearing, operational analysis, diagnostic support, and personnel training.

America's utility industry was created in a business environment where companies were granted exclusive monopolies over their service territories. They received a guaranteed return on their investments – in return, they had an "obligation to serve" that meant that everyone had access to electricity and that there was enough generation to ensure that the lights would come on when customers flipped the switch. These companies typically were vertically-integrated: they owned generation, transmission, and distribution systems and were responsible for the entire process of generating electricity and delivering it to customers.

In 1992, the Energy Policy Act required transmission owners to let other companies transmit power over their lines, making it possible to create markets for generation. The idea was that customers would be able to buy power from a variety of providers, and that this competition would reduce prices.

While this sounded good in theory, in practice the cost savings have not materialized. There have been structural issues related to market design, and gaming of the system has occurred - both of which have contributed to higher prices and reduced reliability.

The Federal Energy Regulatory Commission, referred to as FERC, is the federal agency that regulates the interstate transmission of natural gas, oil, and electricity as well as natural gas and hydropower projects. In spite of the problems that have been experienced to date, FERC believes that the best way to meet the nation's future energy needs is by establishing competitive markets for generation. Originally, they encouraged the development of regional transmission organizations (RTOs) to operate transmission assets and ensure that all generators have equal opportunity to use the transmission system. Many states, especially those in the south where power costs have always been low, have resisted the formation of RTO's since they believe that they will result in price increases for the region as their low-cost generation is sold to other regions. FERC is now focusing on establishing market monitoring functions to ensure that companies are not unfairly exercising market power. These new regulatory functions involve costs that were not previously in the system which contribute to the high costs of creating and operating generation markets.

In the old monopoly environment, utilities made decisions on when and where new generation was needed based on projected growth. In a market-based environment, independent power producers – speculators - build power plants wherever they can get access to fuel and transmission service, regardless of whether that's where the power is needed. This has led to significant over-construction of generation in some regions and caused transmission system congestion. Most of these plants run on natural gas. Since natural gas prices have skyrocketed and economic growth has slowed, plants are sitting idle in many parts of the country.

One result of this generation "boom" is that investors will likely be less willing to build additional plants until power shortages result in electricity prices going high enough to provide high returns, which will probably lead to another boom in generation. These boom/bust cycles are common in commodity industries; the difference in the electricity industry is that there is no inventory to smooth out disruptions in production capacity. There is no cost-effective way to provide enough long-term electricity storage, so it's likely that some parts of the country will see periodic swings in power costs and reliability unless regional planning processes can be established and enforced.

The transmission system, which was designed and built to deliver power within a local region, is now being called upon to deliver increasing amounts of electricity over longer and longer distances. Power flows according to the laws of physics - like water, it takes the path of least resistance. Complex computer models must be run on a continuous basis to evaluate the impact of proposed contracts to deliver power from a specific generator to a specific customer. If too many transactions are scheduled, transmission lines can be overloaded which requires the transmission operator to cut some transactions. This means more expensive generators may be forced to run, resulting in congestion costs that increase the delivered cost of power.

TVA was not involved in the massive overbuilding of speculative generation that affected much of the industry over the past few years. TVA only builds or contracts for generation based on meeting expected load growth in the Valley. However, we are impacted by the potential for loss of load if our present customers switch to other power producers.

As I mentioned, most of the generating plants that have been constructed over the past five years use natural gas. This was because these types of plants - called combustion turbines - cost less to build than nuclear or coal-fired plants and can be built in less than two years. The downside is that natural gas prices have gone up significantly and are very volatile - they experience frequent large price swings. For example, natural gas prices for delivery in July 2005 have gone from a little over $5 to almost $8 in just one year.

Nuclear and coal-fired plants have much lower fuel costs but take longer and cost more to build. The problem is that in order to keep electricity prices low, those are the types of plants that you need to invest in. But how can companies afford to spend billions of dollars on a plant if their customers can leave before they even get it built? Competitive generation markets drive generators to make investments in assets with short paybacks. These suboptimal decisions may not support the lower prices expected by proponents of deregulation.

It has been said that the electric power system is the world's most complex machine. It takes more than just the generation of kilowatt hours for the lights to come on when you flip the switch. The power system must also have ancillary services like load following, spinning reserve, and voltage support. Load following is the ability to increase or decrease generation output quickly to help match changes in demand. Spinning reserve is the ability of units to quickly begin generating to replace a unit that is forced off line due to equipment problems. Voltage support is needed to help keep power flowing across transmission lines. In order to provide these services, you have to reduce your ability to generate kilowatt hours. In the old integrated utility model, the power company took care of making sure that everything was in place and operated as required to ensure the reliable delivery of electricity. In a competitive market, generating companies are in business to maximize their profits, and they operate their plants to produce the products that generate the most revenue. So when you have competitive generation markets, you either have to regulate the provision of these products or create markets to provide them, and these markets must work together well enough to make sure generators have the right incentives to deliver the mix of products needed.

The second issue is the uncertainty in environmental regulation. TVA is one of the largest coal-users in the nation - nearly 60 percent of our electricity is generated from coal. We are in the midst of a $5 billion program to reduce our emissions - the most aggressive emission-reduction effort in the country. TVA is spending a million dollars a day on equipment that will reduce our emissions of nitrogen oxides and sulfur dioxide – NOx and SOx. The good news is the air quality in the Tennessee Valley region is good and getting better. The latest annual air-quality trends report issued by the Environmental Protection Agency (EPA) shows air quality in the nation has steadily improved over the past 12 years for all six principal pollutants: sulfur dioxide, nitrogen dioxide, ozone, carbon monoxide, particulate matter, and lead. Air quality data for the Tennessee Valley region shows reductions in all of these pollutants. You may have read recently about counties being designated as non-attainment for various pollutants. This is due to tightening standards, not poorer performance.

TVA has reduced sulfur dioxide (SO2) emissions by 75 percent since 1976. This reduction contributed to a 40 percent decline in overall SO2 concentrations in the Tennessee Valley air between 1979 and 1998, according to EPA figures. When we complete installation of additional controls, we expect to achieve a total SO2 emissions reduction of 85 percent.

Ground-level ozone, a primary ingredient in smog, is formed when volatile organic compounds (VOCs) and NOx react chemically in the presence of sunlight. Cars, trucks, power plants and industrial facilities are the primary human-caused sources of these emissions. Regulations require that power plant emissions of NOx during ozone season, which is from May through September, be reduced. TVA's ozone season NOX emissions in 2004 were 78 percent below 1995 levels.

Some people have suggested that the utility industry should stop spending money adding emission controls to old, coal-fired plants and instead build new plants. TVA makes investment decisions based on existing legislation and regulations as well as our best estimates of future legislation and regulations. It is less expensive for our customers for us to add controls to existing plants rather than building new coal plants, gas-fired plants, or nuclear plants. This is true even with the new, more stringent regulations on SO2, NOx, and mercury emissions. Capital costs of a new plant are significantly higher than the cost of adding emission controls to existing plants.

Because there is so much uncertainty about which emissions are going to be regulated and what the allowable levels of emissions will be, and because no one knows what is going to happen about industry restructuring and how that will impact long-term contracts, everyone in the electricity industry is being driven to make incremental investments in existing assets rather than making billion dollar bets on new plants.

The biggest wildcard is the potential for regulations on carbon dioxide emissions. Carbon regulation could make much of our nation's coal-fired generation non-economic because there are no cost-effective ways to capture carbon dioxide emissions from existing coal plants. Some new "clean coal" technologies like integrated gasification combined cycle (IGCC) plants do make it possible to capture carbon dioxide. These plants use chemical processes to turn coal into gas - during this process the carbon dioxide can be captured. However, we still haven't found any good ways to store, or sequester, carbon dioxide. Underground storage is a possibility, but no one knows how long the carbon dioxide can be stored or what would happen if large amounts of carbon dioxide were released quickly, for example due to an earthquake. There are also transportation issues to be addressed unless you only locate new plants near CO2 storage sites.

However, for the foreseeable future there are no other generation options that could replace coal. Renewables are too expensive and, especially in this part of the country are very limited – there just aren't many sites with good wind resources. It would take more than 22,000 wind turbines like the ones recently installed at Buffalo Mountain to replace our coal plants. The problem is, we don't have 3,000 miles of mountain ridges where they could be installed. We could use biomass, but again, not to replace 60 percent of our generation.

Nuclear is a carbon reduction option, because there are no air emissions from nuclear plants. TVA is completing the recovery of its oldest nuclear unit at Browns Ferry, and we are also increasing capacity at the other two units at Browns Ferry. When completed in 2007, these projects will add almost 1,500 MW of non-carbon emitting capacity to the

TVA system. TVA is also participating in two consortia with other utilities and equipment manufacturers looking at building next-generation nuclear plants. However, no one is willing to commit the billions of dollars it would take to build a new nuclear plant until we know more about how Congress is going to deal with restructuring and environmental regulation. In the nuclear arena, you also have to worry about how difficult it may be to license a new plant or to get existing licenses renewed.

TVA is also adding generation capacity as we update our existing hydro plants. By the time this program is completed in 2015 we will have added an additional 700 MW of emission-free capacity at existing hydro plants while improving water quality across the reservoir system.

We are taking other steps to reduce carbon emissions by improving the efficiency of our existing generation plants and reducing our internal energy consumption. We are participating in studies of carbon removal and sequestration technologies. And we are working with partners to plant vegetation to sequester carbon. One project underway at our Paradise Fossil Plant in Kentucky is looking at how we can increase vegetation growth rates through use of power plant byproducts and wastewater. This project uses the sludge produced by the scrubbers that remove sulfur dioxide from plant emissions to improve the soil on reclaimed surface coal mine lands and irrigates the soil with plant wastewater. Since January 2002, TVA has grown commercial-grade trees and cover crops and expects to sequester an average of 3.4 to 4.5 tons of carbon per acre per year.

Now I want to talk about water issues.

In most parts of the country, various federal and state agencies have responsibility for managing water resources for specific uses within specific political jurisdictions. This is also the case in most other countries. They work river by river, project by project — building a dam for irrigation here, another for navigation or water supply there. But TVA, in the words of its early chairman, David Lilienthal, *"was to envision in its entirety* *the potentialities of the whole river system, for navigation, for power, for flood control, and for recreation."*

Lilienthal was determined that the Tennessee River would be developed differently than other rivers. He wrote these words in 1944:

> *"Not far from where I write are other rivers developed by private interests or public agencies. On these rivers it is common practice … to build a single dam without first having fixed upon a general plan that will ultimately insure the full use of the whole river as a unit. There are dams built for the single purpose of power development. Such individual dams, in order to yield an immediate return in power, impair or destroy the river's full development of power at other sites, for they were not designed with the whole river thought of as it is in nature, a unit. These power dams are not built or operated to control floods, and do not provide a continuous navigable channel. The full usefulness of the river is lessened. Similarly, hundreds of millions of dollars in public funds have been expended for the single purpose of navigation on some of our rivers, but most of the dams constructed will not control the rivers' floods or create electric energy. They now stand as massive barriers against the erection of multi-purpose structures."*

I cannot overemphasize how this vision changed the nature of water management at TVA.

TVA's system of 49 dams was designed to work as an integrated system – regulating stream flows to maintain a year-long navigable channel, holding water back to limit damage caused by spring flooding, and using and reusing water to generate clean, low-cost electricity.

The Tennessee River begins just east of Knoxville where the Holston and French Broad Rivers come together. I've used the term watershed, several times – a watershed is the land area that drains into a particular body of water. Rainfall that lands in the Tennessee

River watershed eventually ends up in the Tennessee River. There are over 42,000 miles of streams and rivers in the Tennessee River watershed. TVA has ten major dams on tributaries located in the mountains of Virginia, North Carolina, Georgia, and East Tennessee that provide most of our flood storage.

All of these major tributaries feed into the Tennessee River above Chattanooga (located just south of Chickamauga Dam). You can think of the mountains in East Tennessee as the walls of a funnel that pours all of this water through Chattanooga – the most flood-prone area in the Valley.

The Tennessee River system is still very important to TVA's ability to meet the electricity needs of the region. All of TVA's nuclear plants and most of its coal plants were sited on the Tennessee River and its tributaries to provide another opportunity for integration - we manage water flows to ensure these thermal plants have a reliable supply of cooling water so they can stay online and at maximum capacity even when river and air temperatures reach their peaks in the summer. In addition, our hydro and pumped storage generation is operated to provide critical ancillary services for the power system: services such as voltage support, load following, and spinning reserve – services and capabilities that thermal plants lack or can only produce at higher cost.

When you dam a river, it changes the ecosystem. When water is held behind a dam, it tends to stratify based on water temperature, and levels of dissolved oxygen near the bottom decrease. When this low-oxygen water is released through the dam, it may decrease oxygen concentrations downstream to levels that are inadequate to support aquatic life. Low oxygen levels also decrease the ability of streams to break down waste, a process that requires and consumes oxygen.

When cold water from the bottom of a reservoir is released, water temperatures downstream are altered—sometimes so much so that streams below the dam are no longer suitable for warm-water aquatic life. Also, sudden, intermittent releases through dams, such as those caused by hydroelectric power peaking operations, can affect water quality. They can change water temperatures downstream and produce up to 100-fold increases or decreases in flow within a matter of minutes one or more times a day. This can result in scouring of streambeds during high releases and drying much of the streambed during low releases, both of which can severely degrade habitat conditions for aquatic life. To reduce these negative impacts, TVA has invested millions of dollars and developed new technologies to increase dissolved oxygen in water and provide minimum flows below our dams.

TVA operates its reservoir system on an annual cycle and traditionally started dropping water levels on its reservoirs in August. This was done to improve water quality, provide power needed to meet late-summer air conditioning loads, and increase flood storage to prepare for hurricane-related rainfall events. This caused conflicts with people who lived near or recreated on reservoirs who wanted water levels to stay higher, longer. Businesses that rely on people who recreate on TVA reservoirs make more money and create more jobs when water levels are up. Over time, the value placed by the public on the various benefits provided by the reservoir system changes. Today there are more people wanting to use the reservoir system in many different ways. In addition, our ability to manage the system improved with real-time data collection and sophisticated computer analysis capability.

We are fortunate that TVA’s broad mandate lets us continually respond to these changing public needs. In response to stakeholder requests that we delay the summer drawdown, we conducted a two year study to find out if we could create greater public value by modifying our reservoir operating policy. Public participation was a key component of the Reservoir Operations Study. TVA heard from thousands of stakeholders across the region who provided input on how our operation of the system could better meet their needs. Having this kind of public participation helps ensure that policies are durable and have been developed with the future in mind.

In support of this study, TVA developed new flood risk and water quality models that allowed us to tweak the system to provide increased benefits. In some areas we pushed the science of reservoir analysis and created capabilities that we continue to use on a daily basis. The study indicated that we could maintain reservoir levels higher in the summer and in the winter without significantly impacting water quality, flood risk, or power costs. We implemented this new policy last June, and had a successful first year. To help put this accomplishment into perspective, it usually takes about 7 years for dam owners to go through their public relicensing processes. We were able to complete our process for 35 dams in only two years. We were able to do this because of the integration of the TVA system.

TVA has no regulatory authority in the area of water quality. We don't set pollutant limits or enforce standards for discharges; these are state responsibilities. But because we built the dams and manage the water's flow, the public holds us responsible for the health of the Tennessee River and reservoir system.

TVA influences water quality by working cooperatively with Federal and State regulators, cities, industries, and individual water users. Across the nation, the vast majority of water quality problems are caused by non-point sources: things other than industrial or municipal discharges to waterways. TVA addresses non-point source problems through coalition building. We've created watershed teams consisting of water and natural resource experts and community and education specialists. The teams have been charged with building partnerships among the different groups of people to whom the water is important: citizens, farmers, businesses, federal, state and local agencies, and environmental groups.

TVA works with stakeholders to assess water quality conditions and identify resource needs and then to develop cooperative protection and improvement projects. The focus is on finding creative ways to achieve desired water quality improvements and on encouraging local ownership of and responsibility for watershed conditions. Improvement projects are designed to reduce or eliminate local pollution sources. Depending on local needs, projects may include activities such as planting of waterfront vegetation to establish riparian buffers that filter pollutants, stabilizing shorelines to reduce erosion, instituting best management practices for farming and livestock operations, and restoration of abandoned mine lands.

One example of how this cooperative approach to addressing water quality problems is the Brasstown Creek area near the North Carolina - Tennessee border. This stream suffered from siltation and bacteria from agriculture and other sources and was listed by the states as an impaired water body. Working with the Hiwassee River Watershed Coalition, the Natural Resources Conservation Service, the North Carolina Clean Water Management Trust Fund, the Georgia Department of Natural Resources, the North Carolina Department of Environment and Natural Resources, and local counties and businesses, over $3.5 million has been invested in stream restoration work. Over 5 miles of stream have been restored, 50 acres of wooded riparian buffer were created and protected, and 60 acres of critically eroding areas were revegetated. Thanks to these efforts, the North Carolina portion of creek was recently taken off the state's list of impaired water bodies.

TVA also works with stakeholders to help protect water quality from boating activities. TVA's Clean Marina Initiative was established to address sewage management, oil and gas control, marina siting, and erosion prevention. The program certifies marinas that are in compliance with pollution-control standards and allows them to use the Clean Marina logo and flag. Since 2000, 39 marinas have been certified.

The concepts of water quality and water quantity are closely linked. Communities and industries need access to adequate supplies of clean water in order to grow. In times of low rainfall, flow in rivers and streams decrease, reducing their ability to assimilate waste. In the summer, low flow can also result in water temperature increases that are harmful to aquatic life.

Up to now, we haven't had to worry about water availability in the Southeast -- but even here we are beginning to see water scarcity. The Tennessee Valley is a water-rich region. Annual average rainfall is about 52 inches making it one of the wettest areas in the country. Even though we talk about average rainfall, our hydrologists say that there really aren't very many average years. If you just consider total rainfall, last year would be considered average – however, what really happened was the first half of the year was dryer than normal and the second half was very wet, including the wettest September on record.

We began to realize we needed a much better understanding of water coming in and going out of the system, so in 2000, TVA and the US Geological Survey conducted a study to identify the critical water supply areas and issues that are expected to affect the Tennessee River watershed over the next 30 years. We needed this data for our reservoir operations study and also to help guide our efforts to support economic development in Valley communities. We found that total water use in 2000 was 12.2 billion gallons per day. Only about 5% of this water is consumed during use, through evaporation, transpiration, incorporation into products or crops, or consumption by people or livestock. This makes the Tennessee River system both the most intensively utilized river system in the nation and the system with the lowest consumptive loss.

About 84 percent of the water extracted from the system is used to cool TVA's thermal power plants. Industrial use is about 10 percent, public supply is 5 percent, and irrigation is 1 percent.

In 2030, water use is expected to increase by 15 percent, to almost 14 billion gallons per day. Consumptive use is expected to increase from 5 percent to 7 percent. These increases are not expected to have significant impacts on the Tennessee River system in most years. In low-rainfall years, there could be slightly lower water levels in tributary reservoirs.   The study identified both existing and potential water-supply shortages on unregulated streams: those on which flow is not controlled. This information is helping communities plan for future growth.

One of our responsibilities under the TVA Act is to issue permits for water intakes for industrial sites and water authorities, which involves us in the issue of interbasin water transfer. An interbasin transfer is when water is exported from one watershed to another.

When you send water out of the watershed, it is no longer available to existing downstream users. It can also have impacts upstream impacts, especially in dry years. In order to maintain minimum flows for navigation and aquatic habitat, losses through interbasin transfers could require additional releases from upstream tributaries. Because we will maintain the depth of the navigation channel**,** we will drain some water from the upstream reservoirs. These additional reductions in water levels could impact recreation opportunities and local economies. Depending on how the transfers are conducted, there can also environmental issues associated with mixing different ecosystems.

There are already some interbasin transfers that occur on the TVA system. Typically, they occur when a water authority takes water from the river system and uses it to serve demand from its local customers who live in an adjoining watershed. In 2000, these transfers represented less than a tenth of one percent of daily use.

Water also leaves the Tennessee River watershed through the Tennessee-Tombigbee Waterway – a navigation channel created to connect the Tennessee River to the Tombigbee River to provide a shorter route to the Gulf of Mexico. The USGS study identified the potential for water loss through the Tenn-Tom to increase from 200 to 393 million gallons per day by 2030.

Various interests in Georgia, Alabama, and Mississippi are talking about taking water from the Tennessee River to help meet water demand in their regions. The USGS study estimated that interbasin transfers to Atlanta, Birmingham, and northeast Mississippi could reach 460 million gallons per day by 2030.

There are precedents for charging water users within the Tennessee River watershed when their use of water from the system reduces power generation. A number of political, environmental, and financial concerns will have to be addressed before widespread interbasin transfers are allowed to occur.

Even inside the watershed, there is increasing concern about water quantity. Communities are becoming worried that they may not have access to enough clean water to meet future demand. TVA's Growth Readiness program encourages growth management practices that preserve open space and reduce the amount and impact of impervious surfaces. TVA works with planning and public works officials who are intimately involved in the day-to-day, nuts-and-bolts of their community's land use and water quality decisions. The program helps them build awareness of how land use affects water quality, and the choices they have for preserving water quality as their communities grow.

Water is used and reused as it flows from watersheds into streams, tributaries, and rivers. Water sources are not always aligned with state lines, and the consequences of actions in one state can be felt in other states. Communities and businesses not located near surface water sources rely on groundwater, and the aquifers that make up these groundwater sources don't follow state boundaries, either. Since groundwater flows into streams and surface water recharges aquifers, all of our water sources are interrelated through a complex hydrologic cycle that is not well defined or understood. In order to enhance overall cooperation and communication on water quantity issues, TVA is organizing a Tennessee Valley Water Supply Partnership among Valley states and regional federal agencies. The goal is to obtain and share data and to improve regional water planning.

Today I've attempted to provide you with some perspective on the energy and water resources here in the Tennessee Valley. We are fortunate to have the benefits of bountiful rainfall and a strong electricity infrastructure with a diverse fuel supply. The river system provides a reliable water supply, low cost navigation that saves shippers a billion dollars per year, and flatwater and whitewater recreation opportunities that underlie a multimillion dollar recreation industry. Today, the air and the water quality in the Tennessee Valley are good and getting better. Power system reliability is high, and electricity costs are low relative to the rest of the country.

There are still major issues to be faced – national and energy security, environmental consequences related to oil, natural gas, and electricity production and use, and increasing demand for water. Restructuring and increasingly restrictive environmental regulations are changing the rules of the game. Soon, the players will also be changing, since the average age of workers in the utility industry is about 48. This means there will soon be many opportunities for your generation to play an active role in helping find innovative solutions to these problems – solutions that will allow us to continue to have a strong economy and a good quality of life.

Thank you for your attention, and I'll be glad to take your questions.