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MISSOURI PUBLIC SERVICE COMMISSION

CASE NO. ER-2011-0028

DIRECT TESTIMONY

OF

PAUL C. RIZZO

ON

BEHALF OF

UNION ELECTRIC COMPANY
d/b/a AmerenUE

Pittsburgh, Pennsylvania
September, 2010

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DIRECT TESTIMONY

OF

PAUL C. RIZZO

CASE NO. ER-2011-0028

I. INTRODUCTION

Q. Please state your name and business address.

A. My name is Paul C. Rizzo. My business address is 500 Penn Center Boulevard, Pittsburgh, Pennsylvania.

Q. By whom and in what capacity are you employed?

A. I am employed as President and Chief Executive Officer of Paul C. Rizzo Associates, Inc., an engineering and consulting firm specializing in dams and hydroelectric projects.

Q. Please describe your educational background and employment experience.

A. In 1963 I received a Bachelor of Science degree in civil engineering from Carnegie Mellon University. In 1964, I received a Master's degree in civil engineering, and in 1966 I received a Ph.D. in civil engineering, also from Carnegie Mellon. I am a registered professional engineer in 29 states, and I am a member of 15 technical societies. I have more than 40 years of experience providing engineering consulting services for a wide variety of dam projects, including embankment dams, gravity dams, earth and Rockfilled dams, Amburson dams, arch dams and timber crib dams. I have served as principal-in-charge of all of the Dam Projects of Paul C. Rizzo Associates, Inc., located in the U.S. and overseas, over the past 26 years. I also have extensive experience addressing the civil engineering aspects of nuclear plants, thermal plants and hydro-electric plants. I have lectured on a variety of civil and geotechnical topics and served on consulting boards dealing with various issues related to dams, seismic design, and geotechnical engineering. I have authored or co-authored over 100 publications in areas of my expertise. I have attached my curriculum vitae as Schedule PCR-E1 to my testimony.

II. PURPOSE OF TESTIMONY

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony is to address Union Electric Company d/b/a AmerenUE's ("AmerenUE" or "Company") construction of the new and improved Upper Reservoir for its Taum Sauk Pumped Storage Plant. In particular, I will address the considerable enhancements to the Upper Reservoir that were realized as a result of this project, and I will explain the steps AmerenUE would have been required to take by the Federal Energy Regulatory Commission ("FERC") if the December 2005, failure of the Upper Reservoir had not occurred.

Q. Are you familiar with the history of the Taum Sauk Project?

A. Yes, I am intimately familiar with the circumstances surrounding the failure of the Upper Reservoir in December, 2005, the investigation into the cause of the failure, and the Company's construction of the new Upper Reservoir. Immediately following the 2005 breach, AmerenUE retained our firm to perform a Forensic Investigation and Root Cause Analysis, to perform inspections and analysis to ensure the immediate safety of the remaining sections of the Upper Reservoir, and to develop a conceptual design for a rebuilt Dam. In summary, our evaluation revealed that the Dam breach was directly caused by over-pumping associated with faulty instrument control systems coupled with substandard construction and 1960's-era design practices that are not considered adequate today. While conducting the investigation, Rizzo Associates began work on a conceptual rebuild design that addressed schedule, costs, environmental impact, licensing conditions, FERC Engineering and Dam Safety Guidelines and overall dam safety. Based on numerous tests and the construction quality of the remaining structure, we concluded that a partial rebuild of the original Concrete Faced Rockfill Dam ("CFRD") was not technically feasible. The FERC indicated that a repair of the old facility would not be acceptable and approved a new structure constructed in accordance with their current Dam Safety Guidelines found at 18 CFR Part 12. I have closely followed this project from the date of the failure in 2005, to completion of the construction of the new Upper Reservoir in April, 2010.

III. EXPLANATION OF ENHANCEMENTS

Q. You mentioned that the new Upper Reservoir has a number of enhancements compared to the old Upper Reservoir. Could you please explain what you mean?

A. Yes. The old Upper Reservoir was designed in the late 1950's and constructed in the early 1960's. As I mentioned, it was a Concrete Faced Rockfill Dam, which consisted of dumped rock covered by a reinforced concrete face. The Dam was not constructed on a solid foundation, and, prior to the failure, it leaked considerably. It was not designed to meet modern seismic standards and it did not have adequate instrumentation and safety features.

The new Upper Reservoir is a much more substantial structure, designed and constructed in accordance with modern standards, and in compliance with detailed guidelines contained in FERC Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter III—Gravity Dams. The Dam is constructed of roller compacted concrete ("RCC"), which makes it much more robust than the old CFRD structure. As a consequence, the safety of the new Upper Reservoir is significantly improved, and the long-term behavior of the Dam is predictable, reliable, and the maintenance is considerably less costly. Specific enhancements to the structure that contribute to these impacts are summarized as follows:

- The new Dam is a massive, robust concrete gravity structure as opposed to an un-compacted rockfill dam with a leaky upstream face. Consequently, stability is enhanced, rock weathering is eliminated, and leakage is diminished to almost nothing. Moreover, the operating life of the new Dam can be expected to be at least 80 years, far longer than the old CFRD structure could last.

- The new Dam has a symmetrical cross-section designed to much better accommodate the relatively low-strength foundation rock. The symmetrical section allows the static load to be distributed over a wider base with consequential lower bearing pressures.

- The foundation of the Dam is constructed directly on top of bedrock, as opposed to the old CFRD, which was constructed on top of fines, soil, vegetation and other material between the foundation and bedrock.

- The Dam is a rigid gravity structure with a wide base, and settlement is expected to be low to non-detectable, as opposed to several inches to feet that would be expected with a rockfill dam.

- The new Dam does not utilize a parapet wall to retain water, unlike the old facility.

- The Dam has a number of other features that enhance the operation and safety of the Dam such as:

    - A low permeability upstream face on an RCC main section compared to a leaky and pervious CFRD;

    - A set of foundation drains that drain off excess pore pressures in the rock, should they develop over the life of the Dam;

    - A Gallery to allow for collection and release of drainage from the foundation drains and to monitor the internal behavior of the Dam;

    - Materially improved instrumentation and dam surveillance equipment; and

    - An Overflow Release Structure to release water in an emergency.

In summary, the new Dam contains a number of enhancements which make it materially safer and more reliable, as well as giving it a considerably longer life expectancy than the CFRD Dam it replaced.

ORIGINAL UPPER RESERVOIR CONCRETE FACED ROCKFILL DAM

THE RESERVOIR BREACH – DECEMBER 15, 2010

THE NEW ROLLER COMPACTED CONCRETE UPPER RESERVOIR DAM

Q. You mentioned that the new Dam was constructed to meet modern seismic standards. Can you please elaborate on that point?

A. Certainly. In the early 1960's when the original Dam was built, far less consideration was given to seismic issues. But the fact is that some of the largest earthquakes in the recorded history of the United States, the 1811-1812 New Madrid Earthquakes, occurred near the Taum Sauk Plant. As a consequence, the new Upper Reservoir has been constructed to be in full compliance with FERC's Chapter 13 Engineering Guidelines—Evaluation of Seismic Hazards (Draft). These guidelines outline the best available technology for dams and hydroelectric projects, and Rizzo Associates embraced the concepts in these guidelines in the design of the new Upper Reservoir. The new facility was designed and constructed with the capability of withstanding a magnitude 7.7 event in the New Madrid Seismic Zone or a magnitude 5.8 event within the local area immediately around the Taum Sauk Plant. In contrast, based on information I reviewed regarding the design of the original facility as well as my own forensic investigation of the failure, the previous facility was designed to resist only minimal earthquakes, and poor construction made it unlikely that the facility could resist even those earthquakes.

The specific enhancements that make the new Dam able to resist earthquakes postulated to occur in Central and Eastern Missouri are as follows:

- The new Dam is a massive, robust concrete gravity structure as opposed to an un-compacted rockfill dam with a leaky upstream face.
- The foundation of the new Dam is set on bedrock, and the Dam is designed specifically to withstand a repeat of the 1811-1812 New Madrid Earthquakes or a significant earthquake in the location of the Dam.
- The new Dam has a symmetrical cross-section capable of resisting earthquake ground motion in any direction regardless of whether the Reservoir is filled or not.

Q. You also cited the fact that the new Dam does not hold water on the parapet wall as an improvement. Can you explain that further?

A. Yes. The original CFRD included a parapet wall constructed of reinforced concrete sections 10 feet high and 60 feet long, weighing up to 120 tons each, supported by foundation footings embedded into the concrete-lined slopes of the original dike. This parapet wall was used to retain water in the Upper Reservoir during normal operation, except in the winter months. Modern dam design does not allow for parapet walls to retain water on an everyday operating basis; a parapet wall can only be used to retain possible wave action and as a safety barrier for vehicular traffic. The parapet wall was a portion of the Upper Reservoir that breached in 2005. Moreover, during our forensic investigation, we observed considerable undermining of the wall well away from the location of the actual breach in the northwest corner of the Reservoir.

The 3.5-foot reinforced concrete parapet wall was constructed along the upstream side of the Reservoir crest as a vehicle guard rail. Even in the event of an accidental over-pumping situation, the excess water would be handled by the Dam's new Overflow Release Structure, and water would not be retained by the parapet wall.

OLD PARAPET WALL AS IT APPEARED AFTER THE BREACH

THE NEW PARAPET WALL – DOWNSTREAM SIDE

Q. You previously mentioned that the old Upper Reservoir was plagued by leaks. How significant was the leakage problem?

A. The leakage problem at the old Upper Reservoir was quite significant. Throughout its lifetime, there was excessive leakage through the concrete face and under the CFRD through the Dam foundation. This leakage, as high as 40 to 60 cubic feet per second (18,000 to 27,000 gallons per minute) prompted the installation of a geo-membrane liner on the upstream face of the Reservoir to combat this leakage. A drainage and pump-back system was installed to reduce water flow to the surrounding environment and to help maintain the water level in the Reservoir. The leakage was attributable to poor construction of the concrete face on the CFRD, and an inadequate grout curtain.

Q. What is a grout curtain?

A. A grout curtain is a series of holes drilled through the Reservoir floor along a line immediately upstream of the interior toe of the Dam. These holes are filled with cement grout under pressure. The grouted holes form a cemented-rock barrier to inhibit water from leaking under the Dam. Although there was an original grout curtain installed under a portion of the length of the old Reservoir, and although the original grout curtain was reinforced and expanded over the life of the facility, the grout curtain was not adequate to prevent excessive leakage. The Forensic Investigation disclosed that both the initial grout curtain and the supplemental grout curtain may have been inadequately designed and constructed, particularly with respect to depth. In my opinion, although the inadequate grout curtain did not play a substantial role in the breach event, it may have been a secondary contributing factor.

Q. Is the grout curtain in the new Reservoir an improvement?

A. The new grout curtain is a significant enhancement over the old one. It consists of a line of grout holes installed along the entire length of the Dam, approximately 10 feet from the upstream toe of the Dam. To intercept vertical fractures in the rock, the grout holes were drilled at an angle of 30 degrees from vertical. At several locations, an additional line of grout holes was installed approximately 20 feet from the toe of the Dam to address highly fractured rock conditions, and finally, tertiary grout holes were added between primary and secondary grout holes where leakage would have been unacceptable. A grout line was also installed around the perimeter of the vertical shaft. All grout holes were drilled at least 50 feet in depth and 30 feet into rock and in some instances deeper depending on the existing foundation conditions. When compared to the original grout curtain that was installed for just a portion of the length of the Dam and at much shallower depths, the new curtain is quite robust and was put through substantial testing during the refill test program. During the testing program it was determined that the grout curtain was functioning as intended and preventing unacceptable leakage under the new RCC Dam. In fact, as previously discussed, there has been no significant leakage from the new Reservoir.

Q. You also mentioned the drainage Gallery as an enhancement in the new Reservoir. What is a drainage Gallery and why is it an enhancement?

A. A drainage Gallery is a tunnel inside the actual Dam around the entire perimeter of the Reservoir. Its primary functions include:

- Providing a pathway for drainage from drain holes drilled into the foundation;
- Providing a pathway for drainage, if any, from the Crest-to-Gallery drains drilled from the upstream face of the Dam;
- Relieving upward acting water pressure on the base of the Dam; and
- Allowing for the installation of instrumentation inside the Dam to monitor its behavior as a dam safety measure.

The old CFRD did not have a drainage Gallery, and the drainage Gallery in the new Reservoir represents a material enhancement that provides a major contribution to dam safety by allowing the performance of the Dam to be continuously monitored.

Q. What type of instrumentation has been installed in the drainage Gallery in the new facility?

A. The instrumentation includes vibrating wire piezometers that measure the pressure head at a range of depths below the Dam. Readings from the piezometers are used to verify uplift assumptions made during the design phase and allow monitoring during operation. Piezometers have been installed at 11 stations throughout the Dam. Two of these stations are at the Gallery Adits, which are tunnels with a small cross-section that provide access to the Gallery. These Adits house four piezometers between the Gallery, which is near the upstream toe, and the downstream toe where the Adit "daylights." Another group of four piezometers has been installed at the Reservoir access tunnel, with the most upstream piezometer near the heel of the Dam. Groups of two piezometers, one at the Gallery and one at the toe of the Dam, have been placed at a critical clay seam encountered during construction. Additional piezometers have been placed between the Gallery flumes.

Flumes have also been installed within the Gallery as part of the internal monitoring system. The purpose of the flumes is to measure the seepage through the Dam and foundation by way of the foundation drains. A flume is a small channel in the floor on one side of the Gallery that allows for easy measurement of cumulative flow into the Gallery from several sources, including the foundation drains and the Crest-to-Gallery Drains. Readings from the flumes are used to help identify potential problematic areas with high water flows. A total of ten trapezoidal measurement flumes grouped into five pairs have been installed throughout the Gallery.

Joint meters have also been installed at the construction joints within the Gallery. The joint meters measure the horizontal and vertical displacements at the end of a monolith construction joint.

This extensive monitoring system installed in the Gallery allows the performance and behavior of the Dam to be continuously monitored. There was no comparable monitoring system in the old CFRD.

Q. Please describe the Overflow Release Structure in the new Reservoir.

A. The Overflow Release Structure is simply a spillway that permits water to spill from the Reservoir in a pre-designed location in the event of an over-pumping or other event which could cause the Reservoir to overtop. Although simple in design, the Overflow Release Structure is a critical safety feature for the new Dam, which is now required by FERC Engineering Guidelines for dam construction. The old CFRD did not have an Overflow Release Structure. An Overflow Release Structure would have prevented much of the damage from the 2005 breach. Specifically, the Overflow Release Structure on the new facility will release overflowing water in a controlled manner down the slope on the east side of the Upper Reservoir on AmerenUE property. The risk of damage to public and private property and injury to the public is significantly mitigated by this safety feature.

OVERFLOW RELEASE STRUCTURE – FOREFRONT OF THE PHOTO

Q. Outside of the instrumentation you described in your discussion concerning the drainage Gallery, has the Company installed any additional monitoring/surveillance devices at the Taum Sauk Plant?

A. Yes. The Company has installed sophisticated monitoring/surveillance instrumentation at the plant that did not exist previous to the breach. Again, this instrumentation constitutes a significant enhancement to the safety of the plant. For example, monitoring devices now allow the power plant personnel to read the instruments daily and observe and record any anomalies that may occur. These systems include vibrating wire piezometers and instrumentation at the lower Dam and Reservoir.

Additionally, the new facility has a state-of-the-art level protection and control system that is comprised of two independent subsystems: the Level Control System and the Level Protection system. The Level Control System is used for normal plant operations, whereas the Level Protection System is a backup system. The Level Control System compares the analog level signals to programmable set points and initiates action when the set points are reached. The Level Protection System consists of redundant level switches which are hard-wired to trip the pump or generation cycles. The Company has separate maintenance and monitoring procedures for each system. Readings from each system are compared to staff gauge readings daily. A full, preventative maintenance procedure is performed annually. Weekly comparison of electronic readings with manual readings ensures that the electronic level monitors are working properly and recording the correct water levels.

Video cameras have also been added to the Dam Monitoring Program. Video cameras have been installed on the crest of the Dam, and these cameras are monitored 24 hours per day by operating personnel on-site at the Taum Sauk Plant, as well as off-site locations, including the Osage Dam Monitoring Station and AmerenUE's headquarters in St. Louis. Because these cameras are viewed on a constant basis, they act as part of the back-up system for the Level Control System and Level Protection System.

Additional video cameras have been installed around the perimeter of the Upper Reservoir. These cameras are used for site security and were planned in the wake of the September 11, 2001 terrorist attacks. These cameras also provide constant surveillance accessible by personnel at Taum Sauk, as well as in St. Louis.

Surface monuments comprise the final component of the Dam Surveillance Program. There are 23 monuments used to measure horizontal and vertical displacements at the crest of the Dam. The surface monuments are located as part of the alignment survey using survey equipment capable of achieving a horizontal and vertical accuracy of plus or minus 5 millimeters. Surface monuments are also an enhancement that was not used to monitor the old CFRD facility. A typical surface monument is shown in the photograph below.

TYPICAL SURVEY MONUMENT ON CREST

Q. Are there any other enhancements that the new Reservoir provides?

A. Yes. In my opinion, perhaps the most significant enhancement from a customer's perspective is the significantly longer life that the new facility will have, which is made possible by the new, state-of-the-practice design, which includes a robust foundation situated on bedrock and the use of RCC. I conservatively estimate that the new Upper Reservoir will be operational for 80 years – two typical FERC hydroelectric project license lives. The new Reservoir is a very robust facility constructed of approximately 2.8 million cubic yards of roller compacted concrete and 300,000 cubic yards of conventional concrete. It is a symmetrical concrete gravity structure, constructed on a well-prepared bedrock foundation, in accordance with modern dam construction and seismic guidelines. It has enhancements which will limit leakage and permit safe operation of the facility for decades to come.

The old CFRD facility, in contrast, was near the end of its life. Even if the 2005 breach had not occurred, in my opinion the facility would ultimately have been retired as a result of the scheduled 2008 FERC inspection, as I explain in the next section of my testimony. As a consequence, construction of the new Upper Reservoir provides decades of additional life for the Taum Sauk facility.

IV. COSTS THAT WOULD HAVE BEEN INCURRED IN THE ABSENCE OF THE DECEMBER 2005 BREACH

Q. In the previous section, you stated that even in the absence of the December, 2005 breach the Upper Reservoir would have been retired as a result of the scheduled 2008 FERC inspection. Can you please explain how that would have occurred?

A. Yes. The Taum Sauk Plant is regulated by the FERC, and under federal regulations it and other similar facilities have been subject to a major independent dam safety inspection every five years beginning in 1985. The last such inspection for Taum Sauk was performed in 2003 and reported in April, 2005. The Taum Sauk Plant passed that inspection.

However, beginning in 2003 the FERC began applying a much more rigorous dam safety inspection process that, in the absence of the breach, would have applied to its next inspection of the Taum Sauk Plant, scheduled for 2008. Specifically, FERC began applying its Potential Failure Modes Analysis ("PFMA") Program to dam safety inspections. Where the previous inspection process focused on only a limited number of standard-based concerns such as the hydraulic capacity of spillways and the stability of structures under a relatively narrow set of pre-defined load conditions, the PFMA broadened the scope of the evaluation considerably to include potential failure scenarios that may have been overlooked in past investigations. In fact, a PFMA is an exercise to identify all potential failure modes under static loading, normal operating conditions, as well as flood and earthquake conditions, including consideration of all external loading conditions for water retaining structures. It is also an exercise in assessing potential failure modes of enough significance to warrant visual observation, monitoring, and remediation as appropriate.

A PFMA is typically conducted by a team of engineers and inspectors, who conduct a formal identification and examination of all potential failure modes for an existing dam, based on a comprehensive review of all existing data and information, input from field and operations personnel, a site inspection, and a review of completed engineering analyses. The team identifies potential failure modes, causes and developments, and determines the consequences of each type of failure. The PFMA is intended to provide enhanced understanding and insight on the risk exposure associated with the Dam. This is accomplished by going beyond the traditional means for assessing the safety of a dam by seeking input from a diverse group of people that have information about the Dam. Based on the results of the PFMA, a Performance Monitoring Program is developed to monitor the water retaining structures based on the

PFMA. Ultimately, as a consequence of the PFMA, remediation measures may be required to address safety issues, or an unsafe dam may be required to shut down.

As a result of the 2005 breach, a PFMA was never conducted for the original Taum Sauk CFRD. Nonetheless, based on the PFMA protocol it is clear that significant dam safety issues would have been identified in the 2008 PFMA of the CFRD that would have directly impacted AmerenUE's ability to continue operating the CFRD.

Q. If the failure had not occurred, and if a PFMA would have been conducted on the original CFRD in 2008, what safety issues would have been identified?

A. In my opinion, the following deficiencies in the CFRD would have been identified through the PFMA process:

- Improper use of the parapet wall for water retention;
- Foundation failure of the parapet wall;
- Poor CFRD foundation conditions;
- Fines in the Rockfill;
- Inadequate seismic design; and
- Voids under the concrete facing.

As a result of these deficiencies, in my opinion the FERC would have required AmerenUE to cease operating the Taum Sauk Plant.

Q. Please explain the first safety problem you listed, improper use of the parapet wall for water retention.

A. The parapet wall on the crest of the CFRD was used to retain 10 feet of water under normal operations, except during winter months. As I noted in the prior section of this testimony, current practice calls for a parapet wall to be used only if necessary to act as a short-term barrier against flood levels or wave action. A parapet wall should not be used to retain water on an everyday basis. Other CFRDs generally do not use their parapet walls to retain water. For example, the Strawberry Dam and Salt Springs Dam, both rockfill dams located in California, both have normal maximum water storage levels 1-2 feet below the crest of the rockfill, although the water level could encroach on the parapet walls in times of floods. (See May 25, 2006 Independent Panel of Consultants Report as presented on the FERC Website.) To my knowledge, the decision to store water 6-8 feet high on a 10-foot parapet wall is unprecedented for a CFRD. In my opinion, if a PFMA of the Taum Sauk CFRD had been conducted in 2008 fairly early in the PFMA process it would have become apparent that the parapet wall was being used to retain water, and at that point, the FERC would have required AmerenUE to reduce the everyday water level at the Upper Reservoir to a level below the base of the parapet wall.

Q. The second safety problem you listed was foundation failure at the parapet wall. Can you explain that issue?

A. Yes. After the 2005 failure, considerable undermining of the parapet wall was observed. This problem would also have been discovered relatively early in the PFMA process, had a PFMA been conducted in 2008, and the FERC would have directed that the operating level of the Upper Reservoir immediately be lowered even further. In addition, the FERC would have required AmerenUE to repair or replace the parapet wall. As the parapet wall was embedded into the upstream concrete face of the facility, the entire wall would have had to be replaced, along with a portion of the upstream concrete face. I estimate that effort would have taken at least 2 years, with a cost on the order of $5 million.

Q. The third safety issue you listed that would be identified through a PFMA is poor CFRD foundation conditions. Can you please explain that issue further?

A. Yes. A poor or improperly prepared foundation can lead to gross stability failure of a dam and, in fact, the weak foundation conditions at Taum Sauk contributed to the 2005 failure. Therefore, this topic unquestionably would have been addressed in a PFMA. As indicated in the Pickel Report (1964) and the Nickell Report (1959), both prepared contemporaneously with the design, construction and start up of Taum Sauk, the methods and procedures that were used during construction of the original Dam were not in accordance with the intent of the design at that time. For example, the Report documents a shortage of water on top of the mountain available for sluicing fines from the dumped rockfill. Furthermore, neither the design nor the construction was in accordance with modern standards of care. For example, the design called for the foundation rock to be cleaned of organic material, top soil, residual soil, and weathered rock with a bulldozer such that no more than 2 inches of such material was left in place. Yet our field investigation disclosed areas where as much as 18 inches of virgin, low-strength material, including top soil and vegetation, was left in place under the CFRD.

The photographs below show some of the material that was found below the foundation of the CFRD.

DEBRIS AT THE ORIGINAL FOUNDATION ROCK INTERFACE

SILTY CLAYEY SAND AT THE ORIGINAL FOUNDATION ROCK INTERFACE

CLAYEY MATERIAL AT ORIGINAL FOUNDATION ROCK INTERFACE

In contrast, today's design and construction standards place a great deal of emphasis on the proper preparation of the foundation rock, including hand cleaning and removal of all vegetation, organics, top soil, weathered rock and other low-strength material. In constructing the new Reservoir, AmerenUE was careful to adhere to those standards before any concrete was placed. The Company excavated down to bedrock, even in locations where it was necessary to dig out large clay seams, which in places required excavation 60 feet below the surface. The bedrock was carefully cleaned of all low-strength material, and cracks in the bedrock were filled with "dental" material. The photos below show this process.

FOUNDATION PREPARATION AND DENTAL CONCRETE PLACEMENT

DENTAL CONCRETE PLACEMENT

DENTAL CONCRETE PLACED AND FOUNDATION READY FOR RCC

There is no question that the deficiencies in the condition of the CFRD foundation would have been revealed through the PFMA investigation, although it is likely that the problems with the parapet wall would have been discovered earlier in the process. The first analysis that would have led to the ultimate discovery of the inadequate foundation conditions would have been disclosed in test borings drilled through the CFRD. Then a stability analysis that addressed sliding along Taum Sauk's foundation-CFRD interface, conducted as part of the PFMA and reviewed by the Independent Inspector, would have indicated a serious deficiency in the stability of the CFRD, especially under earthquake conditions. This would have necessitated additional borings and comprehensive laboratory testing and that investigatory pits be excavated along the downstream toe of the Reservoir, which would have uncovered excessive low-strength material under the CFRD's foundation.

As a result of these findings, the FERC would have required AmerenUE to substantially lower the level of the Upper Reservoir even further, possibly to a level where it would not have been practical to operate the plant. At a minimum, remediation to address these problems would also have required a toe buttress, flattening of slopes by placement of additional material on the slopes, retaining walls and drainage upgrades; at a cost I have estimated to be in excess of $272 million. (See RIZZO Report: Rebuild Alternative Analysis, Upper Reservoir Dike, Taum Sauk Plant issued in 2006.)

However, in my opinion, even a substantial remediation of this type would not have been sufficient to adequately protect against the failure of the structure. Consequently, it is my opinion that the FERC would have required a complete rebuild of the facility, like the rebuild AmerenUE actually did, in order to fully address the safety risks posed by the poor foundation conditions in the old CFRD.

Q. The fourth safety issue you mentioned was fines in the rockfill. Can you please explain this issue?

A. Certainly. CFRDs are designed with relatively steep slopes. The upstream and downstream slopes of the original CFRD were 1.3 horizontal to 1.0 vertical. By way of comparison, an earth-fill dam is normally designed with slopes of 2.5 to 1.0, or about half as steep as a CFRD. The steeper slopes on a CFRD are possible because the larger rock particles interlock to a much higher degree than soil particles in an earth-fill dam. In addition, if the rock particles are subject to vibratory compaction after they have been placed, the interlocking effect is dramatically increased.

As the interlocking of rock particles is critically important to the stability of a CFRD, smaller soil particles, referred to as “fines,” must be minimized or excluded from the rockfill mass comprising the CFRD. Otherwise, the fines will prevent the interlocking and serve as a lubricant, so that the rockfill CFRD will have inherently lower shear strength, with a consequential diminishment in stability.

While the water sluicing process used to remove fine in the original CFRD was consistent with the general practice of the late 1950's and early 1960's, it is not consistent with modern practices. Specifically, when the CFRD was constructed the rock was end-dumped, it was then sluiced with water-jet monitors to remove fines and move the rock into a more dense state. Today water sluicing is an abandoned practice. Instead, rockfill is compacted with heavy vibratory compactors and bulldozers, and carefully screened to prevent the inclusion of fines with the rock.

Nonetheless, if properly and completely implemented, sluicing could have removed an acceptable level of fines from the rock. However, the sluicing was clearly not successful for this CFRD. Observation of the inside conditions of the CFRD at the cuts associated with the breach clearly indicated that an unacceptable amount of fines were left in the rock during construction. In fact, the percentage of fines was so high that there were safety concerns during the excavation and removal of the CFRD after the failure. Also, exceptional effort was required to separate the fines from the rockfill during the rock processing operation as part of the new RCC Dam construction.

The existence of a high level of fines in the CFRD is also supported by the Geological Summary Report letter authored by Dr. F.A. Nickell at the time of the construction. This Report states:

> The quarry material was placed by the contractor by dumping and initially, through use of hydraulic monitor. Inadequate provision for water supply and other factors made sluicing operations erratic and generally created spotty areas with higher content of fines.

In addition the Report stated:

> Lack of water for sluicing and the unexpected abundance of fines from quarry operations…caused localized patches of fine material within surrounding blocks of rock. In order to avoid possible sliding or excessive settlement beneath the concrete facing on the inner slope of the dike, the areas will be raked and possibly vibrated to distribute the fines into the body of the rockfill.

However, there is no evidence in the project record that this procedure was ever implemented.

As noted earlier, a stability analysis that considered a circular failure surface through the CFRD, conducted as part of a PFMA and reviewed by the Independent Inspector, would have indicated a serious deficiency in stability of the CFRD itself (in addition to the concerns I discussed earlier about the foundation of the Dam), especially under earthquake conditions. This, like the foundation problems, would also have resulted in a demand to lower the operating level of the Upper Reservoir with a consequential loss in capacity and generation, possibly to a level where it would not have been practical to operate the plant. This too would have required, at a minimum, substantial remediation, which I also believe would not have been sufficient to ensure the safety of the Dam.

Q. The next safety issue you mentioned was inadequate seismic design. Can you elaborate on that issue?

A. Yes. The PFMA schedule for the original CFRD for 2008 would have addressed the ability of the CFRD to resist damage and/or failure during an earthquake. Again, keep in mind that several of the largest earthquakes that ever occurred in the United States had epicenters in nearby New Madrid, Missouri in 1811-1812. The PFMA would have revealed that the original CFRD was highly deficient with respect to earthquake resistance. Specifically, the PFMA would have determined that the facility was not compliant with FERC's Chapter 13 Engineering Guidelines—Evaluation of Seismic Hazards (Draft).

In my opinion, the PFMA would have required AmerenUE to perform a detailed and comprehensive investigation similar to the Forensic Investigation performed by Rizzo Associates after the breach, including subsurface investigations, stability analysis, and installation and monitoring of instruments within the CFRD. This investigation would have taken 2-3 years, and during the investigation AmerenUE would have been required to lower the water level in the Upper Reservoir, possibly to a level where it was not practical to operate the plant. The investigation would have concluded that the existing facility could not withstand a significant seismic event, and would have required, at a minimum, substantial remediation similar to that required to address the foundation problems. The cost of the investigation would have been $6 to $10 million, and cost of the minimum remediation would have been approximately $272 million, as noted earlier.

However, once again, in my opinion such a remediation would not have been practical, nor would it be effective enough in enabling the facility to withstand a significant seismic event. In my opinion, a completely new facility would have been required in order to properly address seismic issues, and to ensure that the facility met modern seismic standards.

Q. The final safety issue you listed was voids under the concrete facing. Once again, can you explain this issue and how it relates to the PFMA?

A. Yes. A rockfill dam is highly pervious and unable to retain water unless an impervious barrier of some type is included in the design. The design of the original CFRD at Taum Sauk included a one foot thick concrete face on its upstream side. The concrete face was placed in panels, approximately 60 feet wide and approximately 84 feet down the inside slope of the Reservoir. The panels were joined together with copper strips, called water-stops, at 60 foot intervals to prevent water from seeping through the face between the panels.

The concrete facing failed to perform as intended, and consequently the loss of water from the Upper Reservoir became so large by 2004 that AmerenUE had to place an additional membrane on the concrete facing to bring the leakage under control. This installation was completed in October, 2004. Following the failure, it was apparent that water movement within the CFRD had created significant voids beneath the concrete facing, compromising the integrity of the CFRD. Voids as large as 3-4 feet can be seen in the photo below.

VOIDS UNDER ORIGINAL UPSTREAM CONCRETE FACE

If the failure had not occurred, due to the history of excessive leakage at the facility, during the 2008 PFMA AmerenUE would have been required to investigate the impact of the leakage on the integrity of the CFRD. A comprehensive investigation of the type suggested above to address the concerns regarding seismic stability would have disclosed the voids behind the concrete facing. The voids would have raised an alarm challenging the integrity of the CFRD. In my opinion, this too (in addition to the foundation problems, the fines in the rockfill, and the seismic inadequacies) would have resulted in the FERC ordering that the water level in the Upper Reservoir be lowered, possibly to a level where it would not be practical to operate the plant. It is also possible that the FERC would have required the Reservoir to be de-watered and a new grout curtain installed at the toe of the upstream slope. While this remediation could have addressed this one problem, it would not address the other serious problems discussed earlier.

Q. Please summarize what would have happened as a result of a PFMA inspection in 2008 if the Dam had not failed?

A. After a preliminary investigation, the FERC would have required AmerenUE to lower the water level in the Upper Reservoir below the level of the foundation of the parapet wall. Further investigation (e.g., the stability analysis) would have suggested more serious concerns, and the FERC would have required a more significant lowering of the water level in the Upper Reservoir during the pendency of the investigation, which might have rendered the plant inoperable, or at a minimum its operations would have been reduced.

A detailed and comprehensive investigation of the CFRD would have been conducted over the next several years. Although it is theoretically possible that such an investigation might have permitted AmerenUE to continue operating the Reservoir after a substantial remediation costing approximately $272 million, in my opinion such a remediation would not have been practical or completely effective. Instead, AmerenUE would have had to build a new Reservoir, as it did after the failure.

Q. Following the PFMA, couldn't AmerenUE have decided to retire the plant?

A. Yes. Retirement would have been a possibility. Retirement would have involved the following elements in accordance with FERC Regulations for retired licenses:

- Removal of the CFRD and processing of the rock to make it suitable for a stabilized fill on top of Profitt Mountain.
- Restoration of the top of Profitt Mountain to its original contours and restoration of the vegetation.
- Filling of the vertical shaft and tunnel with concrete after removal of the steel liner and penstock.
- Removal of the exposed penstock, valves, and piping.
- Complete removal of the Powerhouse and all equipment.
- Filling of the tailrace excavation.
- Removal of the Switchyard.
- Removal, restoration, and re-vegetation of the access road up to the top of Profitt Mountain.
- Removal of the cofferdam desilting structure.
- Removal and landfilling of silt and sediment backed up by the Lower Reservoir Dam.
- Removal of the Lower Reservoir Dam.
- Removal of the transmission lines.
- Restoration and re-vegetation of the transmission line right of way.

I estimate the cost to retire the Taum Sauk Plant would be approximately $840 million.

Q. Does this conclude your direct testimony?

A. Yes it does.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of Union Electric Company d/b/a AmerenUE for Authority to File Tariffs Increasing Rates for Electric Service Provided to Customers in the Company's Missouri Service Area.	)))))	Case No. ER-2011-0028

AFFIDAVIT OF PAUL C. RIZZO

STATE OF PENNSYLVANIA)
) ss
COUNTY OF ALLEGHENY)

Paul C.Rizzo, being first duly sworn on his oath, states:

1. My name is Paul C. Rizzo. I work in the County of Allegheny, Pennsylvania and am President of Paul C. Rizzo Associates, Inc.

2. Attached hereto and made a part hereof for all purposes is my Direct Testimony on behalf of Union Electric Company d/b/a AmerenUE consisting of 33 pages, all of which have been prepared in written form for introduction into evidence in the above-referenced docket.

3. I hereby swear and affirm that my answers contained in the attached testimony to the questions therein propounded are true and correct.

Paul C. Rizzo

Subscribed and sworn to before me this 2nd day of September, 2010.

Notary Public

My commission expires: July 22, 2012

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Mary S. Arnold, Notary Public
Pleasant Hills Boro, Allegheny County
My Commission Expires July 22, 2012

Paul C. Rizzo, Ph.D., P.E.

President and Chief Executive Officer

Years Experience
44

Education
Ph.D., Civil Engineering, Carnegie Mellon University – 1966
M.S., Civil Engineering, Carnegie Mellon University – 1964
B.S., Civil Engineering, Carnegie Mellon University – 1963

Professional Registrations/Certifications
Professional Engineer First Registered – 1968; Alabama, Alaska, California, Delaware, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Massachusetts, Maryland, Michigan, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Puerto Rico, Rhode Island, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, and Wisconsin

Affiliations
Dr. Rizzo is a member of more than 15 technical societies.

Publications

Rizzo, P.C. and J. Charlton, October 2008, "Foundation Preparation for RCC Dams Founded on Difficult Foundation Conditions," Hydro2008, Ljubljana, Slovenia.

Rizzo, P.C., L. Gaekel and C. Rizzo, July 2008, "RCC Mix Design and Testing Program Re-build of the New Upper Reservoir Taum Sauk Pump Storage Project," HydroVision, Sacramento, CA.

Rizzo, P.C. and J. Osterle, July 2008, "Design Basis for the New Upper Reservoir Taum Sauk Pump Storage Project," HydroVision, Sacramento, CA.

Skill Areas:

- Civil Engineering
- Dams
- Hydroelectric Plants
- Nuclear Facilities
- Seismic Engineering
- Geotechnical Engineering
- Structural Dynamics
- Historic Structures
- Expert Testimony
- Liquefaction Analysis

Dr. Rizzo is President and CEO of Paul C. Rizzo Associates, Inc. (RIZZO). He has more than 44 years of experience on a wide variety of dam projects, including embankment dams, gravity dams, Ambursen dams, arch dams, and timber crib dams. He has lectured on a variety of civil and geotechnical topics, and served on consulting boards dealing with various issues in dams, seismic design, and geotechnical engineering. Dr. Rizzo has extensive experience related to civil engineering aspects of nuclear power plants, thermal plants, hydro plants, and earth and rockfill dams. He has actively participated in the industry, dealing with regulations, criteria, and professional practice in his areas of expertise. He is highly recognized for his contributions in earthquake engineering and foundation design of major structures. In addition, he has served as a Consultant to the utility, steel, petroleum, and mining industries. His professional and academic experience is reflected in his more than 100 publications.

Nuclear/Seismic

Dr. Rizzo is an international expert in seismic safety and foundation engineering for nuclear plants. He has experience on a wide variety of nuclear facilities, including commercial nuclear generation plants, nuclear fuel processing facilities, and nuclear weapons facilities. His experience encompasses the first generation commercial facilities of the 1960s, the second generation PWRs and BWRs, plus the Canadian and Russian reactors erected in the eastern block countries, and the latest generation, EPR and passively safe reactors, such as the AP600 and AP1000. He has served as an Outside Expert in the areas of seismic hazards, foundations, geology, and geotechnical engineering for the Defense Nuclear Facilities Safety Board since 1989 for nuclear related projects at U.S. Department of Energy facilities.

Dr. Rizzo has been Principal-in-Charge for several Probabilistic Seismic Hazard Analyses (PSHA) efforts, including: Cernavoda NPP (Romania); Callaway (Missouri); Goesgen (Switzerland); Bell Bend (Pennsylvania); and PBMR (South Africa). He is a member of the NEI and participates in the "seismic issues" resolution initiative with the USNRC. Dr. Rizzo has extensive experience with many types of sites, having worked at more than 100 sites internationally, including deep soil sites, shallow soil sites, rock sites, and high seismic sites around the world. He has consulted to the USNRC, ACRS, and IAEA. He has lectured on seismic safety, geological hazards, and geotechnical engineering aspects of nuclear plants throughout the world.

Publications continued

Rizzo, P.C., June 2007, "The Rebuild of the Upper Reservoir Taum Sauk Pump Storage Project Perspectives of the Owner, Regulator, and Designer/Construction Manager," ICOLD Annual Meeting, St. Petersburg, Russia.

Rizzo, P.C., L. Gaekel, K. Kessler and H. Gault, June 206, "Foundation Treatment for Saluda Dam," ICOLD Annual Meeting, Barcelona, Spain.

Rizzo, P.C., April 2006, "Acceptance Criteria for the Assessment Surface Fault Rupture," 8th U.S. National Conference on Earthquake Engineering, San Francisco, CA.

Rizzo, P.C., J. Blair, J. Osterle, and J. Gault, 2004, "Construction Dewatering at Saluda Dam," ASDSO Regional Conference.

Rizzo, P.C., J. Blair and S. Newhouse, June 2003, "Remediation of Saluda Dam RCC and Rockfill Dams," ASDSO Regional Conference.

Rizzo, P.C., J. Bair, A. Fernandez, K. Massey, April 2003, "Seismic Evaluation of the Semi-Hydraulic Fills Saluda Dam," USSD Annual Conference, Charleston, S.C.

Rizzo, P.C., J. Osterle, L. Gaekel and H. Moxley, April 2003, "Saluda Dam Remediation Mix Design Program," USSD Annual Conference, Charleston, S.C.

Rizzo, P.C. and J. Blaire, "RCC and Rock 'Back-Up' Berm Enhances Seismic Safety of Saluda Dam, USA," Hydropower & Dams Magazine, 2003, Issue 2, pp 118 – 121.

Rizzo, P.C., J. Osterle, W. Argentieri and J. Holchin, April 2003, "Construction Dewatering at Saluda Dam; Design, Testing and Implementation," USSD Annual Conference, Charleston, S.C.

Geotechnical and Civil

Dr. Rizzo has experience related to a wide range of geotechnical and civil engineering projects, including power plant structures, waterfront facilities, pumped storage facilities, and dams. He is an international leading consultant in seismic safety of dams and other structures. He is a recognized expert in the field of safety evaluations and seismic rehabilitation of dams. He has served on numerous panels, committees, and consulting boards charged with the deliberation of seismic hazard evaluation, seismic design basis, soil-structure interaction and other seismic issues related to geotechnical engineering for various types of projects. Dr. Rizzo has extensive experience related to civil engineering structures; hydroelectric, thermal, and nuclear power plants; earth and rockfill dams; harbors and docks; and industrial facilities. His fields of interest include earthquake engineering, foundation engineering, geology, seismology, hydrogeology and groundwater control, stress analysis, vibrations, and structural dynamics. He has lectured on earthquake engineering and nuclear plant siting, and has served on numerous panels, committees, and consulting boards dealing with various issues in geotechnical engineering and seismic design.

Environmental

Dr. Rizzo has more than 44 years of professional consulting experience related to the civil engineering aspects of hazardous and solid waste management facilities, nuclear, thermal, and hydroelectric power plants, and earth and rockfill dams. He served as Principal-in-Charge for a number of remediation projects, including the third site added to the USEPA National Priorities List. He has lectured in the United States and Europe on environmental engineering, Phase II environmental assessments; facility and landfill siting; and design and construction of landfill components. Dr. Rizzo has extensive experience in providing expert testimony, representing clients at public and regulatory meetings, and providing support for community relations programs.

NUCLEAR ACTIVITES

October 2008 – Present
UAE Braka NPP Site Selection/Site Characterization/PSAR and ER – ENEC, United Arab Emirates:

RIZZO is preparing the site investigation and submittal of a PSAR and ER to the Regulatory Authority for the siting of a APR1400 Nuclear Power Plant on this site. As Principal-in-Charge, Dr. Rizzo is responsible for the technical direction of the Project and for reviewing the technical documentation associated with the Project, including reports, calculation results, and PSAR/ER sections. RIZZO is performing the field investigations, PSAR Chapter 2, and the ER.

October 2008 – Present
UAE Site A (Alternate) NPP Site Selection/Site Characterization/PSAR and ER – ENEC, United Arab Emirates:

RIZZO is preparing the site investigation and submittal of a PSAR and ER to the Regulatory Authority for the siting of a APR1400 Nuclear Power

Publications continued

Rizzo, P.C., J. Bair, W. Argentieri, K. Massey and H. Moxley, "Saving Saluda," Civil Engineering Magazine, October 2002, Vol. 72, No. 10 pp. 56.

Rizzo, P.C., September 2002, "RCC Dam and Rockfill Berm at the Saluda Remediation Project," ASDSO Conference, Tampa, FL.

Rizzo, P.C., L. Gaekel, and J. Osterle, September 2002, "Saluda Dam Mix Design Program," Portland Cement Conference, San Diego, CA.

Rizzo, P.C., and R. Ammarell, June 2002, "Overview of the Saluda Dam Remediation," ASDSO Conference, Atlanta, GA.

Rizzo, P.C., J. Bair, W. Argentieri, K. Massey, and H. Moxley, June, 2002, "Design of the RCC Portion of the Saluda Dam Remediation Project," USSD Annual Conference, San Diego, CA.

Rizzo, P.C., J. Bair, C. Weatherford, and K. Dickerson, June 1999, "Conversion of an Ambursen Buttress Dam to a Gravity Dam," USCOLD Annual Meeting, Atlanta, GA.

Rizzo, P.C. and R.R. Bennett, July, 1998, "Financing Small Hydro Projects in the Late 90's, An IPP's Perspective," Hydrovision.

Rizzo, P.C., J. Bair, A. Fernandez, W. Broderick, W. Xia, and L.Y. Yao, March 1998, "Assessing the Impact of Instability of Reservoir Side Slopes," USCOLD Annual Meeting, Buffalo, NY.

Rizzo, P.C., J. Bair, A.H. Hasnay, and T. Meyers, September, 1997, "Rio Dam Hydroelectric Project Stability Investigation, Remedial Design and Construction," ASDSO Conference, Pittsburgh, PA.

Plant on this site. As Principal-in-Charge, Dr. Rizzo is responsible for the technical direction of the Project and for reviewing the technical documentation associated with the Project, including reports, calculation results, and PSAR/ER sections. RIZZO is performing the field investigations, PSAR Chapter 2, and the ER.

December 2006 – December 2008
Callaway Unit 2 EPR Design and COLA Application – UniStar, Callaway, Missouri:

Dr. Rizzo was the Principal-in-Charge for the COLA (FSAR Chapter 2) and Environmental Report (ER) applications, to the US Nuclear Regulatory Commission (USNRC) for siting the US-EPR Nuclear Power Plant (NPP) at the Callaway Site.

RIZZO's Scope of Work was Chapter 2 of the COLA including meteorology, hazards, hydrology, geohydrology, geology, seismic and PSHA, and geotechnical along with all appropriate field investigations. The FSAR was prepared to USNRC codes and regulations and has been docketed for USNRC review.

2005 – Present
Westinghouse Site Characterizations – USA:

Westinghouse – Dr. Rizzo has been the Principal-in-Charge for RIZZO's review, comment, analysis, and recommendations for detailing field investigations for site characterization (e.g., seismic, geotechnical, determination of foundation conditions) for several sites to support construction of a Design Certified Standard Plant in a Combined Operating License Application approach.

- Southern Services – Vogtle
- Duke – William States Lee
- Progress:
  - Shearon Harris
  - Levy County
- SCE&G – Summer
- TVA – Bellafonte

November 2008 – Present
KRSKO NPP Site Characterization – GEN energija, Slovenia:

Dr. Rizzo serves as Technical Expert for the site characterization for siting Nuclear Power Plants. The Scope of Work includes hydrology, geohydrology, geology, seismic and geotechnical investigation, and related field investigation programs appropriate to siting power plants per International Atomic Energy Commission requirements. The results are captured in a Safety Analysis Report, Chapter 2 format and content; proof that siting next generation NPPs is feasible at the KRSKO site.

1989 – Present
Defense Nuclear Facilities Safety Board (DNFSB) – Department of Energy, Washington, D.C.:

The DNFSB is chartered by the National Defense Authorization Act to provide independent safety oversight to the U.S. Department of Energy's defense nuclear facilities. Dr. Rizzo serves as an Independent Reviewer to the Board for review and evaluation of DOE standards and for resolution of geotechnical, structural, and seismic issues at DOE sites, including seismic hazard and ground motion analysis. Dr. Rizzo provides independent

Publications continued

Rizzo, P.C., J. Dulude, M. Carter, and J.D. Holchin, August, 1997, "Stone Columns for Remediating Liquefaction, Prone Sand," Water Power, Atlanta, GA.

Osterle, K.P., B. Howard, and P.C. Rizzo, 1995, "Rehabilitation of Eastvale Dam," Proceedings of the Association of State Dam Safety Officials Annual Conference.

Osterle, J.P., E. Bazan, S. Brown, and P.C. Rizzo, 1994, "Seismic Design Basis Cap and Gas Control System for a California Superfund Site," Proceedings Twenty-Sixth Mid-Atlantic Industrial Waste Conference.

Dr. Rizzo has more than 100 publications; any additional papers will be provided upon request.

reviews of designs for new construction Safety Class facilities at USDOE maintained sites – Hanford (WA), Savannah River (SC), Los Alamos National Lab (NM), Oak Ridge (TN), Pantex (TX), Rocky Flats (CO), and others.

Dr. Rizzo has also reviewed geotechnical and structural design work performed by other engineering firms; performed independent review of geologic and other hazards; provided geotechnical consultation; defined seismic design bases; performed independent stability analyses/settlement analyses; proposed remedial solutions; reviewed and prepared engineering reports; and performed in-the-field evaluations of geotechnical conditions.

1989 – Present
AP1000 Foundation Interface Conditions Report (FICR) – Westinghouse Electric Company, Various Clients, Various Sites:

Dr. Rizzo authored the Foundation Interface Conditions Report for Westinghouse Electric which defines the plant – site interface requirements for the AP1000 Nuclear Power Plant design. Further, Dr. Rizzo has confirmed that the interface conditions are satisfied for the Progress Energy Levy County and Shearon Harris Sites, the Southern Services Vogtle Site, the Duke William States Lee Site, and the South Carolina Electric and Gas Summer Site.

August 2006 – Present
US EPR Foundation Interface Conditions Report (FICR) – AREVA, Various Clients, Various Sites:

Dr. Rizzo provides structural design, geotechnical including Plant Parameter Envelope (PPE) and seismic consultation to AREVA for its EPR Nuclear Power Plant standard design and Design Control Document (DCD) certification licensing effort with the U.S. Nuclear Regulatory Commission. He also served as a member of its Structural Review Board. Mr. Rizzo authored the Foundation Interface Conditions Report for AREVA, which defines the plant – site interface requirements for the EPR.

November 2005 – Present
Arkansas Nuclear One, Entergy – Entergy, Arkansas:

Dr. Rizzo is the firm's Principal-in-Charge for ongoing work at Entergy's Arkansas Nuclear One site. RIZZO is specifically working with Entergy's on-site engineers to (1) confirm the adequacy of the Service Water Pond and impounding dike and (2) develop a new Service Water Pond that will assure long term viability of the plant's service water. This work has involved close interaction with the USNRC Staff as this work is in direct response to challenges raised by the Staff.

1993 – Present
Expended Core Facility, Idaho National Engineering Laboratory – Bettis Atomic Power Laboratory, Idaho:

As Principal-in-Charge, Dr. Rizzo supervised the seismic reassessment of the Expended Core Facility located within the Naval Reactors Facility Complex. He performed a seismic reassessment in order to evaluate the components of the ECF, whose failure could have potential radiological consequences. Dr. Rizzo reviewed the seismic criteria used in the design analysis, the current site geologic and seismological information, and established spectrum to be used as the Evaluation Basis Seismic Criteria.

June 2003 – October 2004
Nuclear Facility Siting Projects – Westinghouse Electric Company, China AP1000 at SanMen, Haiyang and Yangjiang Sites, China:

Dr. Rizzo has been the Principal-in-Charge for RIZZO's role in the Westinghouse initiative to sell multiple AP1000 units in China. He has been responsible for adapting the standard AP1000 layout to the SanMen, Yangjiang, and Haiyang sites, including site layout and compliance with the AP1000 Plant Parameter Envelope (PPE). He has worked with the Owner's engineers in China and has advised of deficiencies and additional field work to be performed. RIZZO reviewed each site to ensure compliance with the PPE (meteorology, geology, seismic, foundation conditions and hydrology, flood, surge, and levee protection). RIZZO developed the concepts and costing for cooling water intake, discharge cooling, tunneling options, and tie-in of the plant site to local infrastructure.

November 2007 – Present
AP1000 COLA at Levy County, Florida – Progress Energy/Sargent & Lundy, Crystal River, Florida:

Dr. Rizzo is Principal-in-Charge for RIZZO's support to the COL Application (FSAR 2.5.4) applications to the U.S. Nuclear Regulatory Commission (USNRC) for siting the AP1000 Nuclear Power Plant (NPP).

RIZZO's Scope of Work is Chapter 2.5.4 of the COLA, including interpretation of geotechnical conditions. The scope also included design of the dewatering, grouting and foundation design. The FSAR was prepared to USNRC codes and regulations for USNRC review.

The RIZZO scope of work includes: conceptual design of the construction dewatering program; excavation planning; design of a Roller Compacted Concrete (RCC) Bridging Mat beneath the Nuclear Island; and specification of backfill and select FSAR sections. Due to high groundwater at the site and porous zones and fractures in the subsurface materials, RIZZO is designing a grouting program in concert with installation of a diaphragm around the Nuclear Island structures to make an impervious zone and prevent the flow of groundwater into the excavation.

September 2007 – December 2008
Koeberg Pebble Bed Modular Reactor (PBMR) Demonstration Project – PBMR/ESKOM, South Africa:

RIZZO has performed several tasks supporting the final design and plan for construction of the PBMR. Dr. Rizzo was Principal-in-Charge for a Probabilistic Seismic Hazard Study (PSHA), including review of geology and catalogs of earthquakes; determining seismic zonations; determining upper magnitude and recurrence parameters; specification of ground motion models/attenuation models, etc.; aggregation and de-aggregation to determine ground motion at hard rock; development of time histories; addressing of randomization/uncertainties; and sensitivity analyses. The effort was completed per RIZZO's QA Program in accordance with ASME NQA-1 (1994), 10CFR 50 Appendix B, and ISO 9001.

December 2006 – December 2008
Bell Bend EPR Design and COLA (Chapter 2.4 and 2.5) – UniStar, Berwick, PA:

Dr. Rizzo was Principal-in-Charge for performance of the field investigation (Work Plan, QA, Boring Program, Geophysical Testing, Lab Testing) and other preparation of Chapter 2, and Site Characterization of the Final Safety Analysis Report for the Bell Bend Combined Operating License Application (COLA). Inclusive of this effort were:

- 2.4 Hydrologic Engineering describing the local surface water and groundwater hydrology, including normal and extreme conditions.
- 2.5 Geology, Seismology and Geotechnical work describing the site geological setting and detailed evaluation of the seismic conditions potentially affecting the design of foundations and structures.

All work was completed in accordance with RIZZO's QA Program in compliance with 10CFR 50, Appendix B and ASME NQA-1-1994. The FSAR was prepared to USNRC codes and regulations for USNRC review.

December 2006 – December 2008
Pelindaba Fuels Facility PSHA – ESKOM, South Africa:

Dr. Rizzo served as Principal-in-Charge for the Probabilistic Seismic Hazards Analysis (PSHA) that supported the design for the Pelindaba Fuels Facility Project in South Africa.

June 1985 – July 1985
El Dabaa Nuclear Power Plant – Westinghouse Electric Company, Egypt:

Dr. Rizzo served as Principal-in-Charge for this project, which established appropriate rock-structure-interaction (RSI) parameters to be used by Westinghouse in the computation of the seismic response of El Dabaa Nuclear Power Plant structures. RIZZO developed stiffness and energy dissipation coefficients for the Reactor Containment Building, the Auxiliary/Control Building, the Fuel Handling Building, and all Safety Category I structures. RIZZO reviewed the subsurface investigation reports to establish the site profile and the properties of the rock layers. Our staff conducted the calculation of the RSI coefficients using a frequency-domain technique that accounts for the layered nature of the site.

December 1985 – November 1986
River Bend Nuclear Station – Saint Francisville, Louisiana:

Dr. Rizzo performed an assessment of the seismic margin for the structures and components of the Category I building structures, piping systems and equipment, and components of the plant. The assessment comprised a review of FSAR and other design documents, a plant walkdown, review of the seismic design basis, review of the design of reinforced concrete and steel structures, reevaluation of soil-structure interaction parameters, dynamic seismic reanalysis, reassessment of floor response spectra, and review of the design of piping systems and equipment supports with emphasis on up-to-date methodologies for seismic analysis.

December 2007 – Present
November 1985 – April 1987
Krško and Prevlaka Nuclear Power Plant – Westinghouse Electric Corporation, Yugoslavia:

Dr. Rizzo was Principal-in-Charge for site characterization and seismic hazard analysis, including capable fault investigations for these two nuclear plants in Yugoslavia. Krško is still operating, but Prevlaka was stopped in the 1980's. The services included both site selection and site characterization using U.S. Nuclear Regulatory Commission criteria. Both sites, located along the Sava River, are deep soil sites influenced by capable faults within 100 km.

For Krško, Dr. Rizzo participated at the outset of design and in construction of the project. Initially, RIZZO advised Westinghouse during the contract negotiations and on all matters related to siting, capability of faults, seismic design parameters, cooling water alternatives, foundation design, dewatering, settlement and bearing capacity, and liquefaction analysis.

During construction, RIZZO provided on-site inspection and consulting services related to the deep excavation, dewatering, and foundation construction.

For Prevlaka, Dr. Rizzo supervised the study of foundation concepts for the site. He evaluated foundation problems associated with potential liquefaction on the top layers of sand under seismic excitation and consolidation of underlying clay layers.

RIZZO has been contracted by GEN-energija to review the Field Investigation methods and results for construction of additional new generation Nuclear Power Plants at Krško II & III.

June 1984 – April 1987
Nuclear Facility Siting Projects – Westinghouse Electric Corporation, China:

Dr. Rizzo was Principal-in-Charge for the RIZZO effort to provide technical consulting services for site characterization of several proposed nuclear facilities. These services included both site selections and site characterizations using U.S. Nuclear Regulatory Commission criteria. Aspects considered included geotechnical engineering, seismology, surface water and groundwater issues, geology, and meteorology.

April 1994 – Ongoing
Savannah River Plant – US Department of Energy, Aiken, South Carolina:

Dr. Rizzo's earliest work at Savannah River involved site characterization and seismic hazard analysis for the Defense Waste Processing Facility (DWPF) in the 1970's and he has been involved in new construction / major modification projects continuously since that early project. Currently, he is providing consulting services as the DNFSB's Outside Expert for seismic hazards, geologic hazards, foundation engineering, and site selection.

CIVIL AND GEOTECHNICAL ACTIVITES

February 2000 – December 2000
Alcona, Loud, Five Channels, Cooke, and Foote Hydroelectric Part 12D Safety Inspections– Consumers Energy, Various Locations, Michigan:

Dr. Rizzo was the lead Independent Consultant for the completion of the FERC Part 12D Safety Inspections of the Alcona, Loud, Five Channels, Cooke, and Foote Dams owned by Consumers Energy. RIZZO performed the Part 12 Safety Inspections for all five dams. The inspections included an assessment of the structural integrity, evaluation of the Spillway adequacy and stability analyses, and recommendations to improve operations at each Project; and working with a diver to inspect the draft tubes of the Powerhouses and a sounding survey team for the downstream aprons. The inspections revealed that the embankment at Five Channels Dam contained voids and RIZZO was retained to locate, evaluate, and oversee the repair of the voids. RIZZO also performed a detailed evaluation of the adequacy of the primary and emergency Spillways at Loud Dam.

May 2004 – July 2004
Blenheim-Gilboa Pumped Storage Project – New York Power Authority, Gilboa, New York:

Dr. Rizzo was the Principal-in-Charge for the duration of this $700,000 design effort and 1,000 MW pumped storage plant. He focused on correcting slope movement that threatened interruption of the main transmission line and failure of a plant access road. Dr. Rizzo’s thorough evaluation of the local geology and existing aerial infrared photography revealed the presence of an ancient landslide. Under his direction, subsurface investigations were conducted to confirm the presence of the ancient slide and fully define the subsurface conditions. Remedial efforts were focused on stabilizing the toe of the slope that could catastrophically fail and threaten the transmission line. The “fix” included both surface drainage improvements and a toe berm of about 400,000 cubic yards. The project results concluded that slope movements previously recorded, at about 2-inches per year over the last 20 years, were virtually eliminated. Total construction costs were about $5 million.

2007 - 2009
Bear Creek Dam – Tennessee Valley Authority, Hodges, Alabama:

RIZZO was selected to investigate, design, and provide oversight for the construction of this project. Dr. Rizzo is the Principal-in-Charge for the engineering and design for the rehabilitation of Bear Creek Dam. RIZZO’s responsibilities include: preparing reports, work plans, cost estimates, and technical specifications; performing stability analyses for the dam; developing design drawings; and managing the overall preparation of all design documents.

June 2004 – 2009
Blue Ridge Dam and Appurtenances – Tennessee Valley Authority, Blue Ridge, Georgia:

The Tennessee Valley Authority retained RIZZO to remediate the intake tower, dam and penstock of this dam. As Principal-in-Charge, Dr. Rizzo supervised the detailed inspection and geotechnical investigation during the 2003 Outage and Lake Drawdown. In order to obtain all necessary information, RIZZO is considering several remediation schemes for the tower, and is proceeding with design and implementation for a re-lining of the penstock.

September 2000 – September 2003
Boskov Most Hydropower Plant – USTDA, Macedonia:

Boskov Most collects water from the mountains of the Mala Reka watershed via a system of intakes, channels, and siphons with transport to a headrace tunnel. The elevation head is such that water will flow back up or down through a 9 km headrace tunnel and fill a dam during non-generating hours; during generation hours, it will help the dam feed the powerhouse Pelton Wheel turbines. As Principal-in-Charge, Dr. Rizzo optimized and detailed the design concept from a run-of-the-river design to a 70 MWe design, operating during peak generation hours. The Final Feasibility Study also included review of field investigation, seismic criteria, cost estimates, financial analyses, major component qualification, and an environmental and regulatory framework reviews.

December 1991 – February 1994
Buckeye Lake Dam Project – Ohio Department of Natural Resources, Ohio:

Dr. Rizzo served as Principal-in-Charge for this geotechnical and slope stability investigation. RIZZO conducted an independent analysis of the pre/post remediation stability of the dam during normal surcharge pool loading conditions. He characterized the soil strength parameters and phreatic surface at cross section locations along the 4.1-mile-long earth dam. RIZZO staff used the parameters to develop slope stability models, perform seepage evaluation, and conduct stability analyses.

September 1988 – September 2002
Carpenter Dam – Entergy, Inc., Hot Springs, Arkansas:

Dr. Rizzo served as Principal-in-Charge for the site investigation and remedial design of this arched gravity concrete dam. His responsibilities included sliding and overturning stability analyses, including PMF and seismic conditions, definition of the seismic hazard and seismic design criteria development.

December 1984 – November 1987
Columbia Dam – South Carolina Electric and Gas, Columbia, South Carolina:

RIZZO converted this timber crib dam to a gravity dam. As Principal-in-Charge, Dr. Rizzo conceived the "fix" for the dam and supervised the design. He conducted negotiations with Federal and State Dam Safety Officials, environmental regulators, and historical preservation groups.

July 1987 – August 1988
Fairfield Pump Storage Project – South Carolina Electric & Gas, Columbia, South Carolina:

Dr. Rizzo has served in multiple roles for this project since its inception in the early 1970’s to the present. His efforts began as a member of the Federal Energy Regulatory Commission (FERC) Board of Consultants, which reviewed and analyzed the original concept and layout, through all of the engineering, construction, start-up, and operation. Later, Dr. Rizzo served as Principal-in-Charge of FERC Part V inspections and follow-up investigations of dam stability, concrete deterioration, and powerhouse leakage. He continues to stay apprised of reservoir-induced seismicity at the project.

2005 - 2006
FERC Operation Inspections – FERC New York Regional Office:

Dr. Rizzo was the Principal-in-Charge for the triennial operation inspections for over 30 low-hazard hydroelectric facilities under the jurisdiction of the New York Regional Office of the Federal Energy Regulatory Commission (FERC). The work was performed as part of a nation-wide pilot project for the FERC. The inspections consisted of a visual inspection of the projects and a review of all available documentation at the facilities and in the FERC New York Regional Office files. RIZZO prepared draft FERC Operation Inspection reports for the projects which addressed dam safety, public safety, security, environmental, and license compliance issues. Final reports were prepared addressing comments provided by FERC. The project also included a project kickoff and project closeout meetings held at the FERC New York Regional Office.

February 2002 – October 2004
Hidrosuroeste/Hidroven Dam – USTDA, Tachira State, Venezuela:

As Principal-in-Charge, Dr. Rizzo directed a review of the watersheds for water availability, current and projected demand, and storage requirements. He developed the conceptual design of the dams, channels, water treatment facility, and pipeline and pumping stations, which will deliver into an existing distribution infrastructure. This Feasibility Study was funded by the USTDA for a Water Supply System for cities in the west of Tachira State. RIZZO evaluated several watersheds for a series of dams and water storage with integration into the existing Hidrosuroeste facilities. The project area is subject to seismic activity, severe storms, and landslides. The Scope of Work also included site study, review of geology, fieldwork, conceptual design of key structures, specifications, costing, project financials, and environmental review.

November 1999 – November 2000
Kayuta Lake and Ogdensburg Hydroelectric Plants FERC Part 12 Inspections – Algonquin Power, Ontario:

As Civil Engineer, Dr. Rizzo performed the 2000 FERC Part 12 Independent Consultant's Dam Safety Inspection Reports at the Kayuta Lake and Ogdensburg Hydroelectric Projects. He inspected the project works and assessed the structural integrity, evaluated the spillway capacity, and reviewed the stability analysis at each project. As part of the inspection, he performed a dye test to determine the possibility of structural leaks. Dr. Rizzo managed the preparation of the Inspection Reports and the "Appendix D" for each project.

January 2005 – December 2006
Lotru-Ciunget Hydropower Plant Refurbishment Project – Bucharest, Romania:

Dr. Rizzo served as the Independent Foreign Consultant for this project. He assisted the owner on this IBRD project with preparation of bidding documents, procurement, tender evaluation, contract negotiation, and provided construction Management Training to the Utility Owner.

November 2002 – February 2003
Mapocho and Molina Hydroelectric Plants – Chile:

Dr. Rizzo has served as Principal-in-Charge for the geologic investigations and seismic design review. His responsibilities included completing the general layout and design of the daily storage pond; civil works such as intake structures, canals, forebays, penstocks, and powerhouse; and specifications of hydro machinery, electrical equipment, and switch yard. Specifications have been prepared to support cost estimates. The Environmental Assessment has been completed per World Bank and per Chilean EIS requirements. Permitting is proceeding.

July 1999 – October 2004
Egypt Valley Recreational Lake and Dam – Ohio Department of Natural Resources, Belmont County, Ohio:

Dr. Rizzo was Principal-In-Charge of the Feasibility Study, design, permitting, and detailed design (including construction documents) for a dam to impound a recreational and fishing lake at a watershed that occupies 1,500 acres of prior strip-mined land in the Egypt Valley Wildlife Area. The project included field investigation and design of a dam, outtake, emergency spillway, and recreational features.

July 1990 – December 1992
Remmel Dam – Entergy, Inc., Hot Springs, Arkansas:

Dr. Rizzo served as Principal-in-Charge for this site investigation and remedial design of this buttress Ambursen dam. He conducted sliding and overturning stability analyses, including PMF and seismic conditions, definition of the seismic criteria, and the development of alternate remediation schemes. Through negotiations with the FERC, Dr. Rizzo conducted the design of a conversion of the buttress dam to a concrete gravity dam with supplemental anchors.

2009 - Present
Rio Dam Part 12D Inspection – Alliance Energy NY GEN-LLC, Orange and Sullivan Counties, New York:

Dr. Rizzo is the Principal-in-Charge for this Part 12D Safety Inspection. The Rio dam is approximately 1,500 feet long and impounds approximately 3,650 acre-feet of water. The dam was constructed to generate electrical power, producing approximately 31,000 MWh of power annually, and normally operates in times of peak demand when sufficient flow is available. RIZZO's Scope includes: inspecting the dam and associated structures; reviewing and evaluating piezometer and weir data for the project to determine if instrumentation is monitoring potential failure modes of the dam adequately, including preparing time histories and correlation curves for each instrument; and preparing a stability analysis for the concrete spillway; and writing the Part 12D Report submitted to the Federal Energy Regulatory Committee (FERC).

March 1985
Rio Dam – Orange & Rockland Utilities, Sullivan County, New York:

RIZZO stabilized an arch gravity dam with anchors and a hydraulic fill dam subject to liquefaction. As the Principal-in-Charge, Dr. Rizzo conceived the "fix," led all communication and negotiation with regulators, supervised the design, and negotiated with contractors. RIZZO resolved all FERC comments associated with previous stability analyses and developed remedial measures to ensure that all sections of the dam meet current FERC criteria. Twenty-one 2,600 kips, post-tensioned rock anchors were installed to stabilize the spillway section of the dam.

July 1990 – September 2005
Saluda Dam Remediation – South Carolina Electric and Gas, Columbia, South Carolina:

Dr. Rizzo served as the Principal-in-Charge for the site investigation and remedial design for a backup to a "puddle" type hydraulic fill dam constructed in the 1930s. His responsibilities included supervision of the static slope stability analyses, dynamic slope stability analyses, and liquefaction and deformation analyses. He worked with the FERC to define the seismic hazard and seismic design criteria. Based on the results, Dr. Rizzo led the development of alternate remediation schemes. This $275 million remediation project focuses on the construction of a backup berm at the toe of the dam. It is approximately the same length, 7,800 feet, and height, 211 feet, as the existing dam. The project was the largest dam during construction in the country, with the placement of 1.3 million cubic yards of roller compacted concrete and 3.5 million cubic yards of rockfill. RIZZO also served as Construction Manager for the project. This project was awarded the 2006 OPAL Award for Engineering Excellence, as presented by the ASCE (international competition).

April 1988 – October 2004
Santee Cooper Project, East Dam and East Dam Extension – Santee Cooper, Moncks Corner, South Carolina:

Dr. Rizzo served as the Principal-in-Charge for the site investigation and remedial design for a backup to a "puddle" type hydraulic fill dam constructed in the 1930s. His responsibilities included supervision of the static slope stability analyses, dynamic slope stability analyses, and liquefaction and deformation analyses. He worked with the FERC to define the seismic hazard and seismic design criteria. Based on the results, Dr. Rizzo led the development of alternate remediation schemes.

July 1988 – January 2003
Stevens Creek Hydroelectric Project – South Carolina Electric and Gas, Georgia:

As Principal-in-Charge, Dr. Rizzo led the investigation of this overflow type gravity concrete dam. He performed sliding and overturning stability analysis, including PMF and seismic conditions, definition of the seismic hazard and seismic design criteria, development of alternate remediation schemes, and design of a rock anchor system.

January 1994 – May 1994
Swinging Bridge Dam – Orange & Rockland Utilities, Sullivan County, New York:

Dr. Rizzo served as Principal-in-Charge of the investigation of this "puddle-type" hydraulic fill dam to assess the potential for settlement induced buckling of the penstock through the dam. Dr. Rizzo performed the slope stability analysis, settlement and deformation analysis, and development of alternate remediation schemes.

January 2006 – Present

Taum Sauk Upper Reservoir – Ameren UE, Reynolds County, Missouri:

Dr. Rizzo served as Principal-in-Charge of the conceptual design of the re-build. RIZZO has analyzed and developed various options to re-build the project. The rebuild of the dam consisted of the construction of a Roller Compacted Concrete (RCC) dam approximately 100 feet high and 6,600 feet long, consisting of 2,838,215 cubic yards of RCC. Construction commenced in 2007 and is scheduled for completion in 2010. The following tasks were successfully completed tasks:

- Developed the design basis for a complete re-build of the Upper Reservoir Dam;
- Developed Construction Drawings and Technical Specifications for the re-build;
- Supervised a site-specific Roller Compacted Concrete Mix Design Program;
- Developed a formal Environmental Report;
- Assisted in the design of the Level Protection and Control System for dam safety and plant operation;
- Developed a Dam Safety Surveillance and Monitoring Program;
- Prepared the Reservoir Refill Plan;
- Developed remedial designs for the water conveyance system at the plant included the vertical shaft, unlined tunnel, and unlined tunnel;
- Developed the grouting program for the new dam; and
- Provided continuous engineering support throughout construction.

Dr. Rizzo served as Principal-in-Charge of the detailed forensic engineering investigation to determine the causes of the failure of this kidney shaped rockfill rim dike. RIZZO's analysis included stability and seepage, dam breach (to determine time of failure), complete review of instrument control systems, sediment transport, detailed mapping of breach zone, and drilling and sampling of remaining portions of the dike.

Dr. Rizzo served as Principal-in-Charge as RIZZO was also the Construction Manager for this $300 million project.

2003 – 2009

Upstream Volobe Hydroelectric Power Project – U.S. Trade & Development Agency, Ivondro River, Toamasina, Madagascar:

Dr. Rizzo is Principal-in-Charge to perform a Feasibility Study for a proposed hydroelectric power project to be located on the Ivondro River near Toamasina, Madagascar. Upstream Volobe will generate approximately 418 gigawatt hours of energy each year. The project configuration impounds a reserve of water with a new dam/dike system with transport of water via an intake structure at the dam, an underground tunnel, and an above ground penstock to a powerhouse. The project will deliver power to the Toamasina Grid. The project Scope of Work consists of environmental review, conceptual design of the project features, civil works; mechanical and electrical equipment; transmission line and interconnection equipment, project schedule, capital costs, electricity market conditions in Madagascar, project risks, and financial model.

January 2009 – Present
Wyaralong Dam – QWI, Brisbane, Australia:

Dr. Rizzo is Principal-in-Charge for the conceptual design for this new RCC dam. RIZZO's responsibilities included: stability analyses and optimization of the cross section of the proposed dam, RCC design details, and interpretation of geotechnical data. During the Dam Design Phase, RIZZO was responsible for the sliding stability analysis of the dam and preparation of portions of the design including design of the drainage gallery, dam instrumentation, and foundation preparation details. RIZZO also performed thermal analysis, finite element analysis, and the preparation of specifications.

June 1984 – December 1992
Youghiogheny Hydroelectric Plant – D/R Hydro, Confluence, Pennsylvania:

RIZZO performed the design, finance and construction management of the complete two-unit 12 MW Plant with vertical Francis units. Dr. Rizzo served as both Owner and Principal-in-Charge of this project. His work included major pump-over diversion, lining and grouting an 18-foot diameter rock tunnel, a penstock bifurcation, gate structure, river cofferdam, road construction and seven miles of transmission line. In addition, Dr. Rizzo prepared all project financial analysis, licensing with the Federal Energy Regulatory Commission, and permitting with all state agencies and the Corps of Engineers.

July 2001 – October 2004
Beirut Central District Waterfront Reclamation Area – Solidere, Beirut, Lebanon:

As Principal-in-Charge of the Feasibility Study, Dr. Rizzo supervised the conceptual land use plan, interpretation of hydraulic model test results, assessment of the environmental risks of constructing on the former landfill areas, assessment of the seismic risk in Beirut, assessment of the behavior of road and buried piping constructed on, or within, the reclaimed land, and established the methods of support for buried piping, cable, conduit, and fiber optic cable in the reclaimed land.

April 1990
Buckeye Pipeline Failure – U.S. Department of Justice, Pennsylvania:

The Buckeye Pipeline failure involved the failure of a petroleum products pipeline discharging into a tributary in the Allegheny River, north of Pittsburgh. This failure caused the shutdown of several water supply treatment plants. Dr. Rizzo supervised the post-failure slope stability investigation where the pipeline failed. RIZZO resolved whether the pipeline caused the slope failure or the slope failure caused the pipeline to fail.

January 2003 – March 2003
Charleston County Courthouse – County of Charleston, Charleston, South Carolina:

As part of the renovation and restoration of this historical building, RIZZO provided structural, geotechnical and civil engineering services for the exterior stabilization and seismic rehabilitation. Dr. Rizzo served as the geotechnical lead and overall lead reviewer for the project. The County of Charleston retained RIZZO to coordinate and monitor the work related to the stabilization, serving as the construction administrator.

October 1990 – November 1990
Discovery Mountain/Magic Kingdom, Disneyland Paris – Walt Disney Imagineering, Villa-De-Marne, France:

RIZZO was retained by Walt Disney Imagineering to perform settlement analyses in association with the construction of the Casey Jr. Ride at the Magic Kingdom site, and to investigate the geotechnical considerations associated with the design of the Discovery Mountain attraction at Disneyland Paris in Marne-La-Ville, France. Dr. Rizzo served as Principal-in-Charge on this project.

June 2002 – November 2003
Mine Subsidence Investigation – Confidential Client:

In an ongoing civil suit, RIZZO was hired to determine whether the operations of a mining company caused significant subsidence and are responsible for damage done to a nearby residence. Duties have included site investigations, the development of an extensive ground monitoring system to establish any continuing movement, and the development of a core boring plan to assess geologic conditions beneath the structure in question. Future duties include the use of specialized software to assess the predicted subsidence due to the proximity of mining operations, as well as preparing a final report to be entered as expert testimony.

December 1988 – December 1995
Carbon Limestone Sanitary Landfill – Browning Ferris Industries of Ohio, Ohio:

RIZZO permitted a 600-acre expansion at this Browning-Ferris Industries of Ohio facility. The Permit Application included excavation and final grading plans, development sequencing, design details, operation plans, and Quality Assurance Plans. RIZZO has provided CQA services for every phase of construction since the landfill began operation. In 1996 and 1997, RIZZO designed and provided construction QA for the initial capping, and supervised the installation of a new landfill gas recovery system.

February 1986 – January 1990
Imperial Landfill – Browning Ferris Industries, Pennsylvania:

RIZZO developed the concept of expansion for this operational landfill during a time period when the Pennsylvania solid waste regulations were being re-written in accordance with Sub-Title D Regulations. Several options including the preparation of financial pro formas for expansion were considered during the course of the work. Ultimately, we permitted the landfill for a 140 acre expansion, which is currently in operation.

October 1989 – February 1994
Capels Rail Haul Transfer Station – Berwind Natural Resources, Pennsylvania:

The transfer station for the Capels Landfill involved the design of a facility to transfer 10,000 tons per day from dedicated hopper cars, box cars, and gondolas to off-road, custom-designed articulated haulers. The facility involved a railroad yard to accommodate 180 cars, two notary car dumpers, a bailing operation and a reloading facility. RIZZO completed all of the conceptual design and permit applications for the facility, the rail yard and access roads, and specified the design of the dedicated rail cars and off-road haulers.

May 1993 – September 1995

Solid Waste Management Plant – Sedesol, Mexico:

Utilizing the proceeds of a World Bank loan, Mexico began a nationwide diagnostic analysis and master planning effort for solid waste management as part of the 100 Cities Program. RIZZO conducted the program for Mexico under the overall direction of the World Bank and addressed the needs and issues for 50 cities. Dr. Rizzo oversaw the conceptual plan, including landfill design, for the 25 cities requiring the most immediate attention.

March 1988

Paris Metro – Grand Palais Segment, France:

Dr. Rizzo served as Principal-in-Charge of the investigation and analysis/design of a segment of the Paris Metro that runs adjacent to the Grande Palais, Petite Palais and Le Pont Alexandre III in downtown Paris, France. Dr. Rizzo took special design considerations because of settlement of historical structures, vibrations in the two art museums, and the impact on the imposing Horsemen Sculptures at the ends of Le Pont Alexandre III. RIZZO constructed this segment with soft ground tunneling techniques with injection grouting being required adjacent the River Seine near Le Pont Alexandre III.

2002 – 2004

Second Avenue Subway – DMJM + Harris, New York City, New York:

RIZZO served on a team of consultants for the Second Avenue Subway Project in New York City. Dr. Rizzo acted as the Chairman of the Geotechnical Advisory Board, which provided an independent review of the overall design and construction philosophy.