

benchmark

HOLTWOOD REDEVELOPMENT RECEIVES LOW IMPACT HYDRO INSTITUTE CERTIFICATION

by Tim Oakes

PPL Generation's Holtwood redevelopment project was granted a Low Impact Hydro Institute (LIHI) Certification on June 23, 2014, marking the culmination of a multi-year licensing, planning, engineering, and construction process. The Holtwood redevelopment project and its LIHI certification provide a great example of how hydropower can be developed in an environmentally sensitive manner without sacrificing project economics. In fact, working creatively with resource agencies to avoid or minimize effects on the environment improved the project economics because Pennsylvania's Alternative Energy Portfolio Standards require LIHI certification in order to trade power produced by the new powerhouse as Tier I power for Renewable Energy Credit (REC).

This issue of the Benchmark highlights the Holtwood redevelopment, the complex challenges PPL faced in developing the project, and the strategies that PPL and



Overview of the completed Holtwood redevelopment looking upstream. The new powerhouse is on the right.

The Low Impact Hydropower Institute is a non-profit organization dedicated to reducing the effects of hydropower generation by certifying hydropower projects that have avoided or reduced their environmental effects pursuant to the Institute's criteria. For more information about the certification, visit lowimpacthydro.org

Kleinschmidt used to overcome those challenges to get the project licensed, engineered, and constructed. This Benchmark focuses on Holtwood not only because Kleinschmidt is proud to have been involved in this

significant accomplishment, but also because, in our view, the Holtwood redevelopment project represents the new paradigm for successful development of hydropower projects.

Located on the lower Susquehanna River in south-central Pennsylvania, the Holtwood hydroelectric station began generating electricity in October 1910. After the last of its original 10 turbines were placed in service in 1924, the station had a generating capacity of approximately 108 megawatts (MW). Although Holtwood was one of the largest hydroelectric stations in North America at that time, it was not

(Continued on page 2)



by **Tim Oakes**



Interior of the original, 1910 powerhouse at Holtwood.

a highly productive or efficient project; river flows exceeded the station's hydraulic capacity 40 percent of the time. Numerous schemes for further development of the site have been studied since the early 1930s, but none were implemented until a proposal that began to take shape in 2004.

A program to restore the Susquehanna River's historic populations of anadromous American shad and river herring that began in the 1980s became a major impetus for finding an economically viable redevelopment strategy at Holtwood. At that time, analysis suggested that river flows in excess of the plant's original hydraulic capacity, which spilled over the dam, tended to direct fish away from the entrances to the fish elevator or to create downstream velocity barriers that the fish could not negotiate. Holtwood's original hydraulic

capacity was only 35 percent of the average river flow during April and May, which is the primary upstream migration period for American shad.

In the summer of 2004, PPL Holtwood began a proactive reexamination of the potential for economically viable redevelopment in preparation for renewing its license from the Federal Energy Regulatory Commission (FERC). Holtwood's 1980 FERC operating license was scheduled to expire in 2014. Changes in site conditions since 1980, including the concerns about fish passage and increasing public use of the site for fishing and white water activities, meant that a new FERC license would need to incorporate substantial changes in requirements to address environmental and recreational concerns likely to be identified during the

relicensing process. Furthermore, deregulation of the mid-Atlantic power markets in the latter 1990s had altered generation revenue streams in the regional transmission area that includes the transmission grid connecting to Holtwood. PPL recognized early in the planning process that ancillary, non-generation services such as area regulation (AR) could provide significant long-term revenue and that new incentives for hydropower generation both federally and within Pennsylvania also could improve project economics.

The redevelopment effort ultimately resulted in adding a new 120-MW powerhouse next to the existing powerhouse to more than double the project output, as well as several large ancillary structures to address environmental issues (e.g., a new skimmer wall to protect the forebay from debris, an overhead railroad bridge to provide above-grade rail crossing for Holtwood staff and the public, an extended draft tube to divert flows for fish passage, a platform for recreational fishing in the tailrace). Read on to learn more about the challenges and benefits of one of the largest hydropower redevelopment projects of the last decade.

Primary Environmental Challenges of the Holtwood Redevelopment

- improving fish passage for anadromous American shad;
- designing project features and planning excavation around forested wetlands, endangered plants, and archaeological sites;
- sequencing construction activities to avoid disturbing bald eagle, osprey, and heron nests;
- relocating and replanting state-endangered trees within the construction area;
- constructing multi-million dollar whitewater boating features to replace boating opportunities lost due to reduced frequency of spill at the project;
- constructing wetlands, removing old dams, and restoring streams within the watershed to mitigate effects of in-stream construction;
- establishing minimum flows to enhance fish habitat in an existing channel below the project and provide for minimum flows below a downstream project;
- creating stormwater detention areas; and
- constructing a new public boat ramp and improving existing boat ramps to provide better access for recreational boaters.

For more information contact Tim.Oakes@KleinschmidtGroup.com

NEED TO IMPROVE FISH PASSAGE INSPIRED HOLTWOOD REDEVELOPMENT

by Tim Oakes

Providing and maintaining adequate opportunity or mechanisms for migratory fish to get past dams without getting trapped within the project works is a significant challenge for hydropower developments, and surmounting that challenge can be costly. Federal regulations require hydropower developers to provide effective fish passage at dams, and FERC licenses incorporate those requirements. At Holtwood, the need to improve passage for American shad to contribute to a federal and state program to restore populations of anadromous fishes in the Susquehanna River prompted a “redevelopment” project that more than doubled power generation while providing an important environmental benefit. Here’s how it happened.

Despite the installation of a permanent upstream fish elevator at Holtwood in 1997, the number of fish passing upstream past Holtwood was generally a small fraction of the number of fish that passed the downstream Conowingo station. Data indicated that the percent passage at Holtwood was inversely related to river flow such that more fish passed the dam at low flows than at higher flows. The resource agencies and PPL believed that spill over the 2,400-foot spillway during periods of high flow confused the fish, preventing them from finding the entrances to the fish



Fish making their journey upstream.

elevator, and that high flows through some narrow areas in the lower tailrace created velocities that the upstream migrating fish could not swim against. The original station’s limited hydraulic capacity resulted in water spilling over the dam an average of 60 percent of the time during April and May, the primary upstream migration period for shad in the Susquehanna River. In 2004, after a particularly poor shad passage year, PPL started looking for ways to improve passage efficiency. A biologist with one of the resource agencies suggested that redeveloping the project to achieve better control of river flows might be a viable option.

The original Holtwood development was undersized for

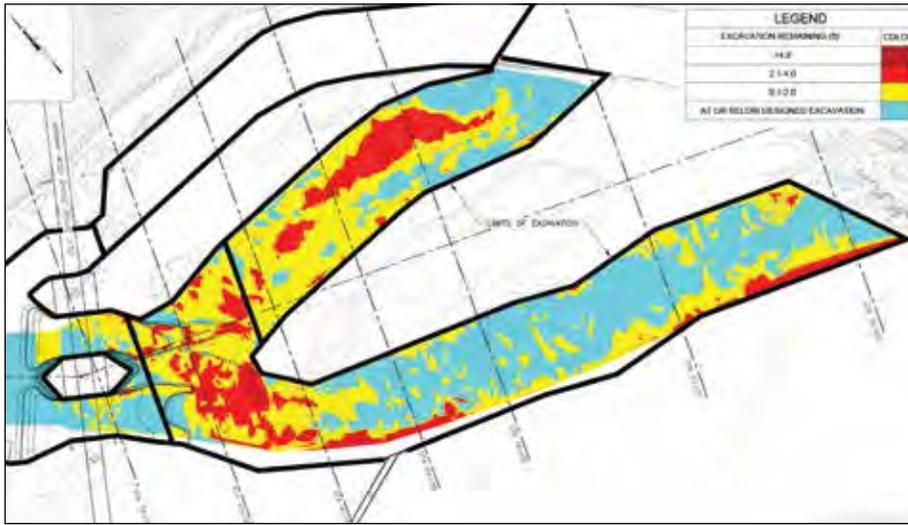
the river. PPL had considered redevelopment previously but had never found it to be economical. With its FERC license set to expire in 2014 and relicensing to be initiated within the next 5 years, PPL decided to reconsider the potential for redevelopment. PPL and Kleinschmidt evaluated several potential redevelopment options that accounted for fish passage needs as well as generation. That evaluation resulted in a conceptual plan to locate a new powerhouse at the downstream end of the existing forebay to concentrate the combined discharges from the original and new plants into the existing main tailrace. PPL’s previous calculations had not considered using that area because it was

the site of a coal-burning, steam electric station that was removed in 1999. The increased discharge from the new powerhouse would attract more fish to the tailrace and would improve upstream fish passage efficiency through the existing elevator without having to construct another upstream passage facility at a different discharge location. The plan offered increased generation capacity with the least civil modifications of the site and without reducing the effective spillway discharge length, thereby avoiding reduction of flood-discharge capacity. The plan also enabled continued, long-term operation of the original station and ensured minimal interference with its

(Continued on page 4)



by **Tim Oakes**



Excavation plan for the lower main tailrace at the Holtwood Project.

that produced tailrace velocities acceptable to the agencies and water levels that produced plant generation values acceptable to PPL. Alden Labs then refined the tailrace geometries using a comprehensive, two-dimensional computer fluid dynamic (CFD)

Another major improvement of fish passage involved diverting discharge from Unit 1 of the original station to the Piney Channel portion of the spillway to provide an alternative passage route to the spillway entrance to the fish elevator. Additional enhancements for fish passage included modifying the fish elevator to provide additional attraction flow, modifying the tailrace crowder mechanism to reduce objectionable shadows, and modifying the spillway-side entrance gate so that it could function better in the difficult flow environment present there.

operation during construction of the new station. Holtwood's FERC license had been issued for a 34-year term and was due to expire in 2014; consequently, PPL decided to pursue an amend-and-extend approach to take advantage of the full 50-year term allowed by Federal Power Act in order to proceed with redevelopment more quickly.

tailrace topography that would satisfy the agencies. Using GIS-based topographic and bathymetric data, Kleinschmidt prepared three-dimensional mathematical models of the existing tailrace geometry. Then the team used one-dimensional HEC-RAS analyses to develop an initial excavation scheme

hydraulic model of the entire tailrace and three-dimensional analysis in selected areas. This allowed the tailrace excavation to be designed to provide acceptable zones of passage for American shad, even when the project is operating at full capacity.

Although the agencies generally supported the proposed redevelopment, primarily because of the potential to improve upstream fish passage, they had several additional concerns. Over the next 3 years, PPL and Kleinschmidt conducted detailed environmental studies to understand and address those concerns, which included potential effects on wetlands, endangered species, cultural resources, recreation, aquatic habitat, and water quality. These studies helped form the conceptual design and resulted in several significant modifications of the site plan to avoid and minimize environmental effects.

In February 2005, PPL initiated discussions about the redevelopment plan with various resource agencies. The agencies' primary concern was that the new main tailrace configuration would allow upstream migrating fish to locate the existing fish elevator readily and would not attract them to new or existing turbines. A team including PPL, Kleinschmidt, and Alden Labs used a variety of conventional and advanced computational fluid dynamic (CFD) hydraulic analysis tools to identify a



Kleinschmidt technician collecting data below Holtwood dam for an environmental study.

For more information contact Tim.Oakes@KleinschmidtGroup.com

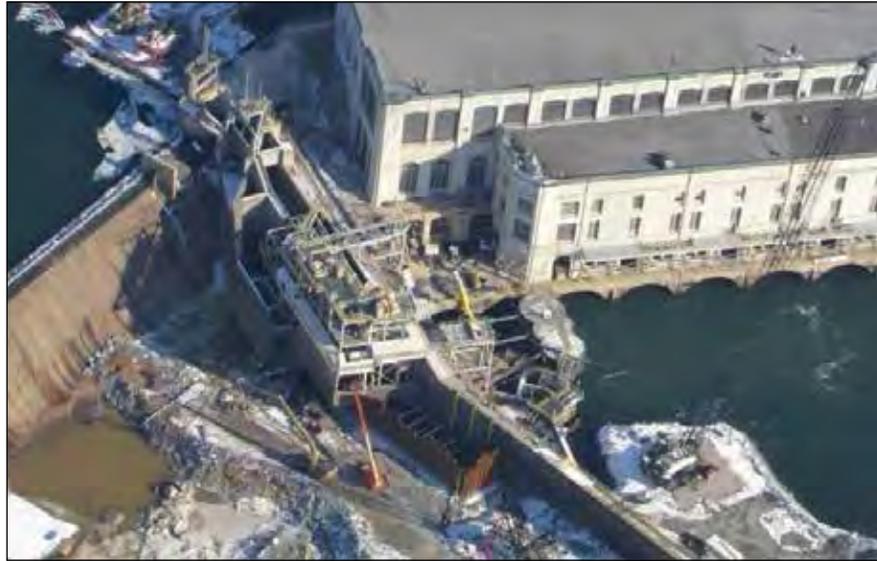
INTEGRATED ENGINEERING PROMOTES A SUCCESSFUL LICENSING PROCESS

by Matt Dunlap

To qualify the Holtwood Redevelopment Project for LIHI certification cost effectively, Kleinschmidt and PPL invested significant engineering resources early in the licensing process. All too often, engineering takes place in a vacuum, focusing solely on defining the solution that costs the least and produces the most revenue within a predefined set of license constraints. For Holtwood, however, Kleinschmidt's engineers engaged a broad community of stakeholders earlier than usual to define the constraints jointly and, thereby, solve or mitigate many issues that could have derailed the project. Two examples of this integrated approach are related to providing fish passage in the tailrace and providing minimum flow in a defined portion of the spillway.

Tailrace Fish Passage

The environmental agencies were particularly concerned about ensuring the availability of upstream fish passage through velocity barriers in the tailrace, which additional flow from the new units could have increased. If the agencies had prescribed an overall low-velocity threshold for the entire tailrace, the excavation of massive volumes of rock required to meet the prescription would have been prohibitively expensive and would have affected archaeological and environmental resources, including habitat for eagles and a rare plant.



New draft-tube tunnel under construction at the original Holtwood powerhouse.

Instead, PPL and Kleinschmidt engaged stakeholders by using three-dimensional topographic and bathymetric flow models based on a geographic information system (GIS) to highlight areas of potential modification that could address the agencies' concerns more economically. The resulting plan involved creating a shallow shelf on the west shore of the tailrace to provide a continuous velocity of approximately 5 feet per second (fps) to the existing fish elevator. Conversely, the east shore of the tailrace was designed with deeper, steeper, and smoother side slopes to produce velocities of 10 fps or greater, thus deterring fish from traveling along the east shore towards the new power station. This minimized excavation cost, improved net head, provided responsible fish passage, and protected natural resources.

Spillway Minimum Flow

The resource agencies also requested a minimum flow discharge down an adjacent spillway channel both to guide fish upstream and to improve habitat. The agencies' original request would have required discharging flow over the spillway or through a set of gates, which would have diminished energy revenue significantly. Physical constraints at the site precluded installing a minimum-flow turbine. Instead, Kleinschmidt's engineers developed the unique solution of extending the discharge from an existing hydroelectric turbine through a new draft-tube tunnel that extends under both the fishlift entranceway and the deflection wall and into the spillway channel. Although the higher spillway water levels reduce the output slightly, the draft tube tunnel

was the most cost-effective long-term solution. Moreover, the turbine allows accurate flow regulation to produce the required seasonal variations in minimum flow and is easily accessible for maintenance and operation.

Summary

The integrated engineering approach satisfied stakeholders that PPL was addressing all parties' concerns throughout the design process, helped to ensure that the project qualified for LIHI certification, and provided the additional benefit of defining risks early, thus avoiding costly delays. Many public and private stakeholders appreciated the approach and, in turn, were exceptionally responsive and flexible later in the design and construction phases, when various modifications needed to be implemented. This cooperative approach proved successful for getting a new project licensed, designed, built and certified by LIHI efficiently.

For more information contact Matt.Dunlap@KleinschmidtGroup.com

DESIGNING AND CONSTRUCTING THE HOLTWOOD EXPANSION: CHALLENGES AND BENEFITS

by Trevor Lykens

The magnitude and complexity of the tasks required to design and construct the Holtwood expansion were enough to test the viability of the project.

The expansion project consists of a new hydroelectric power station that required significant rock excavation and several large ancillary structures (e.g., a new skimmer wall to protect the forebay from debris, an overhead railroad bridge to provide above-grade rail crossing for Holtwood staff and the public, an extended draft tube to divert flows for fish passage, a platform for recreational fishing in the tailrace). Couple the challenges of removing more than 1 million cubic yards of rock from the Susquehanna River and creating a 150-foot-deep hole directly adjacent to an operating hydro station with the technical difficulty of blasting bedrock between the piers of a highway bridge and transporting the excavated rock across an active railroad line, up a vertical elevation of 600 feet to a disposal location on an adjacent hilltop, and the result is a complex project with significant risks and costs. Add to that being situated beside an environmentally sensitive island that is home to endangered plants and animals and harbors archaeological resources, and the complexities increase significantly. These obvious hurdles required significant planning during the engineering design stage of



Overview of the Holtwood expansion under construction.

to ensure timely and successful construction of the project.

To help identify and manage the construction logistics and potential risks associated with the project, Kleinschmidt and PPL initiated a cooperative consultation process and invited many groups to share their ideas and concerns about the plan. The final design and permitting packages incorporated as much of their input as possible to attempt to minimize any adverse effect of the construction on the local environment. Early and continued involvement of stakeholders from local, state, and federal resource agencies was critical for maintaining progress. In

addition, regular communication with indirect stakeholders, such as the State Dept of Transportation and the owner of the railroad line, was essential for adjusting to changing conditions in the field. Planning for construction involved accommodating seasonal work restrictions stemming from environmental sensitivities.

Restrictions precluded excavation of rock from within the water during upstream fish passage seasons, blasting of bedrock during nesting seasons, and any kind of disturbance at any time within defined distances of great blue heron and bald eagle nests. Furthermore, the physical footprint of the work area had to

Serendipitous Funding for a “Shovel-ready” Project

The American Recovery and Reinvestment Act (ARRA) signed into law by President Obama in 2009 provided significant financial assistance for this project. The 30 percent grant for investment in renewable power generation provided by the ARRA helped to make the Holtwood expansion economically viable for the company.

be contained within well-defined limits to prevent potential effects on other environmentally or archaeologically sensitive areas.

The contribution of this construction project to the economy of southeastern Pennsylvania was significant. The total cost of the project is reported to be in excess of \$440 million, and most of that money stayed within the construction area. The general contractor used local union labor for the construction effort. The supplier of the hydroelectric turbine is located in York, PA, within an hour's drive of the construction site, and nearly all major materials were purchased from local suppliers. During peak construction periods, more than 300 construction workers and supervisors tended to the construction of this project. This direct infusion of money into the local economy was recognized at local hotels, stores, and restaurants.

Despite the significant challenges and a full year increase in the anticipated duration of construction of the powerhouse (due in part to high river flows and one significant flood) the Holtwood expansion project is considered to be a success. The new power station has been generating more than 120 megawatts of hydropower for almost a year, and the Low Impact Hydro Institute (LIHI) certified the project for Tier

1 renewable energy credit (REC) trading. This certification of power for more than 100,000 typical homes is a testament to the diligence and commitment of the PPL team to avoid adverse environmental effects where possible and to

mitigate unavoidable effects in cooperation with regulatory and environmental stakeholders throughout the construction process. The short-term economic benefit of the construction effort for the local economy and the long-term renewable generation

from the completed power station are important benefits for the people of southeastern Pennsylvania.

For more information contact Trevor.Lykens@KleinschmidtGroup.com



Completed Holtwood redevelopment looking downstream. Note the new railroad bridge in the foreground and the new power house on the left.

PROTECTING BALD EAGLES AT HOLTWOOD: ADAPTING TO CONTINGENCIES

by Nicholas Morgan

When the Holtwood expansion project started, the bald eagle was still designated a threatened species according to the Endangered Species Act. Bald eagles nesting and feeding in the area around Holtwood are important ecological resources that clearly needed to be protected during the expansion in order for the FERC license to be renewed and to obtain LIHI certification for the project. Nonetheless, Kleinschmidt and PPL could not have anticipated how challenging that process would become.

We prepared a plan to protect two known bald eagle nests located within a half mile of the project, but far enough from the proposed construction activities to avoid requiring additional permitting. Near the end of the final design phase of the project, while searching for a safe and environmentally acceptable location to construct a bridge across the tailrace for access to an excavation site, we discovered a bald eagle building a new nest in a tree close to the shoreline of Piney Island. At that time, the expansion design involved excavating the island's shoreline to create a shelf to provide passage for migrating American shad. That design needed to be altered to protect the new eagle nest.

We worked with the stakeholders to balance the requirements



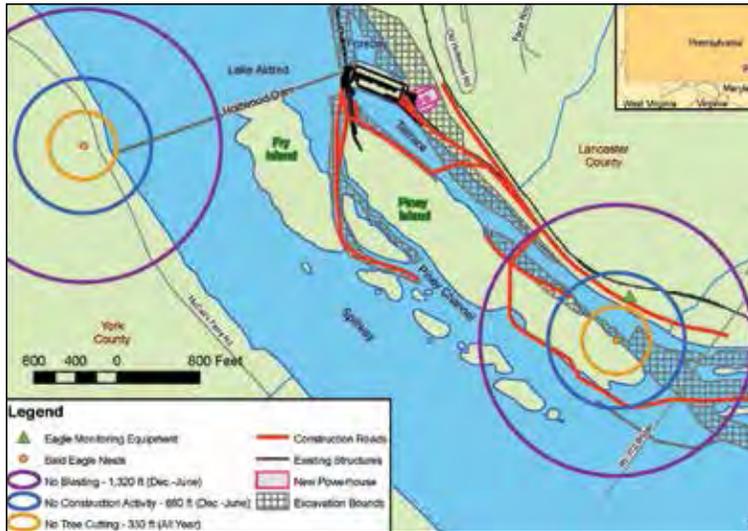
American bald eagle in flight.

for effective fish passage with the nesting requirements of the bald eagle. We developed new designs and tested new flow models to meet fish passage requirements while protecting the shoreline where the bald eagle decided to nest. The new nest was located immediately adjacent to the construction site and literally would be surrounded by proposed activities; therefore, Kleinschmidt and PPL developed the Bald Eagle Management and Monitoring Plan in consultation with the U. S. Fish and Wildlife Service (USFWS) and the Pennsylvania Game Commission (PGC). That plan required the construction contractor to maintain certain distances from the nest during the nesting season and provided a construction sequence and schedule that limited the footprint of the expansion project and preserved foraging areas for the eagles throughout the

year. One significant sequence in the schedule was to complete the diversion of Unit 1 into Piney Channel during the first part of construction to create a consistent foraging habitat in an existing river channel that originally received only intermittent flow. This created a safe place for the bald eagles to forage during and after construction. Based on such provisions, the USFWS and PGC concluded that the expansion project would not adversely affect bald eagles and approved the plan without requiring PPL to obtain an incidental take permit.

The Bald Eagle Management and Monitoring Plan included robust monitoring during every blast required for excavation throughout the nesting season. Given the enormous volume of excavation and the estimated number of blasts (i.e., two blasts each day, 6 days a week, for 3

years), innovation was required to minimize the cost of monitoring. Kleinschmidt developed a system for monitoring the eagles in real time using a camera and sound meter linked to a remote computer that recorded the activity of eagles in or near the nest 24 hours a day, 7 days a week. Our biologists could access the video and sound recordings remotely during each blast. This enabled biologists in offices in Maine, Connecticut, South Carolina, or Pennsylvania to contribute to monitoring at Holtwood, which turned out to be far more economical than expected because it allowed the construction contractor to blast on short notice. Our local staff did not have to remain on site during delays in scheduled blasts because they were merely a phone call away from accessing the monitoring equipment and allowing the contractor to execute



Detail from bald eagle monitoring and management plan for Holtwood redevelopment.

the blast when ready.

As the project progressed, the bald eagle was delisted from the Endangered Species Act. Similar protection for the species continues under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act; however, a regulatory framework for granting an incidental take permit for bald eagles was temporarily unavailable. This was not an issue, until an unforeseen natural disaster interrupted the expansion project. In 2011, Hurricane Irene and Tropical Storm Lee dropped record precipitation in the watershed back to back, causing massive flooding in the Susquehanna River and flooding out the excavation of the new powerhouse at Holtwood. The flooding caused the contractor to miss approximately 6 weeks of tailrace excavation during the

season when bald eagles were not nesting, which jeopardized the scheduled completion of the project.

Recognizing that the contractor would need to blast more aggressively and probably would need to blast within the restricted zones during the nesting season to make up time, Kleinschmidt consulted the USFWS and PGC



Kleinschmidt's Nick Morgan observing nests at Holtwood during redevelopment.

regarding increasing the amount of blasting allowed closer to the eagle nest during the nesting season. The agencies approved a revised plan but required an incidental take permit and mitigation in the form of funding for a wildlife rescue center as precautions for potential disturbance of the nesting bald eagle. As part of the revised plan, Kleinschmidt developed a study in which two juvenile eagles in a nearby nest were outfitted with global positioning system (GPS) radio transmitters to determine how the recently fledged eagles responded to construction activities within their limited foraging territory. The study showed that adjacent construction activities had no effect on the newly fledged, juvenile bald eagles. The eagles remained near their nesting site and most frequently were found using the Piney Channel fishing habitat created during the first

stage of construction. When the study eagles were large enough to migrate farther, they used communal roosting sites and traveled in the Chesapeake Bay and the mouth of the Susquehanna River. Like other juvenile bald eagles, the study eagles returned to the Holtwood construction site for brief visits after leaving the nests. We are continuing to track those eagles today.

The bald eagle monitoring and mitigation studies at Holtwood have provided new insight into the effects of blasting and construction near bald eagle nesting and foraging habitat. We found that it is possible to safely blast closer to bald eagle nests than current regulations allow; blast mats used to minimize flying rock also reduced blasting noise and, consequently, reduced the risk of disturbing eagles. Our study also provided the first set of data for evaluating whether seismic movement disturbs bald eagles. Although our seismic data are inconclusive, they offer a baseline for comparison with future research into the effects of blasting on bald eagles in other regions. These studies provide a model for future studies and best management practices that will reduce disturbance of bald eagles.

For more information contact Nicholas.Morgan@KleinschmidtGroup.com

Kudos from our Clients!

Our corporate Vision statement affirms, “We strive for excellent client relationships and to make our clients’ lives and the global environment better.” We have a robust process for assessing our relationships with clients that includes asking for your feedback through project performance surveys. Feedback from you, our valued clients, is essential to achieving our goal of continuous improvement and is a significant part of our quality enhancement

program. We benefit from both your compliments and your constructive suggestions for improvement.

We plan to share statistical information regarding your responses to project performance surveys once we have collected enough data, but in the meanwhile, we’d like to share a few responses to one of the questions.

“Did anything stand out as exceptional?”



Jennifer Jones, Civil Engineer

“I enjoyed working with Jenny Jones very much. Her responsiveness and communications were excellent.”

“All quality reports. We did not solicit RFQs for next 5 years of Part 12s due to quality of staff and products and due to consistent timeliness of report submittals.”

“Jeff was extremely knowledgeable and wrote a fantastic report.”



Jeff Coffin, Senior Civil Engineer



Kelly Miller, Licensing Coordinator

"Tom and his team were very helpful and responsive to our requests. All interactions were highly professional. We would welcome the chance to work with Kleinschmidt again in the future."

"Kelly Miller's organizational and coordination skills!"

"Service, attitude of staff, knowledge of staff."

"Nick and your staff have done an excellent job managing this project over the past 10+ years. We have developed a great working relationship with your company over the years. Keep up the good work!"

"I enjoyed working with the staff assigned to the project. They were very knowledgeable & easy to work with."

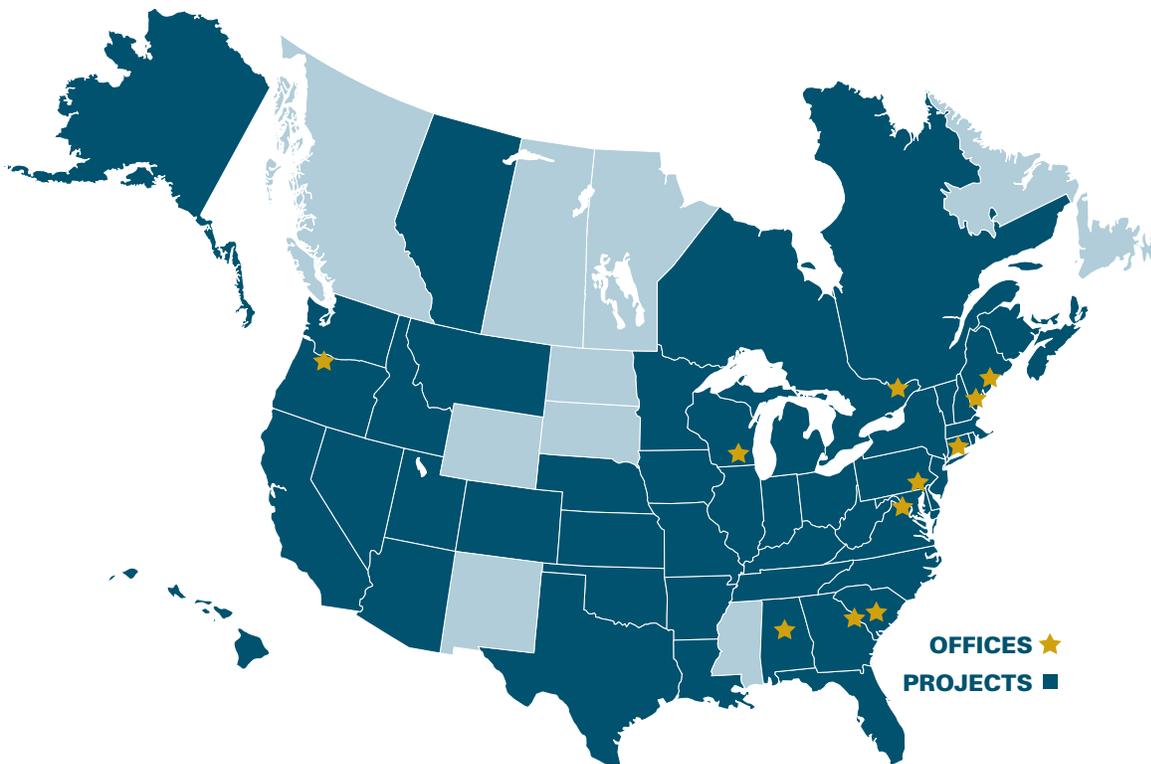
"Kleinschmidt performed in an exceptional manner dealing with old FERC issues, other consulting firms and a client who was under the gun to complete the work."

"He [Eric] was responsive to my changes and timely with getting me what I needed. Also good at getting back to me."



Eric Turgeon, Structural Engineer

KLEINSCHMIDT OFFICES and PROJECTS



Our Services:

- Hydropower Consulting
- Regulatory & Permitting
- Fish Passage
- Marine Renewables
- Onshore Wind
- Fisheries & Aquatic Sciences
- Terrestrial & Wetland Sciences
- Water Resource Engineering
- Valuations
- Dam Safety

Our Mission:

*“Do good work and make a living at it.
Enjoy what you are doing, and the rest will
take care of itself.”*

KleinschmidtGroup.com

888.224.5942