SANDIA REPORT

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Viability Report for the ByWater Lakes Project

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Abstract

This report presents the results from the hydrological, ecological, and renewable energy assessments conducted by Sandia National Laboratories at the ByWater Lakes site in Espanola, New Mexico for ByWater Recreation LLC and Avanyu Energy Services through the New Mexico small business assistance (NMSBA) program. Sandia's role was to assess the viability and provide perspective for enhancing the site to take advantage of renewable energy resources, improve and sustain the natural systems, develop a profitable operation, and provide an asset for the local community. Integral to this work was the identification the pertinent data and data gaps as well as making general observations about the potential issues and concerns that may arise from further developing the site. This report is informational only with no consideration with regards to the business feasibility of the various options that ByWater and Avanyu may be pursuing.
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ACKNOWLEDGMENTS

Sandia would like to acknowledge ByWater Recreation LLC and Avanyu Energy Services for their help and support in producing this assessment. Many of the conclusions and assessments contained herein are built on the foundational work that ByWater and Avanyu completed prior to our involvement.

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NOMENCLATURE

af/yr	Acre-feet per year
cfs	Cubic feet per second
EPA	Environmental Protection Agency
gpm	Gallons per minute
LBNL	Lawrence Berkeley National Laboratory
LLC	Limited Liability Corporation
L/s	Liters per second
NMED	New Mexico Environmental Department
NMRAM	New Mexico Rapid Assessment Method
NMSBA	New Mexico Small Business Assistance
NMWP	New Mexico Wetlands Program
NREL	National Renewable Energy Laboratory
PV	Photovoltaic
REAP	Rural Energy for America Program
RERI	River Ecosystem Restoration Initiative
SAM	System Advisory Model
SNL	Sandia National Laboratories
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service

1. INTRODUCTION

This report presents the results from the hydrological, ecological, and renewable energy assessments conducted by Sandia National Laboratories (SNL) at the ByWater Lakes site in Espanola, New Mexico for ByWater Recreation LLC (ByWater) and Avanyu Energy Services (Avanyu) through the New Mexico small business assistance (NMSBA) program. Sandia's role was to assess the viability and provide perspective for enhancing the site to take advantage of renewable energy resources, improve and sustain the natural systems, develop a profitable operation, and provide an asset for the local community. Integral to this work was the identification the pertinent data and data gaps as well as making general observations about the potential issues and concerns that may arise from further developing the site. This report is informational only with no consideration with regards to the business feasibility of the various options that ByWater and Avanyu may be pursuing.

The assessments focus on the geology, hydrology, ecology, and renewable energy potential at the site. The purpose of the geological, hydrological, and ecological assessments are to describe the overall physical environment of the site and to identify considerations for developing the site as proposed. With regards to the renewable energy potential, assessments of the energy production from solar and wind are made as well as the identification of any incentives, tax credits, and the like for which the clients' may qualify.

The balance of this report begins with the general physical setting of the ByWater Lakes site, including the geologic, hydrologic, and geohydrologic settings. This is followed by a description of the ecology of the site, the services provided by the ecology, as well as the educational opportunities that the ecologic setting may bring. The next section discusses the energy assessment with respect to solar, wind, and micro-hydro. As mentioned above, the energy assessment also discusses potential tax credits and funding sources that may be available to ByWater, as well as a discussion of the limitations and other factors that could be important to consider for installing the generation hardware (e.g., solar panels, wind turbines, etc.). The report ends with a list of references to any data sources, reports, articles, and the like that have been used in preparing this report.

1.1 Business Plan

The following text is reproduced from the ByWater Development Plan as obtained from Avanyu with permission from ByWater. It is reproduced here to provide context and background to the rest of this report. Edits to the original text are shown in italics.

> ByWater Recreation LLC also known as and doing business as Ohkay Lakes opened for business in April 2011 as an outdoor recreation and RV business located on the Ohkay Owingeh Tribal Lakes *site*. The business currently offers lake fishing, RV site rentals, a septic dump facility, camping, small lake boating, picnicking, touring, and 3 sites for group activities. The business is owned and operated by William C. Marcus.
>
> Recognizing that recreation is a critical factor in the quality of life of a community and that the Espanola Valley has limited recreational outlets Mr. Marcus believes that now is the

right time, and that Ohkay Lakes & RV Park, is the right place to provide additional recreational opportunities for the Espanola Valley and the RV tourist community while increasing economic opportunities through this business.

Additionally, Mr. Marcus*, in staying* consistent with his heritage and cultural beliefs intends for this project to utilize Solar, Wind and Hydro-technologies to provide Green Energy for the total operational use of the park. When optimal conditions are applied, this project is scheduled to be a Net-Zero facility.

Projected Improvements:

Mr. Marcus' goal to offer additional recreational options to his customers includes an expansion of the boat rental operation, a remodel *of* the laundry area to convert it into an eatery/café and juice bar; re-activation of the downed RV sites; improvement and expansion of the camp site options to include cabin and improved covered lakeside camping; improvement of the sites for group activities, creation of a lakeside swimming/beach area and putt-putt and wetland observatory. Additionally, the Owner plans to add concessions/educational kiosk for the lakeside venue and an open air market for local venders. Mr. Marcus has engaged Avanyu LLC (Avanyu Energy Services and Avanyu General Contracting) and Anchor Engineering to assist in generating a Development Plan and carrying it through to fruition. The joint venture consists of AGC, AES and Anchor Engineering is known as the ByWater Lakes Project.

The ByWater Lakes Project is currently in its start-up phase of the Development Plan and is seeking additional financing to complete the initial RV Park/Lakes improvements and to conduct the initial assessments and feasibility studies necessary to enter into Phase II. Mr. Marcus wants to expand the business with an overall goal of creating a model for utilizing Green Energy Solutions and advanced sustainable technologies for other communities to replicate for their own advancements. Included in these technologies Mr. Marcus is researching the viability of harnessing the wetlands drainage run-off for hydro-electrical power, wind patterns for wind-tower electricity and square footage for solar array.

ByWater Recreation is a Limited Liability Company owned and operated 100% by William C. Marcus. The outdoor family recreation business began in April 2011, with Phase 1, opening at Ohkay Owingeh Tribal Lakes for fishing on two scenic lakes covering approximately 15 acres. The RV Park with a septic dump facility, electrical, sewer and water hookups opened in September on a limited basis, 25 sites out of 74 available. Other activities include camping, small lake boating, picnicking, touring, and three (3) large covered sites for group activities.

Ohkay Lakes and RV Park is located between Santa Fe and Taos, (just north of Espanola) nestled among the cottonwoods of the Rio Grande, with spectacular views of the Jemez and Sangre de Cristo Mountains. Two (2) full gaming Casinos, local restaurants, gas stations and Wal-Mart are located within 1 1/4 miles from the business site.

The Lake and RV Park is an existing facility leased from Tsay Corp., (owned by the Ohkay Owingeh Tribe). It is a 22 acre lot with the two lakes covering 15 acres, 74 RV sites, 24 camp sites, and two commercial buildings. The site *was* formerly operated by the Tsay Corp. *and* had been abandoned and neglected for several years, open only intermittently for fishing *before being acquired by ByWater*. The five (5) year lease to ByWater Recreation began in April 2011, and lasts to 2016, with option to renew. During this first year of operation Mr. Marcus repaired and refurbished broken and damaged infrastructure, buildings (laundry, shower and ranger station), improved the landscaping, cleared overgrown vegetation, removed debris, and improved the roads and camp sites. The Laundry and Bath House remain closed though the buildings have been restored with plans of remodeling the building to convert to and eatery/café, office space, information center as well as a Health Center and Spa.

Mr. Marcus wants to expand the business offer to the public by adding to the fishing activity the following:

- Boating
- Lakeside camping,
- Lakeside swimming area,
- Putt-putt mini golf,
- Wetland Observatory
- Concession venue at lakeside,
- Archery Range
- Improved sites for family or group activities,
- Boardwalk
- Fish Hatchery
- Add an Eatery/Juice and Beverage Bar,
- Expand from 25 to 74 full service RV parking sites *with* drive through parking
- Add an open air market for local venders to sell their products
- Sand Volleyball Court

The current laundry and shower buildings will be remodeled to accommodate the eatery/ juice and beverage bar, business office and information center, with future plans to add a massage/hydro-therapy facility, featuring hot tub, mineral bath, and whirlpool baths. The location will provide local massage therapists with a convenient and professional site to serve their customers.

It is with these activities in mind that this assessment and report is being created.

2. PHYSICAL SETTING

2.1 Location and History

The ByWater Lakes site is located east of the Rio Grande River off of Hwy 68 in the north end of the city of Espanola, New Mexico. The total area of the site is approximately 220 acres, centered on latitude 36^{o} 01' 18.24" north and longitude 106^{o} 04' 17.28" west, at an elevation of approximately 5600 feet above sea level **Error! Not a valid bookmark self-reference.**. The site contains two small lakes of 28 and 7.6 acres (north and south lake, respectively) and a wetlands area of approximately 30 acres Figure 2. The site has two RV Park areas of 28 and 46 sites each, 24 camp sites, and a commons area that consists of a 1516 square foot laundry facility and men's and women's bath-houses and restrooms totaling 2080 square feet. Surrounding each of the lakes are numerous day-use picnic shelters, and viewing benches. A larger group area is located directly west of the small lake. A small wildlife walking area complete with interpretive signs is located at the extreme north end of the site.

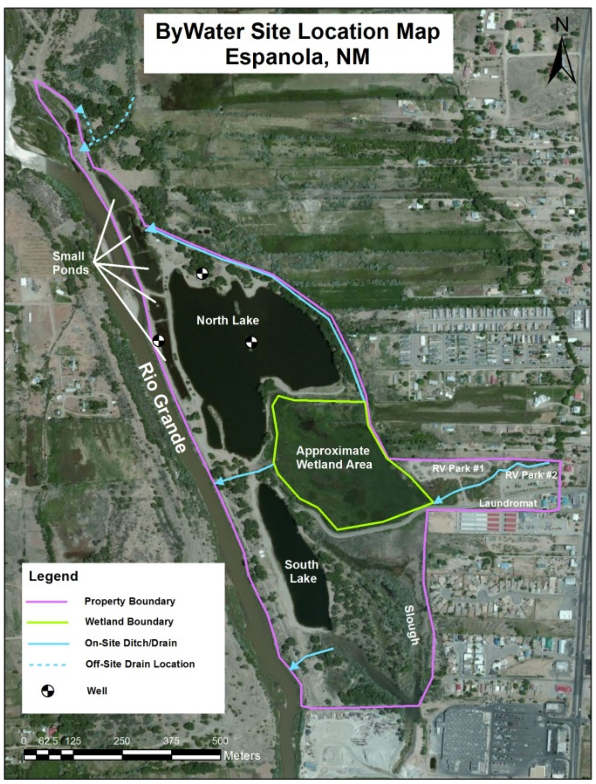


Figure 1. The ByWater Lakes site. The blue arrows show the surface water pathways onto and off the site.

The site was originally operated as a gravel pit, which resulted in the formation of the two lakes and numerous small ponds on the site. The site was converted to an RV Park and recreation area by the tribe who managed the lakes as a put-and-take fishery for trout and bass. The tribe closed the site when it proved to be unprofitable to run. The site had been mostly unused until April 2011 when it was leased to ByWater on a 5 year renewable contract.

2.2 Geologic Setting

The ByWater Lakes project site is geologically located in the east-central area of the Espanola Basin [Biehler, *et al.* 1991] (Figure 3). The Espanola Basin is a set of complex, asymmetric grabens about 70 km long by 60 km wide (a graben is a depressed geologic block bordered by faults). It borders the San Luis Basin to the north, and the Albuquerque Basin to the south. The northern and western basin margins are defined by the Embudo and Pajarito fault zones [Carter and Winter 1995], respectively.

Figure 2. Photos of the south lake, looking towards the southwest, and the wetlands, looking to the northeast.

The basin is crossed north to south by the Rio Grande and includes the confluence of the Rio Grande with the Rio Chama as well as with several smaller tributaries. The topographic relief of the basin exceeds 2100 m between its lowest and highest points. The climate is semi-arid with total precipitation ranging from 18 to 86 cm/yr, with the higher rainfall rates associated with the higher elevations. The basin is mainly filled with Tertiary and younger rift fill sediments [Carter and Winter 1995] that comprise the Santa Fe Group rocks, which are characterized as poorly consolidated basin-fill sediments that range in thickness from 0 to 3000 m [Cordell 1979]. The Santa Fe Group is subdivided into two formations (Tesuque and Chamita formations), each with several sub-members that reflect the diverse geology of the alluvial deposits that comprise the Group [Biehler *et al.* 1991; Smith 2004; Cevik 2009]. At the ByWater Lakes site, the Santa Fe Group is approximately 1500 m thick and consists of mainly river, floodplain, and alluvial deposits ranging in age from the Pliocene to the lower Pleistocene (5.3 to 1.8 million years ago). It is overlain by a thin layer (100-300 m) of younger alluvium ranging in age from the upper Pleistocene through the Holocene (126,000 years ago to the present) [Robson and Banta 1995; Wilks 2005]. The younger alluvium was the material mined during the gravel operations.

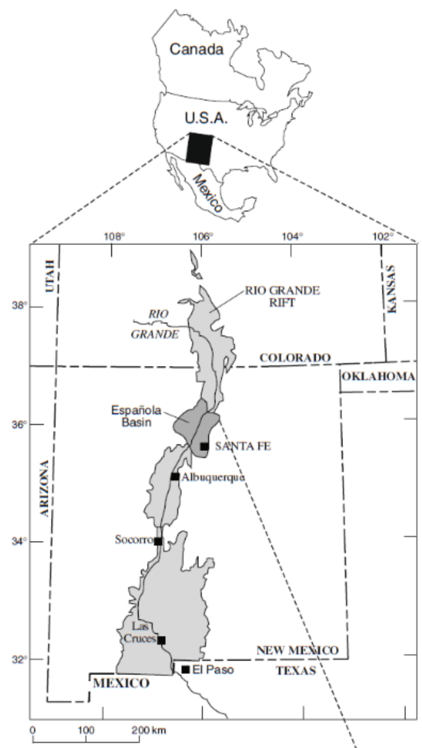


Figure 3. Location of the Espanola Basin. Reproduced from Manning [2011].

2.3 Hydrologic and Hydrogeologic Setting

The geologic setting describe above has important implications for the ByWater Lakes project with regards to the existence and sustainability of the lakes and other water features on the site. The alluvium of the Santa Fe Group forms the underlying aquifer, which is a major source of water for the various pueblos, municipalities, and agricultural communities that lie within the basins' confines and includes the cities of Espanola, Los Alamos, as well as the Los Alamos National Laboratory [Vesselinov, *et al.* 2002; Bexfield and McAda 2003; Keating, *et al.* 2003].

Recharge enters the basin in the higher elevations along its margins with estimates ranging from 7% to 26% of the total precipitation [Vesselinov *et al.* 2002]. Groundwater in the basin generally flow from the mountains to the Rio Grande, where most of it discharges [Manning 2011]. Keating *et al.* [2003] estimate the total recharge to the basin to be 3,845 L/s (97,000 af/yr), with another 235 L/s contributed from basins to the north via subsurface flow. Their water balance shows most of the inflows being discharged to the Rio Grande (3,516 L/s) with the balance (564 L/s) exiting as subsurface flow to basins to the south and west.

2.3.1 Site Observations

Two site visits were conducted on October 3, 2012 (Thomas Lowry and Andrea Holling) and November 7, 2012 (Thomas Lowry, Geoff Klise, and Will Peplinski) to observe the physical layout and current conditions. Hydrologically, the site is sandwiched between agricultural return-flow ditches from the local Acequias on its north, east, and southern boundaries, the Rio Grande on the western boundary, and the groundwater aquifer system below. The agricultural return-flow enters the property just north of the access road where it meanders between the two RV sites and then empties into the wetlands (Figure 4). Water from the wetlands drains northward along a cascade of culvert-connected small ponds, to the south, under the access road where it enters a smaller wetlands and slough area, and to the west through a ditch between the lakes. All the outlets drain directly into the Rio Grande.

The north ditch follows the northern property line for approximately 500 m until it enters a cascade of four culvert-connected ponds with widths on the scale of 25 feet. While not directly observed during the site visits, it appears that water could also be entering the site from direct runoff of the agricultural lands that are directly adjacent to the north ditch. The water works its way from the first pond to the fourth where it enters another set of five ponds that follow the axis of the river between the river control levee and the north lake. The five ponds are also connected by culverts with the majority of the water moving south until it reaches the southernmost pond, where it drains into the Rio Grande through a culvert in the levee Figure 5. The flow through the entire pond system is gravity fed (i.e., water is not pumped from on pond to the next).

Figure 4. Pathways of surface water flows onto and off of the ByWater Lakes site. The yellow arrows depict pathways for water entering the site. The blue arrows depict pathways internal to the site, and the green arrow, depict pathways leaving the site and entering the Rio Grande.

Figure 5. The southern-most pond adjacent to the north lake. The culvert through the levee to the Rio Grande can be seen in the lower left of the picture. View is to the north.

The drainage from the wetlands to the south crosses under the access road where it enters a system of smaller wetlands and sloughs Figure 6. The slough system appears to be fed by drainage from the active gravel operation directly south of the ByWater Lakes site. The slough system drains into the Rio Grande through a ditch that has been cut in the levee.

The wetland fills with a foot or two of water during the irrigation season and then drains during the fall. During the site visit in November, there was no visible standing water in the wetland but the soil was still moist at the wetland's eastern edge (sticky mud) and the plant assemblage was dominated by cattails (no observation of the water depth in the wetland was made during the October visit). According to Mr. Marcus, the Acequia ditches stopped flowing approximately 2 weeks earlier. Mr. Marcus also reported that the wetlands are active with migratory birds during the fall and that there is a central pond area visible when the cattails are burned off. The wetland is burned in a controlled manner every second or third year to reduce wildfire danger. Water from the central pond area drains to the west through a ditch between the north and south lakes and then through a culvert through the levee where it enters the Rio Grande.

Figure 6. The western end of the slough system before it drains through the levee. View is towards the southwest.

Figure 7. The central ditch that drains the wetlands to the west. View it towards the west.

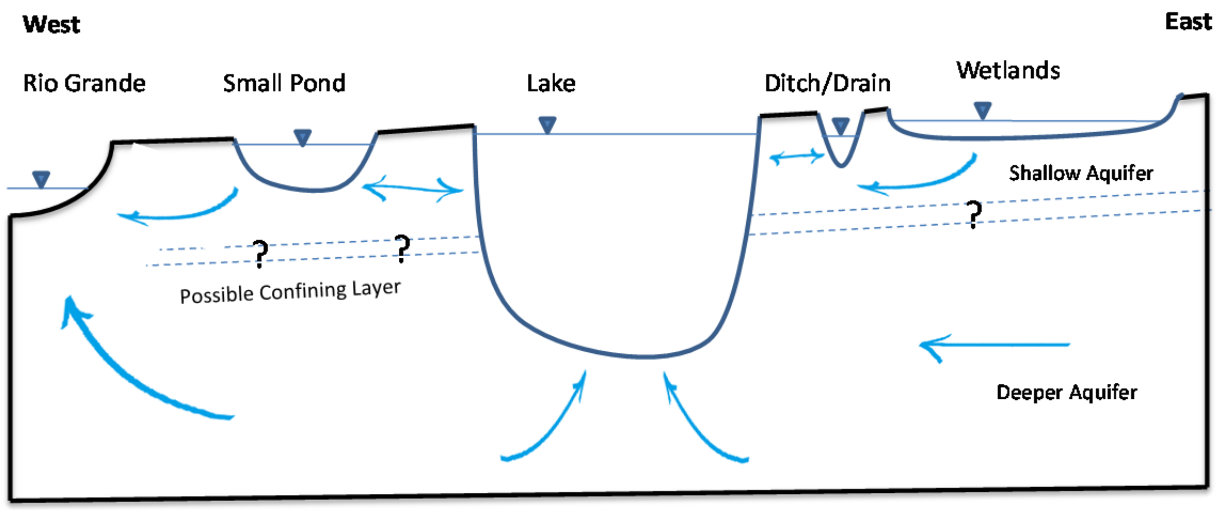
The flow in the ditches is seasonally variable, flowing at its highest in June and July, and diminishing to zero from about November through March. During the October visit, flow was observed in all the ditches as well as through all three pathways that flowed into the Rio Grande. A photo of the ditch draining to the west of the wetlands as exits the culvert running under the access road to the north lake is shown in Figure 7. During the November visit, no flow was observed in the ditches with flow into the Rio Grande observed only from the pond system adjacent to the north lake and was estimated to be ~2-3 gpm. Closer inspection of the culvert on the Rio Grande side of the levee revealed a small spring directly below the culvert about 2 feet above the river surface elevation. A rough survey using a person's height as measure estimated the spring to be approximately 8-9 feet below the northern lake surface. Algae in the water draining from the spring suggested a nutrient-rich environment. It was not clear whether the water was coming from the north lake, the shallow pond system, or from some other source. Water quality sampling in the spring, the ponds, and the lakes could help determine its source.

As discussed above, in the Espanola basin, groundwater flows from the surrounding highlands, the Jemez Mountains to the west and the Sangre de Cristo to the east, toward the Rio Grande. Three wells are located on the property that could be used to measure ground water flow direction and help verify the surface water / groundwater connection but were not accessible during the site visits. Of the three wells one was locked, the second appeared to be sealed to facilitate water production and the third was inaccessible due to its location on an island. The second well is a currently unused water supply well for campers and is believed to be shallow (less than 30 feet) (Figure 8). The quality of the water from the supply well is unknown. Depth to water likely varies across the site, shallower to the east and deeper toward the river. During the irrigation season (Spring to early Fall) ground water mounding likely occurs beneath the wetland as surface water infiltrates into the a perched, near-surface aquifer. Depth to water near

Figure 8. The currently unused water supply well to the northeast of the north lake.

the river is probably 12 to 14 feet below ground surface, as shown by the spring observed at the drainage outlet.

Conceptually, it appears that the two large lakes are being fed and sustained by groundwater discharge from the deeper aquifer (Figure 9). This is evidenced by the fact that the elevation of the lakes is estimated to be approximately 10 feet above the river surface elevation. A survey of the site should be done to verify this difference. This suggests an upward gradient in the ground water system as a more lateral gradient toward the river would likely produce a series of springs along the river and the lake and river elevations would be closer. One explanation is that there is a perched aquifer beneath the site. The Santa Fe Group is a complex assemblage of gravel, sand, silt, and clay. River overbank deposits of clay could easily confine deeper sand and gravel deposits allowing for a perched aquifer system. As mentioned above, recharge of the perched aquifer could take place from the on-site wetlands or further east off-site. In the perched aquifer scenario, the deepness of the lakes (which we were told are ~30 feet) means the lakes penetrate the confining layer to gain access to the deeper groundwater system. This would also explain the difference in elevations between the pond system and the north lake. Other explanations of the surface water / groundwater interaction are likely to be more complex but none can be completely verified without a substantial effort involving data collection and numerical modeling. The connection of the lakes to the deeper groundwater system has strong implications for the sustainability of the lakes during dry years.



E-W Cross Section of Conceptual Ground Water Flow

Figure 9. Conceptual diagram of the groundwater – surface water interaction. Water from the deeper aquifer appears to be supplying the lakes while the ponds, ditches, and wetlands are isolated from a possible confining layer. The lakes depth is deeper than the confining layer which allows the deep aquifers to feed the lakes. This conceptualization should be confirmed with future data collection and analysis.

3. ECOLOGY

3.1 General Description

The most important ecological issues associated with the ByWater Lakes project include the wetland and water quality characteristics at the site, the Rio Grande itself, and the endangered species that may be present in the area. Although these issues may place constraints on development plans, they could also be used to increase educational and eco-tourism values by highlighting the importance of ecosystem services provided by riparian and wetland habitats and by river and riparian restoration approaches.

This section will include some basic information about New Mexico wetlands, river and riparian habitats, and wetland and river restoration projects implemented by other native communities in New Mexico.

3.2 Wetlands

Wetlands provide a multitude of ecological, economic and social benefits. They provide habitat for fish, wildlife and a variety of plants. Wetlands are nurseries for many saltwater and freshwater fishes and shellfish of commercial and recreational importance. Wetlands are also important landscape features because they hold and slowly release flood water and snow melt, recharge groundwater, act as filters to cleanse water of impurities, recycle nutrients, and provide recreation and wildlife viewing opportunities for millions of people.

Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Indeed, wetlands are found from the tundra to the tropics and on every continent except Antarctica[1].

For regulatory purposes under the Clean Water Act, the term wetlands means "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."[2]

3.3 Environmental Protection Agency and the Clean Water Act

More than a dozen major statutes or laws form the legal basis for the programs of the Environmental Protection Agency (EPA) with regards to water and air, with some quite specific to wetlands and surface water quality. Below are EPA's laws and regulations that may apply to tribal government operations. These include[3]:

[1] http://www.fws.gov/wetlands/Other/What-are-wetlands.html
[2] http://water.epa.gov/type/wetlands/index.cfm
[3] http://www.epa.gov/tribal/laws/index.htm

- Tribal Assumption of Federal Environment Programs
- Clean Water Act
- Clean Air Act
- Safe Water Drinking Act
- Resource Conservation and Recovery Act
- Emergency Planning and Community Right to Know Programs
- Federal Insecticide, Fungicide, and Rodenticide Act
- Toxic Substances Control Act
- National Environmental Policy Act
- Endangered Species Act
- Comprehensive Environmental Response, Compensation and Liability Act

Section 404 of the Clean Water Act is noteworthy for the ByWater Lakes project in that it defines 'compensatory mitigation' by which any wetlands removed from the system must be replaced at some other location. This law once stipulated a 1:1 replacement based upon two dimensional area, however more recently the replacement of functional capability has been emphasized. Functional capability refers the capability of the site to provide some particular set of ecosystem services that might be expressed in overall species diversity or the richness (density) of some particular set of indicator species, including both animals and plants[4].

An important approach for maintaining high water quality in surface water systems, including wetlands and rivers, is to reduce the flow of suspended solids associated with storm water runoff into the surface water system. Organic chemicals and other toxins from road surfaces, parking lots, roofs, or lawns or fields treated with fertilizers, pesticides or herbicides, adhere to sediments and are often carried with storm flows directly to surface water systems. These organic compounds can include fecal materials, petrochemicals, PCBs, and metals. These can have a direct toxic effect for animal and plant species, and can reduce oxygen levels by increasing chemical and biological oxygen demand. Slowing and reducing the direct storm flows to the surface water with settling basins or swales, porous pavements, or French drains can reduce organic loading by up to 75%.

3.4 River and Riparian Restoration Projects

River and riparian restoration projects generally include efforts to restore natural flows, river bed morphologies, and biological species to river and riparian zones. Various funding sources including state and federal agencies and non-governmental organizations have been available to support these efforts. Numerous river and riparian restoration projects have been implemented by native communities along the Rio Grande in northern and central New Mexico. Some approaches and partnerships from the efforts raised by nearby Pueblos may be useful for the ByWater Lakes project.

[4] Personal communication with Dr. Joel Lusk, Senior Fish and Wildlife Biologist, USFWS, Albuquerque

3.4.1 Ohkay Owingeh

Ohkay Owingeh, Santa Clara, and San Ildefonso Pueblos teamed with Audubon New Mexico and the U.S. Army Corps of Engineers on a river restoration project along 12 miles of the river above Espanola[5].

3.4.2 Santa Ana

Since 1998, the Pueblo of Santa Ana has worked to restore the riparian and riverine ecosystems along the Rio Grande within the reservation. The Rio Grande holds great economic, environmental, cultural, and aesthetic significance, not only for the native communities who have lived here for millennia, but for all New Mexicans. Sixty years of flood control and channelization projects on the Middle Rio Grande have significantly changed the character of the Rio Grande flood plain on the Pueblo, which have negatively impacted the riparian and aquatic communities. The Pueblo has implemented an ecosystem-based restoration program, designed to reverse these trends and restore a healthy, functioning Rio Grande ecosystem. Restoration activities are implemented to restore the river channel, active floodplain, and the historic floodplain.

Program Highlights include:

- Creating over 100-acres of riparian wetland habitat;
- Restoring the 6-river miles of the Rio Grande traversing through the Pueblo;
- Restoring 1300-acres of cottonwood bosque by clearing salt cedar and Russian olive thickets; and
- Restoring native wildlife habitat throughout the Santa Ana Rio Grande Bosque.

The Restoration Program provides the following benefits to the Pueblo and the entire Middle Rio Grande Valley:

- Preserves the bosque for cultural and recreational uses by tribal members and guests.
- Reduces the risk of wildfire and protects the Pueblo's residential communities and economic interests.
- Preserves water resources by protecting further declines in the groundwater table.
- Enhances economic development (Hyatt-Tamaya) and provides employment for tribal members.
- Provides habitat for the endangered Rio Grande Silvery Minnow and the Southwest Willow Flycatcher.
- Openings created in the bosque enhance wildlife habitat for all species utilizing the Rio Grande corridor.

[5] http://www.togethergreen.org/grant/rio-grande-restoration

Although the Pueblo of Santa Ana has committed a significant amount of tribal resources towards this project, the work could not be completed without the financial and technical support provide by their, which include[6]:

- U.S. Army Corps of Engineers,
- Bureau of Indian Affairs,
- Bureau of Reclamation,
- Fish & Wildlife Service,
- Ducks Unlimited (North American Waterfowl Conservation Act)
- National Fish & Wildlife Foundation
- Environmental Protection Agency
- Hyatt Regency Tamaya Resort

3.4.3 San Felipe Pueblo

The Pueblo of San Felipe (Pueblo) is a federally recognized Indian Tribe with tribal lands along the Rio Grande floodplain. Serious environmental issues in the Middle Rio Grande Basin have the potential to affect the traditional way of life for the Pueblo, especially in the bosque, the deciduous riparian forest that borders the river. This area was once subject to frequent flooding, but changes in river hydrology have nearly eliminated the overbank flows and, as a result, the natural regeneration of many riparian plant species. There has also been a concurrent increase in non-native vegetation and loss of biological and hydrological diversity in this area.

As non-native salt cedar, Russian olive, and other exotics spread along the Rio Grande, funding for the removal of these species and site restoration has increased. Many projects of the type and magnitude proposed for this area have been carried out and the environmental consequences have been well studied. Overall, if carried out properly in terms of timing and avoidance of direct negative to impacts to wildlife, the results of restoring native trees and shrubs have been generally positive or neutral for wildlife, water quality, and water quantity. In addition, the Pueblo, which views the bosque as a cultural resource, would reap the benefits of having plants of cultural importance restored. The Pueblo has begun to work with several federal entities on restoration and other projects in order to help preserve and sustain the Rio Grande, the bosque, and Pueblo lands. The Pueblo proposes to clear non-native vegetation from 10 acres of tribal land in the bosque on the east bank of the Rio Grande and replant it with native species[7].

3.4.4 Zia Pueblo

On May 23rd and 24th, 2009, Rio Grande Return joined Zia Pueblo members in a project to restore a sacred pueblo spring that had gone dry. A group of enthusiastic volunteers spent two rainy days helping members of Zia Pueblo build rock dams above the spring in order to slow erosion, allow the soil to recharge with rainwater and hold moisture in the surrounding hills.

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[6] http://www.santaanadnr.org/restoration.php
[7] http://www.usbr.gov/uc/albuq/envdocs/ea/sanfelipe/index.html

The spring has long been an important sacred site and water source for Zia Pueblo. The water from this spring was traditionally collected during summer solstice pilgrimages, and then taken back to the pueblo. But erosion, climate change and increasing water needs have kept the spring from flowing for the last several years.

Peter Pino, former Zia Pueblo Governor, contacted Alan Hamilton of Rio Grande Return with the idea of organizing a project to restore the spring. When the group of volunteers and pueblo members gathered on the beautiful, rainy Saturday morning Pino spoke, "Mother Nature and the spirit world are showering us with rain. I personally believe that when people are coming together for a good cause that these kinds of things happen. This is good weather."

Hamilton recruited Steve Vrooman, a professional restoration ecologist, and two of his employees to direct the volunteers and give instruction on building rock dams. Vrooman was optimistic about the spring's potential to begin flowing again in a couple of years, given normal rainfall. By the end of the weekend, many rock dams later, and after planting native grass seed at the sites, volunteers celebrated the sight of rainwater pooling behind the dams and soaking into the hills instead of running off and taking soil with it.

As Hamilton reflected, "it is time for people of all cultures to work together to find solutions to the effects of climate change and environmental damage. We are at a critical place, a crossroads, a threshold where we have to start living differently and more responsibly. We have to figure out a way of being more attentive to each other and to the earth and to respond to things before the degradation becomes insurmountable."

The participants from the event and others will be glad to know that a second phase of restoration is being planned with the added support of the Quivera Coalition. Former Governor Pino captures the spirit of the effort in the following words, "everything that we do within our lives in the pueblo has to do with realizing that we don't have much water ... We should accept the fact that we are part of Mother Earth and that we don't own it. It's really ownership that is a foreign concept to tribes ... In the past, everything was shared by the people, the animals, the birds, the insects, the plants, all of that. If you try to assist nature, you can make things happen."

3.5 New Mexico Environmental Department (NMED) programs

Two NMED programs may be useful to the ByWater Lakes project, which are the NM Wetlands Program (NMWP) and the River Ecosystem Restoration Initiative (RERI). Each of the programs are briefly described below.

3.5.1 New Mexico Wetlands Program

As stated on the NMED Wetlands Program website, the goal of this program is “to protect and restore New Mexico’s remaining wetlands and riparian areas and to increase self-sustaining, naturally functioning wetlands and riparian areas so they continue to benefit New Mexico’s future”. The NMED has developed the ‘New Mexico Rapid Assessment Method’ (NMRAM), which is a methodology for rapidly assessing the ecological status of wetlands throughout New

Mexico [Muldavin, *et al*. 2011, 2011]. While written specifically for riverine-type wetlands, the approach may provide a money-saving framework for use at the ByWater Lakes site. To understand the potential impacts of different activities on the site, the site must first be assessed and its status determined.

More broadly, the NM Wetlands Program promotes planning, restoration, protection, education, and community support in support of its goal, with their activities described as follows:

- PLANNING - The NMWP facilitates the development of comprehensive plans for wetlands restoration and protection in watersheds throughout New Mexico.
- RESTORATION - The NMWP promotes wetland restoration as an integral part of watershed restoration and health. Participation in the program requires the creation of at least 30 acres of new or restored wetlands in the watershed.
- PROTECTION – The NMWP works towards increasing wetlands protection through monitoring and strengthening water quality standards that pertain to the State's wetland resources.
- EDUCATION - The NMWP encourages volunteer participation in on-the-ground wetland restoration projects, and helps obtain funding for projects. They also provide wetland/riparian education and outreach for schools and interest groups.
- COMMUNITY SUPPORT – The NMWP is interested in helping to organize local community efforts focused on wetlands in their watershed and composed of local organizations, tribal and cultural groups, private landowners, state and federal agency representatives, and other stakeholders.

The relevance of these programs to the ByWater Lakes project varies but there may be sufficient opportunity within those programs for collaborative work that could benefit the ecological and business success of the project. It is recommended *that future activities explore these opportunities more thoroughly to assess their value and usefulness to the project.*

3.5.2 New Mexico River Ecosystem Restoration Initiative

The River Ecosystem Restoration Initiative was established in 2007 as part of Governor Richardson's 'Year of Water, 2007' agenda and is designed "to sustain, re-establish, and rehabilitate the integrity and understanding of New Mexico's river ecosystems through the enhancement of physical, chemical, and biological characteristics".

4. ENERGY ASSESSMENT

4.1 Overview

ByWater has stated that they are interested in multiple renewable energy options to offset electricity and natural gas usage at the property. Ideas expressed included solar photovoltaics (PV) for offsetting electricity used at the site and solar hot water for offsetting natural gas used to heat water for either showering, laundry or spa facilities. With the information available, we focused on solar PV, wind, and micro-hydropower. An assessment of the solar hot water potential was not completed for this study. *When more detailed facility plans and system loads are available, ByWater should contact a solar hot water installer for a detailed assessment of system sizing, options, and potential costs*.

4.2 Solar

4.2.1 Solar PV Options for RV Park Demand Offset

To determine the available solar resource as well as the potential gross cost to install a solar PV system, the System Advisor Model (SAM)[8] was utilized. 10-km grid Satellite data was downloaded from the Solar Prospector[9] for the exact location of the ByWater Lakes property, which was used to determine the production potential of different PV system sizes. For a flat plate photovoltaic system, the annual solar resource at the property is approximately 6,270 Wh/m^2/day.[10]

Demand for electricity was estimated using data from different studies, where typical overnight usage by an RV for a 50 amp hookup averages around 14 kWh/night using estimates where RV visitors paid between 16 and 24 cents/kWh per night [Tomasso 2010]. Data was not available from ByWater regarding the rates they will be charging for electricity to RV customers, and our assumption for this study puts the charge between 18 and 20 cents/kWh. According to the Development Plan prepared by Mr. Marcus, there will be a total of 73 RV sites, though the analysis here was limited to "68 full service sites" which was assumed to mean that electrical hookups will be available to at least 68 sites. For the solar PV system sizing, it should also be noted that electricity usage was only estimated for the RV hookups and not for any other facilities associated with the property.

As noted in the Development Plan excel spreadsheet supplied to the assessment team by Avanyu, a 32 kW solar PV system is listed in the "Proposed Property Amenities" section. This was used as a starting point for system size analysis, though other system sizes were analyzed to look at different offset percentages for ByWater to consider. Using an assumed value of 14 kWh/night and 68 sites, Table 1 shows the annual average RV usage under 5 different 'scenarios' that are used to calculate the load required by RV visitors to the site. For the purposes of this analysis, 'night' is assumed to be the usage consumed in a 24 hour period by a visitor. No information on average stay per site or projected visitation and usage of the RV Park was available for this

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[8] https://sam.nrel.gov/
[9] http://maps.nrel.gov/prospector
[10] http://maps.nrel.gov/re_atlas

analysis, so the assumptions here were made to cover a range of potential visitation rates in a one-year time period. Only one scenario assumed higher usage during the peak ‘summer’ months due to air conditioning load, where approximately 19 kWh/night is estimated.

Table 1. RV electricity demand scenarios used in the solar power assessment.

Case	Occupancy	kWh/night usage	Annual usage (kWh)
1	100% occupancy, 365 days/year	14	347,480
2	50% occupancy, 365 days/year	14	173,740
3	25% occupancy, 365 days/year	14	86,870
4	80% occupancy for peak months (153 days/year) & 40% occupancy for non-peak (212 days/year)	14	197,254
5	80% occupancy for peak months (153 days/year at 19 kWh/night) & 40% occupancy for non-peak (212 days/year at 14 kWh/night)	14/19	238,870

Determining PV System size is done to estimate gross installed cost as well as to understand how much of the demand can be met by the PV system. The PV system size and associated costs only considers a fixed-tilt PV system and does not look at specific locations at the site as there are multiple shade-free locations that could be utilized. This analysis only provides a high-level view of the potential offset using estimates available from ByWater and assumptions made by SNL. Working with an installer to determine the best locations due to potential shading and other concerns, such as proximity to utility transformers or tie-in points will help better refine the analysis presented here.

The following assumptions were made in this analysis using the SAM model for a fixed-tilt PV system. Degradation rates are set to 0.5%/year for an array of crystalline modules, 100% availability (always on), 0.82 DC to AC derate (electrical losses, soiling), latitude tilt, 180° azimuth (facing south) and no shading. Table 2 shows the output of the 32 kW system as proposed in the “Proposed Property Amenities” section in the development plan spreadsheet. The annual output is shown as well as the output as a percentage of demand. Results show that at the lowest occupancy scenario, 65% of electricity demand by the RV can be met by a 32 kW PV system. For the highest occupancy scenario, 16% of electricity demand can be met by a 32 kW PV system.

Table 2. Analysis results for the 32 kW system.

Case	Occupancy	System Size (kW)	First year annual output (kWh)	Output as percentage of demand (%)
1	100% occupancy, 365 days/year	32	56,620	16
2	50% occupancy, 365 days/year	32	56,620	33
3	25% occupancy, 365 days/year	32	56,620	65
4	80% occupancy for peak months (153 days/year) & 40% occupancy for non-peak (212 days/year)	32	56,620	29
5	80% occupancy for peak months (153 days/year at 19 kWh/night) & 40% occupancy for non-peak (212 days/year at 14 kWh/night)	32	56,620	24

Table 3 shows the different system sizes and costs necessary to meet each demand scenario listed in Table 2. This is presented to show ByWater the gross installed cost of the PV system, which is essentially the cost before any tax credits or grants are applied. These costs do not consider financing rates that may be applied if a loan is required to purchase the PV system. A discussion of potential tax credits, benefits and loan programs that may be available to potentially lower these costs is presented in section 4.5 below.

For data in
Table 3, the 32 kW system is estimated at $106,240 using a $3.32/Watt estimate. If ByWater believes the RV Park occupancy is similar to one of the scenarios presented in Table 2, then the top end of that cost is the value shown above where 100% of the demand is met by the solar PV system. An installer can give a more detailed estimate of costs, especially once an exact offset is determined.

Other costs that should be considered include the energy charge by Jemez Mountain Electric Co-op. The Co-op considers "Large Power Service[11]" as systems that require greater than 50 KVA capacity, which is equivalent to 40 kW. The larger systems in
Table 3 would fall under this category. The electricity fees at this range includes a $85.00 facility charge and $11.50 demand charge per month. The Energy charge is 5.5 cents/kWh. There is also a monthly transformer capacity fee that should be considered. Any solar PV

[11] http://www.jemezcoop.org/News/rates_112011.pdf

system that backfeeds into the grid needs the appropriate size transformer installed, and that would incur a $1.25/KVA/month charge for installed transformer capacity.

Table 3. System sizes and estimates of gross installed cost.

Case	Occupancy	System Size (kW)	First year annual output (kWh)	Output as percentage of demand (%)	$/Watt (2012 New Mexico Estimate)[ii]	Estimated Gross Installed Cost ($)
N/A	N/A	32	56,620	See Table 2	3.32	106,240[i]
1	100% occupancy, 365 days/year	211	37,338	100	3.32	700,520
2	50% occupancy, 365 days/year	106	187,554	100	3.32	351,920
3	25% occupancy, 365 days/year	53	93,776	100	3.32	175,960
4	80% occupancy for peak months (153 days/year) & 40% occupancy for non-peak (212 days/year)	119	210,556	100	3.32	395,080
5	80% occupancy for peak months (153 days/year at 19 kWh/night) & 40% occupancy for non-peak (212 days/year at 14 kWh/night)	145	256,560	100	3.32	481,400

i – Cost for 32 kW system in Table 2.
ii – Average cost estimate from Albuquerque-based solar installer's commercial gross installed cost range of $2.90 to $3.75/Watt for New Mexico installations in 2012.

4.2.2 Solar PV Options Fish Lake Lighting

ByWater is interested in installing lighting at different locations around the lakes. One option is installing solar powered lights at different locations around each lake. This is done using a solar PV panel connected to a battery backup. The size of the panel and battery storage is a function of the light bulb used and the number of hours required for lighting.

One company has different items with different lighting ranges and battery technologies that could be utilized in this manner. Costs range from $800 to over $3,000.[12] When ByWater determines the number of hours needed, as well as the level of illumination required at each location, then a better estimate of the technology required and costs can be made. There are multiple companies that provide this technology and it may be worth asking local solar PV installers if they can also install this technology.

Comparing this off-grid option for lighting locations near the lakes with conventional grid-tied lights would help better understand if the economics of an off-grid lighting system is viable. Weighing the potential battery life and maintenance would have to be considered in the analysis along with the value of the electricity not being utilized at these locations. This analysis could be completed by a solar installer with better estimates of lighting needs, O&M, and labor costs.

4.3 Wind

To determine the amount of electricity that could potentially be produced using wind power, data from the National Renewable Energy Laboratory (NREL) was analyzed. According to the NREL wind detail map, the wind resource as mapped at the north end of the north lake has been classified as wind power class '2', which roughly translates into a wind power density range of 0 to 100 W/m^2 with a speed of 4.4 m/s at a 10 meter height. For a higher tower at 50 meters, the wind power density is 0 to 200 W/m^2 with a speed of 5.6 m/s [13] (Figure 10. Wind resource potential from the National Renewable Energy Laboratory database at the ByWater Lakes site.Figure 10). The wind resource could be determined at other locations, however a more detailed analysis (i.e. wind speed data collection) would need to be completed to determine the variability in the wind resource in those areas not identified in the NREL data.

The System Advisory Model (SAM) was also used for the wind power analysis. Using the coordinates for the best wind resource as shown on the wind power maps, results from SAM show the desired turbine hub height for analysis at 20 meters, with an average wind speed of 4.01448 m/s. Default values for shear coefficient (0.14) and turbulence coefficient (0.1) are used in this analysis. Analysis was done with a 5 kW turbine (Endurance Wind S-343), which is in the SAM wind turbine library. For a single 5 kW turbine, the cut-in wind speed as stated on the spec sheet is 4.1 m/s and running the model gives an estimated annual energy production value of 4,617 kWh.

Using the feature within SAM that allows for placing multiple turbines in a specific area, a 400 meter linear area was analyzed, which represents the northern edge of the north lake with the highest wind resource potential (Figure 11). The system size for this layout with 5 turbines with a 100 meter linear spacing results in a 25 kW nameplate capacity system producing 23,083 kWh annually. Within the same location, but adding 2 more turbines and using a tighter 65 meter linear spacing results in a 35 kW nameplate capacity system producing 32,295 kWh annually

[12] http://www.solarilluminations.com/acatalog/pdf_US/FL17_BusShelter.pdf, http://www.solarilluminations.com/acatalog/pdf_US/SL08.pdf, http://www.solarilluminations.com/acatalog/pdf_US/SL10.pdf

[13] www.nrel.gov/gis/wind_detail.html and http://maps.nrel.gov/re_atlas

(Figure 11). This is approximately 24,000 kWh less on an annual basis than what could be produced with the comparably sized 32 kW solar PV system.

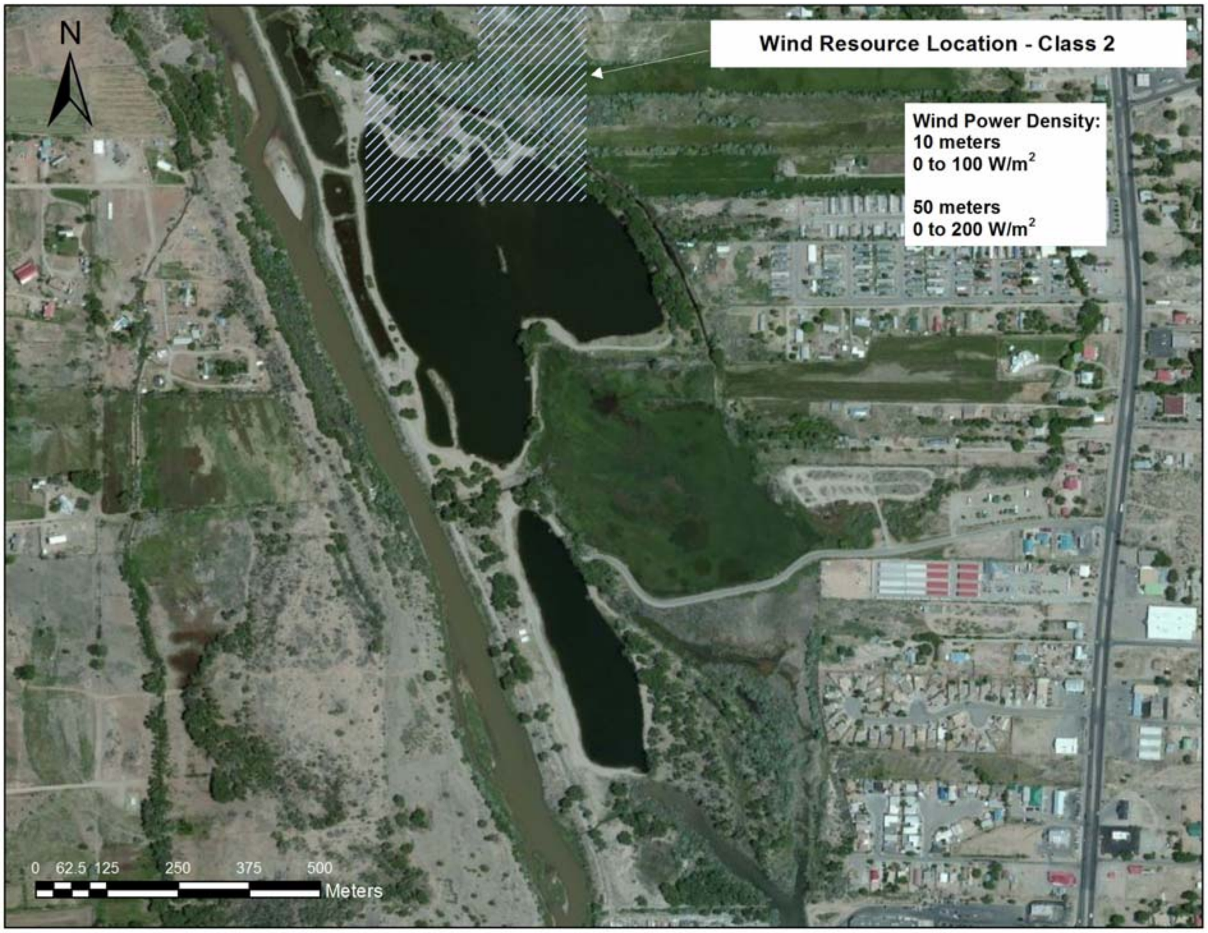

Figure 10. Wind resource potential from the National Renewable Energy Laboratory database at the ByWater Lakes site.

Rough cost estimates for wind turbines are taken from a 2012 report by Lawrence Berkeley National Laboratory (LBNL), stating that from 2009 to 2011, the average cost of systems less than 1 MW installed capacity was $2,442/kW [Wiser and Bolinger 2012]. For a 35 kW system, using this estimate the wind turbines would cost $85,470. To produce the same yearly energy as the 32 kW solar PV system, the total installed wind capacity would need to be 60 kW, which would bring the gross installed cost up to $146,000. Compared to the PV system in Table 3, a 32 kW solar PV system would cost around $100,000 before tax credits.

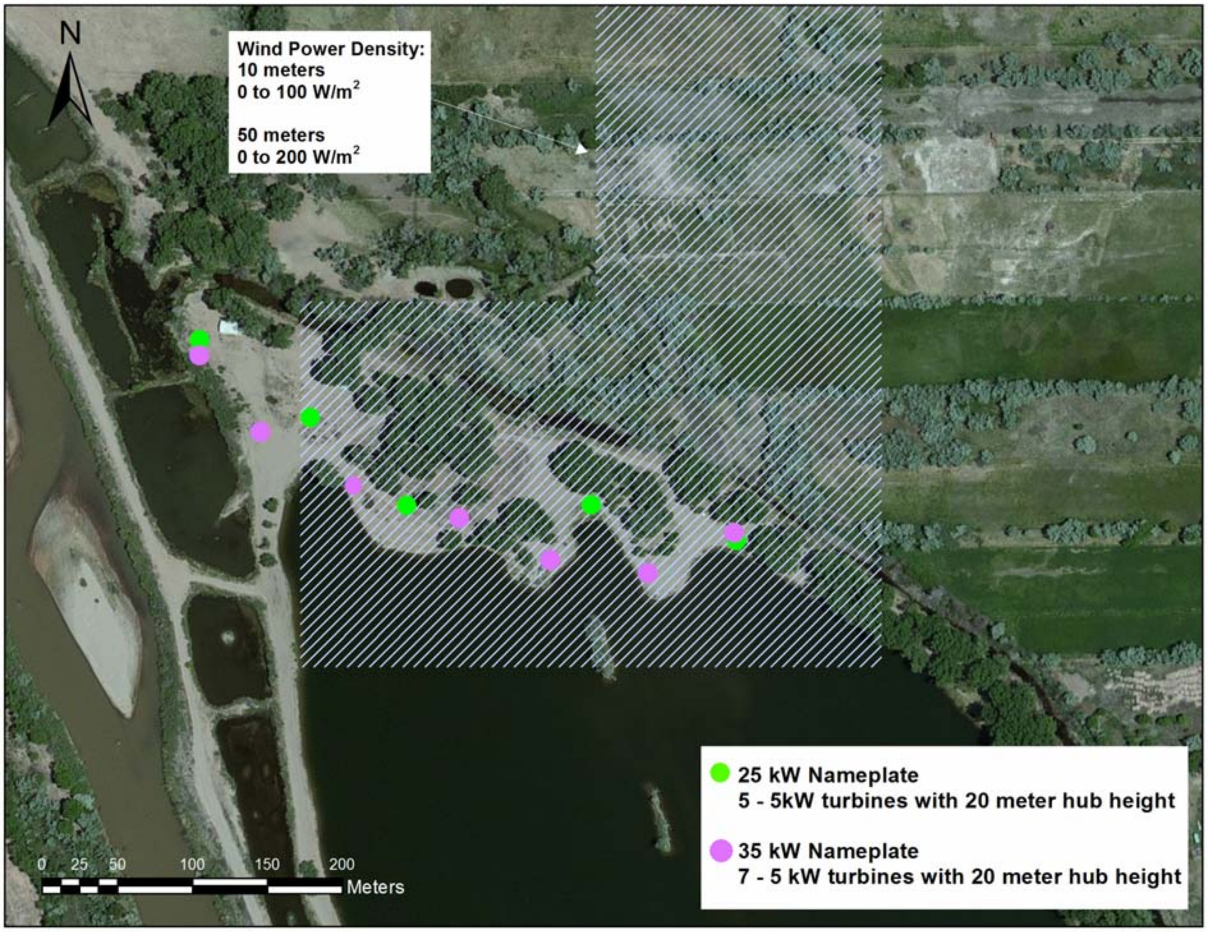

Figure 11. The 25 kW and 35 kW nameplate capacity wind turbine layout.

There are multiple locations available to add additional turbines on the property, however adding more in the area with the best wind resource may result in interference and reduced output. Also, adding turbines in locations that don't have the best wind resource may result in lower production. This analysis is based on models that haven't specifically recorded the wind potential at the site, so having wind monitoring equipment at different locations may show wind speeds either higher or lower than what is utilized for this analysis. As these values are based on multiple assumptions stated above, it is advised that installers of small wind power systems are consulted for a more detailed estimate.

4.4 Micro-Hydropower

According to Mr. Marcus, the seasonal flows in the ditches are large enough to consider the application of micro-hydropower as a power source for the property. Hydroelectric power generation is a function of two variables, the flow rate and the available head (in simplified terms, 'head' is the pressure measurement of falling water expressed as a function of the vertical distance the water falls). On the ByWater Lakes site, the two options for apply micro-hydropower are to use the available head between the outlet culvert elevation and the water surface elevation of the Rio Grande or to use the available head from the eastern most point where the ditch enters the property down to the levee elevation.

In evaluating the first option, it was estimated that the elevation of the 3 outlets ranged from 2-3 meters above the river elevation, which would leave approximately 1.5-2.5 meters of available head once a generating installation is in place. Assuming an average head of 2 meters and a flow rate of 10 cfs (~4500 gpm), the estimated gross power generating capacity is about 0.5 kW, which is enough to keep 12, 100 Watt bulbs lit for a single day. However, since the generating equipment would need to be installed at river level to gain the 2 m of head, it would be susceptible to floods and washouts. In addition, it is not clear as to the legality of installing private power generating equipment within the flood plain of the Rio Grande.

The other option is to take advantage of the head drop from the upper most point on the site, where the ditch first enters the property down to the elevation of the levee, which we estimate to be on the order of 6 meters (~20 feet). This option would require diverting the incoming ditch flow into a pipe and routing the water down to a generator located on or near the levee. This would have the advantage of generating a greater amount of power (~1 kW) than the previous option as well as reducing the seasonality of the flow, since the attenuation through the wetlands and other water features would be avoided. The disadvantage is that diversion of the water at the head end of the property would change the entire hydrological and ecological balance, drying out the wetlands and possibly impacting the sustainability of the water in the lakes.

For these reasons stated above, *we do not believe that micro-hydropower in any form is a viable power-generation option for this site.*

4.5 Tax Credits and Other Funding Sources

A review of available tax credits, net metering or grant programs potentially available to ByWater was completed to see what options are available for reducing the gross installed cost of both solar PV and wind systems. This analysis was not conducted for micro-hydropower due to its infeasibility at the site.

4.5.1 Jemez Mountain Electric Co-Op

The Jemez Mountain Electric Co-Op currently has a net metering program for PV systems at 10kW or under, paying around 8.138 cents/kWh plus the current fuel adjustment. Larger systems above 10kW in the service area currently do not qualify for the net metering program, based on a conversation with Virgil Coriz from the Co-op on November 16, 2012. However, the Co-op has been considering a program for larger PV systems, so this may become an option in the future.

4.5.2 State Tax Credit

A conversation on November 16, 2012 with Michael McDiarmid of New Mexico Energy Conservation and Management, which administers state tax credits and exemptions for renewable energy, revealed the following benefits available to New Mexico businesses interested in installing renewable generation facilities:

- Solar energy systems qualify for a gross receipts tax exemption under 7-9-112 NMSA 1978, however this does not apply to wind powered systems.
- The State of New Mexico offers a renewable energy production tax credit for wind at 1 cent/kWh, however no new credits will be available until 2017 when space is available for new participants. There is currently a waiting list that new applicants can join. For solar, the production tax credit is approximately 2.7 cents/kWh (average paid over 10 years), however that program is also closed to new applications with an anticipated opening date of 2020, and like the wind credit, there is a waiting list that new applicants can join.
- The New Mexico Environment Department offers an advanced energy tax credit, which is an up-front tax exemption of up to 6% of the capital cost of a project, however the system must be greater than 1MW, which is in the range of large commercial or utility-scale PV systems.
- The State of New Mexico offers a renewable energy income tax credit for both PV and solar hot water for taxpayers in New Mexico who own businesses and file New Mexico income tax returns. This program is offered until December 31, 2016 and allows up to 10% off of the system's price, capped at $9,000. Also, the business must be a sole proprietorship, or one that files federal taxes using a 1040 form.

Based on the information available above, it appears that the income tax credit and gross receipts tax exemption may be the only incentives available to ByWater for solar PV and hot water, though checking with solar and small wind installers in New Mexico would also be a good source of relevant and recent information. More detail on the incentives presented above can be found on the Clean Energy Incentives page at the Energy, Minerals and Natural Resources Department.[14]

4.5.3 Federal Tax Credits

There is a federal 30% Business Energy Investment Tax Credit (ITC) that can be used for solar PV and hot water, where the 30% is applied to expenditures. Passive solar and pool heating systems are not eligible. For wind, this tax credit is available for small wind with a nameplate capacity of 100 kW or less that is put into service before December 31, 2016.[15]

[14] http://www.emnrd.state.nm.us/ECMD/CleanEnergyTaxIncentives/cleanenergytaxincentives.html
[15] http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F&re=1&ee=1

4.5.4 USDA Loan Programs

A loan program that ByWater may qualify for is the Rural Energy for America Program (REAP). There is a Guaranteed Loan or Grant program, with a comparison between the terms available at their website.[16] Jesse Bope is the New Mexico contact for the USDA REAP funding and she mentioned that there is still money available in the program for New Mexico. She encourages ByWater to contact here to see if they can qualify. She can be contacted at 505-761-4952 or jesse.bope@nm.usda.gov.

4.5.5 Third-Party ownership/Power Purchase Agreement

There are other options potentially available to ByWater including third-party ownership of the PV System. In this model, ByWater does not have to put up a large amount of money to purchase the system. Instead, ByWater would lease the system from an owner/investor. This would include either 1) utilizing ByWater's tax liability to help finance the system (if large enough) or finding an equity investor that has significant tax liability that could potentially be used to finance the system. Contacting the larger solar installers in New Mexico may reveal some information on whether this model would work for ByWater.

4.6 Other Considerations

Some considerations that may not be readily apparent are the different environmental impacts from solar, which includes ground disturbance in the area where the panels will be installed. Glare from the panels could be an issue depending on the technology chosen as well as proximity to recreational areas at the property. For wind, environmental impacts include ground impacts as well as impacts to birds. This may be an area that needs further study due to the sites proximity to the wetlands.

4.7 Educational Opportunities

Regardless of whether or not different renewable energy sources are viable power-generating options, demonstration installations of each energy source could be used to support the sites educational goals of exposing both primary and secondary students to the pros and cons of the different energy sources, their benefits and impacts on the environment, and how they might be integrated into the larger grid. The examples would help promote the interest and importance of critical thinking when it comes to renewable and sustainable energy generation and allow the students to see real-life applications and how they are being used to off-set and enhance the parks' operations.

Done correctly, this would make the ByWater site unique in its ability to provide a set of real-world renewable energy demonstrations, which in addition to supporting their educational goals would also make the site more attractive for eco-tourism.

[16] http://www.rurdev.usda.gov/rbs/busp/9006_BI_Comparison_with_energy.doc

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