

UNEARTHING NEW JERSEY

NEW JERSEY GEOLOGICAL SURVEY
Department of Environmental Protection

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MESSAGE FROM THE STATE GEOLOGIST

This issue of **Unearthing New Jersey** continues the series of historic stories with Mark French's article *A Plan to Plunder New Jersey's Water*. This story concerns a plan by the Hudson County Water Company and its myriad political allies to divert an enormous portion of the water resources of New Jersey to the City of New York. The scheme was driven by the desire for private gain at the expense of the citizens of New Jersey. Thanks to the swift action of the Legislature, the State Attorney General, the State Geologist and the highest courts in the land, the Hudson County Water Company plot was stymied setting a riparian rights precedent in the process.

A second historic article, *The New York-New Jersey Line War* by Ted Pallis, Mike Girard and Walt Marzulli discusses the geographic boundaries of New Jersey. These have changed since the time of settlement and continue to remain in question in certain areas. The New York–New Jersey Line War was one of the first border disputes and refers to a series of skirmishes and raids that took place during more than half a century between the years 1701 and 1765 at the border between the pre-Revolutionary War Provinces of New Jersey and New York.

Larry Müller continues the historic articles on the mineralogy of copper deposits in New Jersey. This time he focuses on the Old Dutch Mine, near Pahaquarry, Warren County.

Finally, a more practical article is presented by Ian DuBois on *Solar Radiation*. It provides a mathematical model with which the amount of solar radiation reaching the surface of the Earth at any given point based on location, surface slope and time of year can be calculated. This information helps us understand the differences in weather we experience over the course of a year and can be used for agricultural purposes such as finding the most suitable locations for a variety of crops.

The Survey welcomes your [feedback](#) on the content or format of the newsletter. Other recent geologic activities and digital publications of the Survey are noted in the newsletter and elsewhere on the Survey's Web site. Printed maps and reports are available to the public through the DEP Maps and Publications Office (609) 777-1038, PO Box 402, Trenton, N.J. 08625-0402. Due to fiscal constraints, over-the-counter purchases are no longer available. Go to our [website](#) for more information. A [publications price list](#) is maintained on the Web. Unpublished information is provided at cost by writing the State Geologist's Office, N.J. Geological Survey, PO Box 427, Trenton, N.J. 08625-0427. Staff is available to answer your questions 8 a.m. - 5 p.m. Monday through Friday by calling (609) 292-1185.

Karl W. Muessig,
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A PLAN TO PLUNDER NEW JERSEY'S WATER

By Mark French

INTRODUCTION

At the turn of the 20th century, potable water in New Jersey was managed by private companies or municipalities through special grants from the State Legislature or certificates of incorporation granted by the State under the General Incorporation Law of 1875. Clamoring for oversight, the citizenry and the Legislature tried to create a State Water Commission in 1894, but the effort was quashed by water business interests and their friends in the Legislature. Companies were mostly free to traffic in water as they saw fit.



Figure 1. Bayonne, *bottom center on the peninsula*, and Jersey City, *center right*, are in Hudson County. The lands to the west of Newark Bay, including the city of Elizabeth, *lower left*, Newark, *left center*, and Belleville, *left top*, are in Essex County. Staten Island, Richmond County, NY, never more than 3/8 of a mile off the New Jersey shore, is shown, in part, *bottom center and left*. Detail of the Newark Bay area, excerpted from [Atlas Sheet No. 7](#), published by the New Jersey Geological Survey, 1890.

The rapid population growth of New York City and nearby Northeast New Jersey (fig. 1) created enormous opportunities for water companies. The cities in the area demanded more and better quality water as their populations grew. Some cities such as Newark and Jersey City took matters into their own hands, creating municipal water companies and purchasing land and water rights to the west. They built storage reservoirs and pipelines. Other cities either contracted with nearby municipalities or large private suppliers, like Hackensack Water and East Jersey Water Companies, to provide for their needs. Whether private or public, water companies were out to make as much money as possible for their cities, companies and, of course, shareholders.

Through his office, State Geologist John C. Smock attempted to monitor the water supply of the northeastern part of New Jersey. In 1894, *The Final Report of the State Geologist, Volume III*, by C. C. Vermeule, Consulting Engineer, was solely dedicated to water supply issues. Almost every annual report of the State Geologist contained at least a section on water supply, and the Survey office assisted many municipalities, and water companies in the matters of water supply. At the time when Henry B. Kümmel was State Geologist (1901-1937), the Survey had no authority to manage or regulate the water supply. Many within State government believed that should change, but there was no support in the Legislature to bring it about.

New York City's water needs were, for the most part, met without having to resort to importing water from across the Hudson in New Jersey. However, by the turn of the century, the growth of the city had almost outstripped its water companies' ability to provide freshwater for its citizens. The great city reservoirs in the Catskills had not yet been completed but, just across the narrow Kill-von-Kull lay the seemingly inexhaustible water resources of the New Jersey

watersheds. The Borough of Richmond (Staten Island), in particular required more water, so they began to cast about for additional supply and entertained bids from New Jersey Water companies to provide them with water.

Rumors of plans to divert water to New York City from New Jersey had circulated since Vice President Garret Hobart had been manager of the Passaic Water Company in the 1880's. But the rumors did not require immediate and decisive action until the Winter of 1904-1905. First, East Jersey Water Company, which owned water mains in the City of Bayonne, submitted an offer to supply Staten Island with water from its diversion at Little Falls on the Passaic River. The offer was the result of lengthy negotiations between the company and Colonel Robert Grier Monroe, a former Water Commissioner of New York City. The contract was ultimately rejected by Edward M. Grout (fig. 2), Comptroller of New York City, and George Cromwell (fig. 3), Borough of Richmond President.

Coincidentally, it was at this time, December of 1904, that the Richmond Water Company changed its name to the Hudson County Water Company. It received a certificate of incorporation from New Jersey in 1903 and, perhaps, the

name change was designed to mask the company's true purpose. Nonetheless, it quickly and quietly made contracts with East Jersey Water Company and New York and New Jersey Water Company to purchase water and transport it from Little Falls to Bayonne and from there, to Staten Island. Contracts were also entered into with the City of Bayonne to supplant the city's current supplier, Jersey City. East Jersey Water Company offered a discounted rate, new water facilities, tolls and rebates to

sweeten the deal with Bayonne. Their mains were also to be extended to the Bayonne waterfront on the Kill-von-Kull to be linked with the Hudson County Water Company extension under the waterway to Staten Island.

NEW CONTRACT

In March of 1905, Hudson County Water Company contracted with Greater New York City through the Borough of Richmond President Cromwell, to provide water for Staten Island. It was represented that Staten Island was in dire need of a more reliable water supply, at least until the New York's Catskill reservoirs were completed. The claims of an inadequate water supply for Staten Island were denied by the current water supplier for the Island, Crystal Water Company. But the president of the Hudson County Water Company, Turner A. Beale, replied that the contract made by a city official of such high character as that of Borough President Cromwell, was all the proof required for the need of extra water. So the contract was approved by City Controller Grout, with the endorsement of the Mayor of New York,



Figure 2. Edward M. Grout, Borough President of Brooklyn, New York (1898-1901) and Comptroller of the City of New York (1902-1905).



Figure 3. George Cromwell was President of Richmond Borough [Staten Island] (1898-1913).



NJGS

1835



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Figure 4. George B. McClellan, Jr. served as mayor of New York City (1904-1909).

the Honorable George B. McClellan (fig. 4), son of the Civil War general and former Governor of New Jersey.

Once this contract was made public, alarms were raised in New Jersey that the City of New York could, through the auspices of this now exposed contract with the well-connected and supported Hudson County Water Company, aided and abetted by the East Jersey Water Company, appropriate water from New Jersey with impunity!

It was feared by both the State and many of the cities of North Jersey, that New York City had designs on all of the watersheds of New Jersey for the purpose of creating vast reservoirs on Staten Island to supply all the boroughs of New York.

Appeals to the authorities in Bayonne to intervene were fruitless, as the city had been subsidized by large gifts of new and improved water service and facilities and the city was to receive free water for its fire hydrants and public buildings. Lastly, the water companies had agreed to pay Bayonne a toll of \$5 for every million gallons that passed through the city and under the Kill-von-Kull to Staten Island. Action by the State was demanded. The outgoing Governor, Franklin Murphy, sent a final message to the Legislature saying that the plan to furnish water to Staten Island would mean the destruction of the Passaic River. But the Legislature was not in session and the Governor had no authority to act. The water companies had worked so long and hard in secrecy that it seemed that only a short time would be necessary in order to complete the connections.



Figure 5. William H. Taft served as Secretary of War under President Theodore Roosevelt (1904-1908).

While the water company constructed mains, the State turned to the Federal authorities. The Kill-von-Kull, as an interstate waterway, fell under the jurisdiction of the Department of War. But, unbeknownst to the New Jersey authorities, Hudson County Water Company had already received approval to lay its new mains beneath the Kill-von-Kull and had also contracted with the War Department to provide water to the various fortifications on Staten Island. The water company, in response to the appeal to the Federal authorities, painted a grim picture of the possibility of the

brave soldiers dying of thirst if the new supply were blocked. The Secretary of War at the time, William H. Taft (fig. 5), denied any knowledge of the contracts or of the situation at hand and refused to act upon the matter without further information. To this end, and to placate the New Jersey state authorities, he sent a military delegation to investigate the situation. In the meantime, work on the water mains continued.

BACHELLER ACT

In the interim, The Newark Board of Trade met in a very crowded emergency session to discuss the situation. The facts were laid before the Committee on Navigation by the chairman of the Board, George W. Tompkins. Also in attendance was State Senator J. Henry Bacheller, who informed the assembly and the board that the Attorney General, Robert H. McCarter (fig.6), was drawing up an act

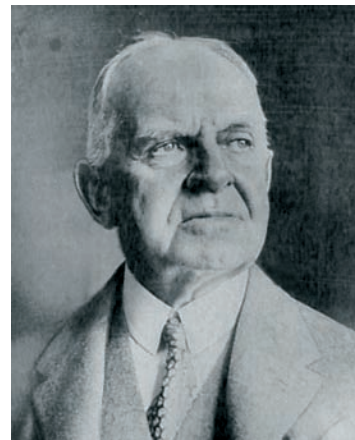


Figure 6. Attorney General Robert H. McCarter (1903-1908).

to forbid the exportation of potable surface water from the state. Senator Bacheller, subsequently introduced the act in the State Senate later that Spring of 1905. The act was held up in committee by Senator Harry S. Scovel of Camden County, a friend of Philadelphian Joseph P. Wharton, who wanted to obtain water for Philadelphia from New Jersey watersheds. Pressure from politicians of Northeastern New Jersey

cities, the press and the public finally forced the act out of committee. It was passed by both Houses of the Legislature on May 11, 1905 and was signed into law by Governor Edward C. Stokes (fig. 7) a short time thereafter. Hudson County Water Company, in defiance of the newly enacted legislation, continued its operations in preparation to provide water to the City of New York at Staten Island.

The act was written to preserve and maintain the surface water resources of the state and prevent these waters from being exported to other states. It empowered the State Geologist to maintain a general oversight to preserve and to protect these resources and prevent their exportation beyond the state's borders, through the Attorney General using injunctions issued by the N.J. Court of Chancery. So in July of 1905, based on facts provided to the State



Figure 7. Governor Edward C. Stokes (1905-1908).

Attorney General by Henry B. Kümmel, State Geologist, upon whom such regulatory status resides as conferred by the Bacheller Act, the water company was sued. An injunction was sought and granted to prevent the completion of the connection between Bayonne and Staten Island for the purpose of supplying surface water to the Borough of Richmond in the City of New York.

The Hudson County Water Company immediately began to fight back. It appealed the injunction to the N.J. Court of Errors and Appeals arguing that the Bacheller Act did not apply to them. They had four arguments, 1) that they had entered into the various contracts to deliver water to Staten Island before the act was passed; 2) that the act was void in its application to the company because it sought to impair the fulfillment of those contracts which were lawfully made before the passage of the statute; 3) because it violated the companies right to due process under the Fourteenth Amendment of the U.S. Constitution and the equal protection clause of the U.S. and N.J. Constitutions, and most importantly, 4) that it violated the interstate commerce clause under the U.S. Constitution.

As the arguments were made in court the water company seized upon a loophole in the law which appeared to exempt groundwater or subterranean waters from the regulation. In 1906, after amending its contract with the Borough of Richmond, it entered into negotiations to lease the Newark Water Company's unused well field in Belleville. The company and the city failed to come to terms, so the company purchased land adjacent to the well field and began to drill its own wells and install water mains in order to fulfill its newly amended contract. At the same time, it began to exert pressure on the State Legislature by having a bill introduced by Senator Edmund W. Wakelee of Bergen County to amend the Batcheller Act.

In support of this bill, the water company began exerting its surprisingly strong political influence. Letters of support, as requested by the water company, were sent by the mayor of New York City; the aforementioned George B. McClellan, the U.S. Secretary of War, W. H. Taft, and the U.S. Secretary of State, Elihu Root. Secretary Taft alluded to a special report he commissioned from the commanding officer of Fort Wadsworth on the lack of a sufficient water supply to meet the needs of the garrisons on Staten Island. All of these letters intimated that the Batcheller Act, as it was written, was injurious to the interests of the Borough of Richmond, the City of New York, and the U.S. Government. Former N.J. Supreme Court Justice Gilbert Collins, Richmond Borough President Cromwell, prominent political activist and lawyer Richard V. Lindabury and several other citizens and politicians were sent to Trenton to lobby for passage of the modification bill. However, in spite of all these efforts and thanks in part to an intolerant public sentiment and native stubbornness, the modification bill was defeated.

By November 1906, the Appeals Court had upheld the

injunction and ruled that Bacheller Act was constitutional, leaving the water company to continue to try and develop its wells at Bellville and carry on its legal battle by appealing the Bacheller Act to the U.S. Supreme Court. While it awaited the verdict, the company began a new line of attack. Under the pretext of the need to furnish the U.S. Government garrisons on Staten Island with sufficient water to meet their needs, the company urged the U.S. Government to override the sovereignty of New Jersey and seize the water for use by its military stationed on Staten Island. Secretary Taft was receptive to the idea. The New Jersey press was in an uproar, denouncing the idea as a usurpation of State's Rights and that the U.S. Government would hold New Jersey

in the grip of eminent domain as it drained the drinking water from her watersheds. Legislation was even introduced in the U.S. Congress in support of this idea.

This scheme was brought to an end after the 1907 election of Taft and his ascendance to the presidency in 1908. A new Secretary of War, Henry L. Stimson (fig. 8) was appointed, and a new Congressional delegation was sent to Washington from New Jersey. Secretary Stimson initiated a thorough inquiry and determined that the garrisons on Staten Island had all the water that they needed. He also unearthed a contract, as mentioned before, that his predecessor had made with the water company. This he peremptorily revoked. After this, the Congressional legislation, which no longer had any basis upon which to rest, was quietly killed.

Then in 1908, the U.S. Supreme court handed down its verdict in the Hudson County Water Company v. McCarter appeal. It ruled that the Bacheller Act was constitutional upon the grounds that the State possesses the sovereign right to preserve, protect and regulate the freshwater resources within its boundaries. This paved the way for creation of a State Water Commission as countenanced by the 1907 Report from the Potable Water Commission, appointed and guided by N.J. State Geologist Kümmel. The history of New Jersey's authority to regulate water supply can be traced beginning with the Bacheller Act, through the 1907 report and the first State Water Commission. It continued with the Department of Conservation and Economic Development and finally, the Department of Environmental Protection where it resides today.

The Bacheller Act, however, failed to expressly prohibit the extraction and sale of subterranean waters to interests outside the state. Consequently, to protect their Belleville well field, the company turned again to the State Legislature in 1910 and lobbied for a bill to legalize the loophole. Meanwhile, public outcry continued over efforts of the water company to divert subterranean waters to Staten Island. This was seen as a way to circumvent the Act by subterfuge, and that there would not be subterranean water but only surface water actually diverted via their Belleville water works. The



Figure 8. Henry L. Stimson was appointed U.S. Attorney for the Southern District of New York (1906-1909) by President Theodore Roosevelt. In this position he became known for successfully prosecuting antitrust cases.

City of Bayonne sued the Borough of North Arlington in 1909 for denying a permit to the New York and New Jersey Water Company to lay water pipes across two of its byways, resulting in an injunction permitting the pipe laying. This work was under contract with the Hudson County Water Company in order to connect its waterworks at their Belleville well field with water mains under Bayonne and thence under the Kill-von-Kull to Staten Island and the Borough of Richmond.

PLUGGING THE LOOPHOLE

To plug this loophole, a competing bill was introduced in the State Assembly by Thomas F. McCran of Passaic at the urging of then Governor J. Franklin Fort (fig. 9). Although the legislation passed through the Assembly, it was buried in a Senate committee. The water company had again used formidable political influence to stall the bill until the end of the legislative session. It reminded Senators of the past support of former Secretary of War, now President Taft, and the former Secretary of State Root. Reports about the water famine now occurring on Staten Island were supplied along with a new letter from the Mayor of New York, G. B. McClellan.

Nearing the end of the 1910 term, Governor Fort had exhausted his personal appeals. In frustration, he sent a

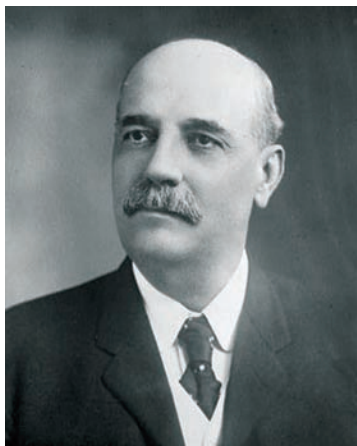


Figure 9. New Jersey Governor John Franklin Fort (1908-1911).

vitriolic public letter to the Senate, urging the release of the McCran legislation from committee and swift passage of the act. He vilified the Hudson County Water Company, calling them, outlaws against the laws of the State and not deserving of any consideration by the State. He stated that any injury to the companies bondholders was to be laid at the feet of the water company and not New Jersey. Governor Fort also said that he would

veto any bill which legitimized the transport of subterranean waters outside the state thus ensuring that the company could not continue its scheme to provide water from New Jersey to Borough of Richmond and, perhaps, ultimately to other parts of New York City. This public appeal succeeded in getting the McCran Act out of committee, passed without amendment, and signed into law. Finally, the Hudson County Water Company, was stopped. With its main, and apparently only reason for existence, now eliminated, faded into bankruptcy.

At the end of his fiery letter to the State Senate, Governor Fort said that a need for New Jersey's water in Staten Island did not exist. He said that the whole scheme was planned within the City of New York, aided and abetted by the City of Bayonne, the East Jersey and New York and New Jersey Water Companies, for private gain at the expense of the people of New Jersey. In his view, Hudson County Water Company was a grasping private corporation which through

long and expensive litigation has defied the rights of the State.

The Hudson County Water Company acted with such total disregard for the sovereign rights of the State that it can be implied that it was supported in its efforts by some very well connected benefactors who were willing and able to sustain the company through its long legal battles with the State of New Jersey. The political influence that it demonstrated again and again, seems far beyond its limited size and holdings. It can be intimated that it was, as per Governor Fort's statements, an agent of the City of New York and as such could rely on the support of such dignitaries as William H. Taft, as Secretary of War and President, Elihu Root (fig.10), Secretary of State, many dignitaries of both New York and New Jersey such as former state Supreme Court justices, former Attorneys General, state political consultants, the President of the Borough of Richmond, the Comptroller of New York, and of course the Mayor of New York City. All of these men had their own political connections and would, of course, call upon their allies to support this endeavor. Perhaps, they even had a stake in the future profits, which, no doubt, would have been vast. New York City was growing fast; to provide a proven, reliable and readily available supply of freshwater from the New Jersey watersheds was not an opportunity to pass up.

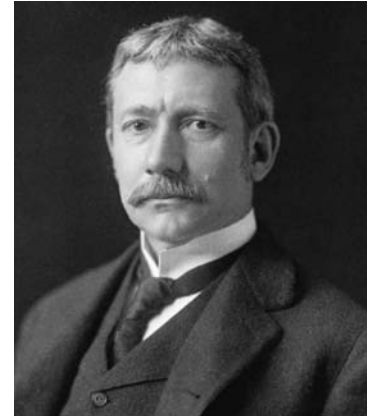


Figure 10. Elihu Root was Secretary of State under President Theodore Roosevelt (1905-1909).

Fortunately, the people and government of New Jersey were able to fend off this effort to expropriate its valued natural resource. New Jerseyans were always leery of the influence of the great city. With stubborn, unrelenting effort, they successfully fought the water company and its benefactors. The decision of the U.S. Supreme Court in *Hudson County Water Company v. McCarter* (1908) set riparian rights precedents that echo to this day. The case is still cited in many riparian rights legal conflicts. It is regularly examined and discussed in many hydrology courses and law schools. Importantly, it provided the basis upon which New Jersey has built its right to regulate its water supplies. And from the beginning it has been both guided and aided by the New Jersey Geological Survey.

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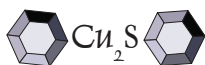
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violence that took place between 1701 and 1765 over the disputed border between New York and New Jersey north of the current northern border (fig. 1). It was one of the largest border disputes during the early years of the American colonies. Eagers' *History of Orange County, New York* reports a "ferocious conflict between the white settlers of New Jersey and New York, dating back to 1701, as a disputed boundary line claimed by both New York and New Jersey ran right through the 1200 acre patent! Boundary conflicts continued for the next 65 years and were a constant source of contention" (Eagers and Eastabrook, 1847).

Border wars were common in the early days of settlement of the American colonies. The reasons why are illustrated by the example that Connecticut claimed a swath of land from its western boundary to the Mississippi River. Because of New Jersey's border dispute with New York, New Jersey was without a settled northern boundary until 1772. The dispute about the boundary and the respective claims under New York and New Jersey patents involved the right to a large strip of land, approximately 200,000 acres, which was in the northern part of New Jersey but was awarded to New York in the final settlement in 1774 (Snell, 1881).

According to Snell's history of Sussex and Warren Counties, New Jersey, "There probably never would have been any very serious difficulty about the boundary line had not certain patentees of the Minisink and Wawayanda patents been disposed to stretch their claims over a portion of Northwestern New Jersey, and to regard them as "floating patents," to be located according to the will or fancy of the holders. This greed to extend their patents over a part of New Jersey and to appropriate the lands of neighboring settlers led, first, to serious contentions, resulting frequently in open violence between the two sections upon the borders of the territory in question, and, secondly, to a befogging of the boundary line between the provinces, which was originally clear and well defined" (Snell, 1881).

The original boundary between New York and New Jersey extended from the west side of the Hudson River at Station Rock at Orangetown, Rockland County, NY and



THE NEW YORK-NEW JERSEY LINE WAR

By Ted Pallis, Mike Girard and Walt Marzulli

The New York–New Jersey Line War, also known as the New Jersey Line War, refers to the occasional

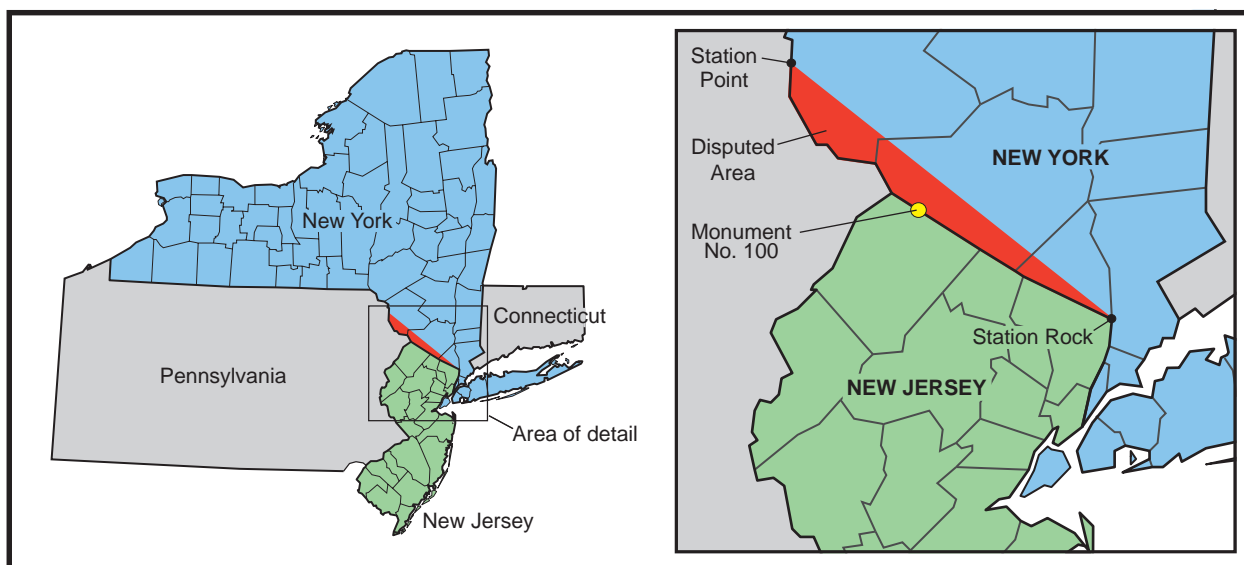


Figure 1. Regional view of disputed area, left, and detail, right, showing locations of Monument No. 100, Station Rock and Station Point. Cartography by Z. Allen-Lafayette



Figure 2. New York State historic marker. Photo by J. Curran.

Alpine, Bergen County, NJ, in a direct line to the Delaware River, at a point on the river at latitude, 41° 40' N, near Cohecton, or Station Point, New York. This point was fixed as the true termination of the boundary line on the Delaware by royal commissioners and by the surveyors-general of both provinces, in pursuance of a joint act of the two legislatures, in 1719, and the "Tripartite Deed" (Snyder, 1969). An earlier 1664 grant from the Duke of York to John, Lord Berkeley and Sir George Carteret also established this claim line (Snyder, 1969).

However, the northbound extension of New Jersey was not respected by settlers from New York who moved westward from Orange County determined to maintain their land claims (fig. 2). The resulting raids and skirmishes were carried out by settlers from both sides with retaliation and general border warfare. (Stickney, 1867).

The last fight broke out in 1765, when the Jerseyans attempted to capture the leaders of the New York faction during a church service. Because the fight took place on the Sabbath, neither side used weapons, only their fists. The New York leaders were captured and kept briefly in the Jersey Colony prison, also known as the Sussex County Jail. (Stickney, 1867).

The conflict was eventually settled by the King of Britain through the royal commission of 1769. He appointed commissioners to establish what would become the permanent and final border between New York and New Jersey that runs southeast from the confluence of the Delaware and Neversink Rivers near Port Jervis to the Hudson River at Station Rock. The commissioners decision was a compromise because New York claimed land south into New Jersey. The New Jersey Commissioners did not like the compromise, but they agreed to it. The King approved it on September 1, 1773 and a survey of the new border was completed in 1774. (Snyder 1968).

Though the New York-New Jersey border dispute was

settled well over two hundred years ago, the New Jersey Geological Survey (NJGS) has been actively involved in surveying the current border with New York since 1872. The NJGS survey crew maintains the state's boundary with New York, as required in a 1954 statute. NJSA 52:29-2 declares that all state monuments be recovered (i.e. located, inspected, re-described, and repaired when necessary) every 3 years. In years past, this was done with a compass and measuring tape from descriptions dating back to the original survey of 1774. These descriptions are updated throughout the years as the monuments are recovered. In today's recoveries, the Global Positioning System (GPS) is used. This system receives triangulated satellite signals to pin-point the location to under one meter of accuracy. As these GPS points are collected, they are added to a digital coverage of the New Jersey state boundary. By the end of 2009, all of the border monuments will have been located using the GPS. This digital coverage will be added to a compilation of datasets

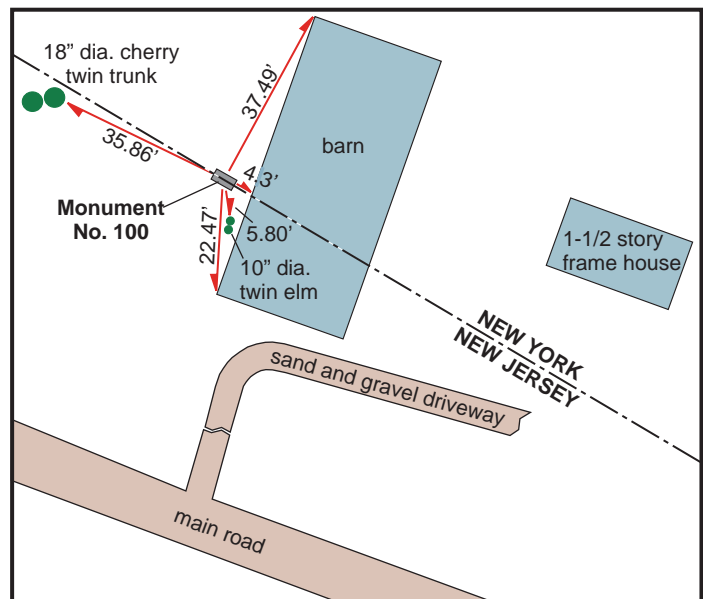


Figure 3. Survey map of Monument No. 100 site. Map by W. Marzulli.



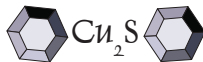
Figure 4. Photograph of Monument No. 100. Photo by J. Rich.

within the New Jersey Geographic Information Network, which will be available for download by the public for overlay with many types of geographic information.

The NJGS has documented the monument recovery process during the last twenty years. Monument No. 100 is an interesting example and can be seen in figures 3 and 4. These figures depict the boundary between New York and New Jersey which runs through the middle of a barn.

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OLD DUTCH MINE

By F. L. Müller

There is an old saying that when a new territory opens, first come the scouts and explorers, then the prospectors and trappers, and finally farmers and traders. Prospectors played an instrumental role in the exploration and development of New Jersey. One of the first resources they sought was copper because of its many useful properties.

It was once thought that the first miners of copper in New Jersey on the Delaware River were Native Americans. However, Herb Kraft, an eminent New Jersey archeologist who has had Native copper artifacts analyzed, reports that spectroscopic, X-ray diffraction, and other tests show that the copper came from sources outside of New Jersey (Kraft, 1996, 22-23). Articles were from the Rozencrans Site on the Wallpack Bend of the Delaware River near the Pahaquarry Mine. Donald N. Wemple Jr., who did the analysis at the General Electric Materials and Processes Laboratory at Syracuse, New York, states "There is no question that the source of the copper was the Michigan mines, as there was no percentage of Pb (lead) or Au (gold) as is found in the copper ore from other mines" (Kraft, 42). As the copper ore at Pahaquarry is chalcocite (Cu₂S) and not in its native form, it would have been impossible for New Jersey Native Americans to extract the copper needed to produce the artifacts associated with them.

Traditions and legends die slowly before the scholarship of careful research. Thus the legend of the Pahaquarry, "Old Dutch", Mines on the Delaware River near the water gap (fig. 1) in Warren County is being revised by the painstaking work of historians and archeologists (Burns Chavez and Clemensen 1995; Kraft, 1996). The mines at Pahaquarry

are found in the gray layer of the red and gray strata of the Bloomsburg Red Beds (High Falls Shale of previous usage) (Drake et al. 1996). The primary ore is the gray-black mineral chalcocite (Cu₂S) with secondary minerals malachite [Cu₂CO₃(OH)₂] and chrysocolla [Cu₂H₂Si₂O₅(OH)₄·nH₂O]. The chalcocite is finely disseminated in the sandstone. The extent and thickness of the ore-bearing strata is thought to be great. Woodward (1944, 135) reports that 100 samples of the gray sandstone were assayed and "yielded an average of 3.25 percent copper in the form of chalcocite". The bright blue and green of the secondary minerals likely pointed the way to the primary ore. The origin of the ore is not clear. "It is believed that the disseminated copper of the Pahaquarry deposit is assuredly epigenetic (near surface) in origin, being concentrated by meteoric (weather related) solutions that leached the metal from minute grains of chalcopyrite previously scattered through the sandstone in detrital form. As the copper minerals are all supergene (formed by descending waters), there is no reason to anticipate richer deposits or for that matter any copper minerals at greater depth" (Woodward 1944, 136-137). The controversy over the early mining by the Dutch looms large: "No documented evidence has been found to confirm the legend that the Dutch operated the Pahaquarry copper mines in the 1650's or constructed a 104 mile road from that location to the village of Esopus on the Hudson River" (Burns Chavez and Clemensen 1995, 32). Arguing against this is the nature of the ore, hostile relations with the Native Americans, the technology of the excavation, refining, and transporting issues (the Dutch had no smelters in what they named New Netherland).

The first historic references of the mine at Pahaquarry are found in the 1750's; they are the John Reading ventures in an area around Mine Brook. Reading, in concert with several partners, constructed buildings, a stamp mill, two dams to provide water power for the mill, and excavated a number of adits, pits and shafts. When the ventures proved to be unprofitable, the activity ceased by 1760 (Burns Chavez and Clemensen 1995, 32).



Figure 1. The remains of the Pahaquarry Mine: mine tailings, foreground, and, left, what the miners called "elephant back" (the top of a very hard layer), Mine Brook, Warren County. Photo by W. Marzulli.

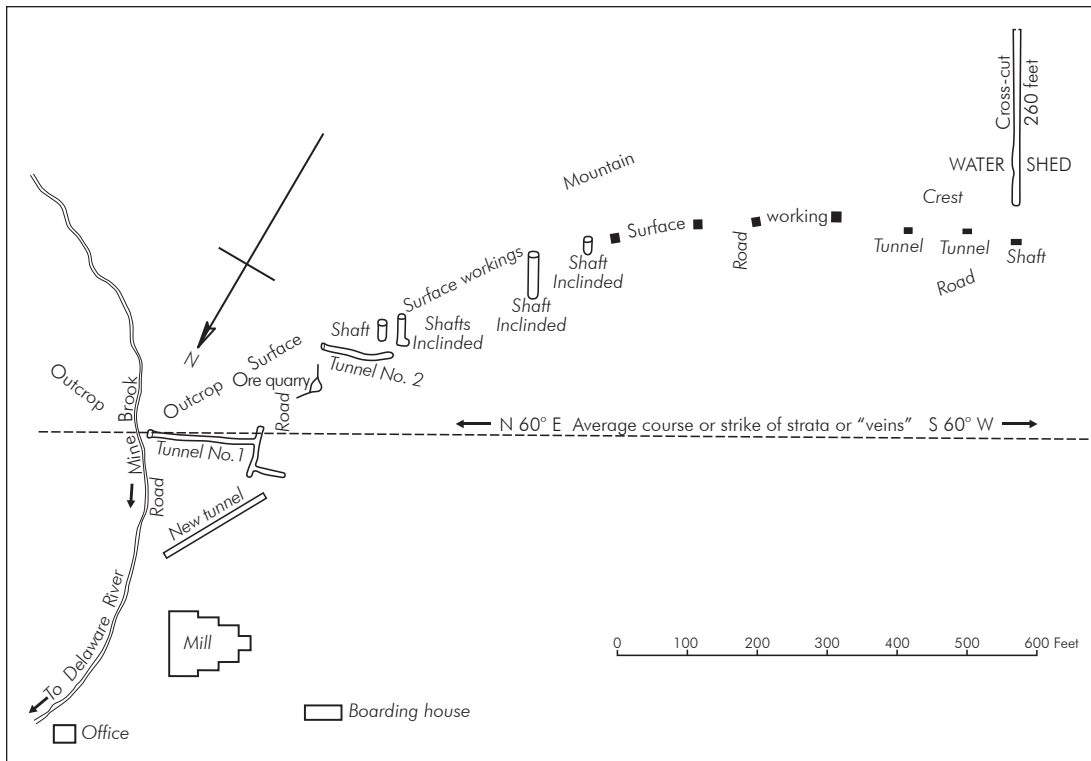


Figure 2. Sketch map of the Pahaquarry Mine area made during the last period of mining showing surface and sub-surface areas. Drawing after a sketch by William Lee Phye (Woodward, 1944, 126).

The Reading grandchildren and associates attempted mining at Pahaquarry between 1828-1834, but little was accomplished because the ore was too lean. Reading and Gordon, a half interest partner, began selling off the property in 1834.

Interest in copper was rekindled by discoveries of this ore in Michigan during the 1840's. The Alleghany Company was formed in 1847 and was made up of property owners of acreage adjacent to the old Pahaquarry workings and other investors. Few improvements in mining technology, with the exception of a Bickford Safety Fuse (for blasting) and harder steel for the rock drills, had been made since the eighteenth century. Although stock in the operation continued to be sold until 1848, the prospecting and mining largely ceased by then.

The Civil War brought about a rise in the price of copper and the company reorganized in 1862. More capital was raised and property purchased which included the adits, shafts, and pits of previous endeavors. They cleared and extended the earlier workings, but the low grade of ore caused this operation to cease that same year, and the land was sold in 1867. They did, however, retain the mineral rights. In 1868 the New Jersey State Geologist, George Cook said, after visiting the mine, that the quality of the ore did not support more investment in the Pahaquarry mine (Burns Chavez and Clemensen 1995). Nevertheless, at the turn of the century an effort was made to develop the mine. Even with the improvement of technology (mechanical drills and dynamite) and the rise in the price of copper, the ore extracted, approximately 100 tons, was of low grade and would not cover the cost of transportation for further processing. The company failed, and the court ordered the

sale of the property and mineral rights in 1902.

In that year, the Montgomery Gold Leaf Company bought the property. The new owner cleared the workings and constructed buildings which included an ice house, a smithy with boiler, a barn, an office building and a lab (fig. 2). A new dam was constructed for water, and new adits were drilled and an old one extended. This was made easier and safer because power drills were now used, and dynamite was exploded electronically. However, the yield was still only low grade ore.

When a new process for this type of ore was developed by Dr. N. S. Kieth, they decided to try

it, and the company was reorganized under the name of the Pahaquarry Copper Company in 1904. A new mill was built to contain Kieth's machinery that would concentrate the copper ore. Finely ground ore was produced and mixed with coal. This mix went to a furnace where copper droplets and rock were produced through a condensing process. The expanded mining required new construction, but Dr. Kieth's method did not work. In 1909-1910 the mill was remodeled to adopt a froth floatation method of separating the copper. This method also failed to produce a profitable concentrate—the chalcocite delivered approximately two percent copper. Finding that a percentage of the copper went down the mill race to the river, the Deshlers tried yet another method using roasting and a chemical leaching that produced a copper cement. But this did not produce sufficient copper to send to the smelter (Ibid). For all of this effort, only a few copper ingots were actually produced. Following litigation and bankruptcy the company and its holdings were sold to Dr. H. H. Wolford who resold it to the Deshlers. They altered the site again, but this time with equipment for a saw mill and barrel making operation. Again the new owners ran into financial difficulties. Ultimately the mining equipment was sold for scrap and the land went to the Boy Scouts of America. The scouts of the Trenton Area Council held the property and ran a summer camp at Pahaquarry until the area became part of the Delaware Water Gap National Recreation Area in the 1960's – 1970's.

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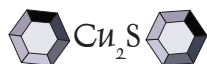
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DERIVATION OF EQUATION GOVERNING THE AREA OF SOLAR RADIATION ON THE EARTH SURFACE AS A FUNCTION OF TIME AND SLOPE

By Ian J. du Bois

INTRODUCTION

Most people have noticed how the Sun appears to move against the horizon through the course of a year. While this may seem unimportant, it is in fact the only reason that we have seasons, and a large factor contributing to Earth's weather. Remembering basic geography and climate, warm places in the world are near the equator, while the cooler places are found nearer the poles. This is because of the apparent movement of the Sun. As it travels higher in the sky, the amount of sunlight hitting the surface of our planet increases per unit area. The equator receives a large amount of surface heating because of this, while the polar regions receive substantially less.

The surface of the Earth heats unevenly, and because of this, atmospheric currents are created. In turn, this leads to weather patterns, or at least a good portion of them. It is these patterns that are of interest in global warming and climate change theories. Understanding the heating of Earth's surface by the Sun helps us better grasp the intricacies of this process.

The Earth is tilted as it orbits the Sun, and this is what leads to our daily weather, the seasons, and most other cycles on Earth. The tilt determines the amount of solar radiation that reaches the planet from location to location, based on the latitude and point of interest. Taking slope into consideration, the amount of radiation that a point receives at noon is calculated by using basic trigonometry. This article explains how to derive the radiation at a point, and illustrates the seasonal change that occurs in a graphical form.

MATHEMATICAL METHOD

The Earth is tilted 23.5° from perpendicular to the ecliptic plane. The ecliptic plane is the apparent path the sun

makes through the sky during the course of a year. With this knowledge, the solar radiation at a point can be determined. It is important to note, that the declination of the Sun (angle above the horizon) is given by $90 - \theta$ where θ is the latitude of the point of interest on Earth. This value is the declination of the sun at either the autumnal or vernal equinox, here called the base declination. Equation (1) shows the way to find the amount of solar radiation at a point.

$$S = a \cos(\beta) \quad (1)$$

Where S is the solar radiation at the source because the Earth is tilted 23.5° toward the Sun. This is the simple explanation why there are higher temperatures in the summer compared to the winter. And it is why the northern summer happens during the southern winter. To find the declination at the winter solstice, simply subtract 23.5° from the base autumnal equinox declination. This gives you the lowest point the Sun will appear in the sky.

In order to cover all of the declinations that the Sun will travel through at a given latitude, we must convert the change to one using the following sine curve:

$$\gamma = 23.5 \sin\left(\frac{360}{365.25}t\right) \quad (2)$$

In these two equations, γ is the value calculated, point a is the incident area of radiation, and β is the angle of incident on the surface from the surface to a perpendicular. Equation (1) is simpler because there is no time dependence or variation in the slope of the surface included. To compensate for this, the change in the Sun's declination with respect to time must be addressed. At the summer solstice, the sun is at the highest point in the sky at noon. It's declination is found by first looking at the base declination of the point, and then adding 23.5° to the value. This is the period of the sine curve. It is left in its fractional form to be more exact than a decimal value would be. The day value used for the calculation is t , the number of days after the autumnal equinox (the first day of fall). Equation (2) provides the value added to the base declination and yields the actual declination of the sun at the point.

Equations that give solar radiation at a point, and a time dependent equation to find the declination of the sun are now in hand. Equation (1) must be adjusted to incorporate the slope of the point of interest. This is simpler than it seems at first glance. Earlier, Equation (1) defined β as the incident angle. By adding a slope value to the surface, we are simply making β either greater or less than a flat surface. Mathematically expressed:

$$\beta = \gamma + \text{base declination} + \text{surface slope} \quad (3)$$

By setting the coordinate system in such a way that toward the noon sun is 0° (due South) and increase our values counter-clock wise for our slope, on an east-west axis, then a negative slope will increase the amount of radiation received per unit area. A positive value will reduce the amount of radiation.

NUMERICAL MODEL

Once the empirical formulas were derived, the next step was to create a model. By selecting constraints such as latitude values, incident ray area, and slope we are able to create a graph showing the resulting area of radiation on the surface. Figure 1 shows a graph for an incident ray of 1m², a slope of 0°, and located at a latitude of 40° north. The first point is at the Autumnal equinox. As is evident, the radiation begins to occupy more area as time moves forward. This

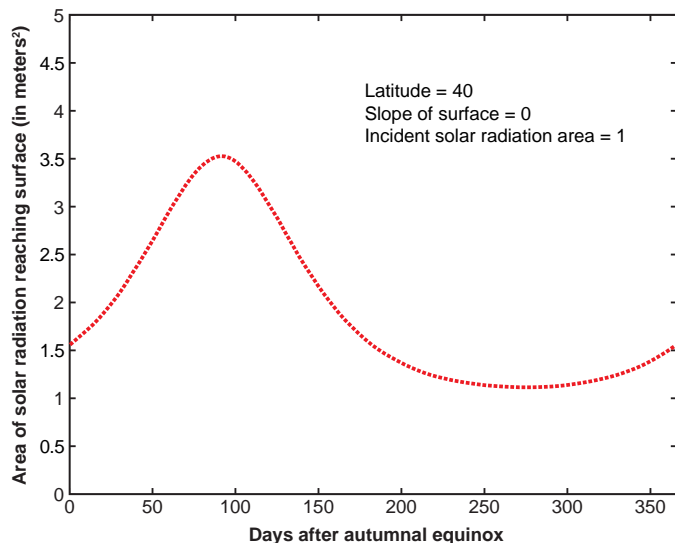


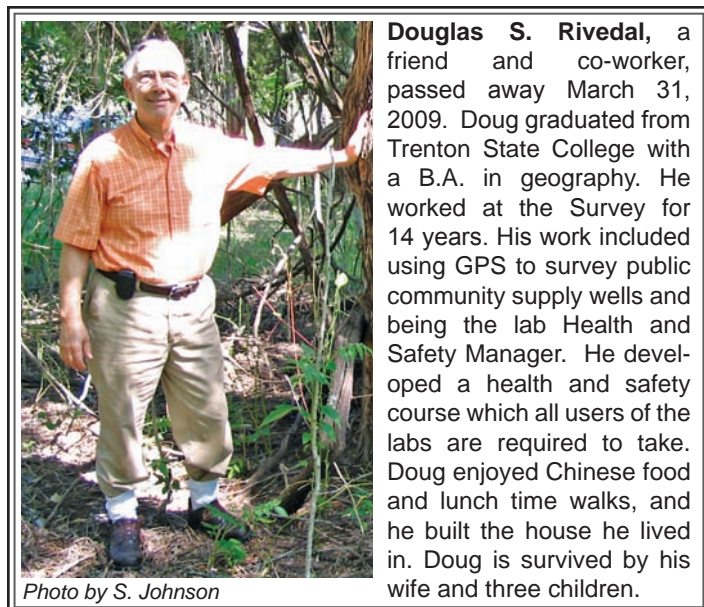
Figure 1. Incident ray graph with a slope of 0° and a latitude of 40° north.

means that less energy is reaching the surface per square meter than during the summer. As summer approaches, the limit nears 1 meter but does not actually become 1 meter. It is slightly more. The only areas of the world that experience a 1 meter to 1 meter exposure are located between the Tropic of Capricorn and Tropic of Cancer (These seemingly arbitrary lines are located at 23.5° North and South). The next step in the evolution of this model is to implement it over the entire state of New Jersey. This is done by applying the equations to a grid of the state. Each point will be placed on the grid based on the latitude and longitude. The longitude is only used as a spacial limiting factor. Each grid point will also contain a slope. This will give values for radiation area at each point based on the time of year. The values will then be contoured to create a map of the state. Values less than 1m will be omitted as physically impossible, though mathematically possible. North facing slopes will not receive very much light, but this is already taken into account by taking due south as 0° for the slope value and a counter-clockwise rotation being positive, as viewed along the east-west intercept.



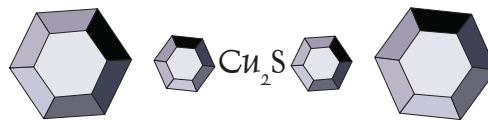
The most exciting phrase to hear in science, the one that heralds new discoveries, is not "Eureka!" but "That's funny..."

Isaac Asimov (1920-1992), scientist



Douglas S. Rivedal, a friend and co-worker, passed away March 31, 2009. Doug graduated from Trenton State College with a B.A. in geography. He worked at the Survey for 14 years. His work included using GPS to survey public community supply wells and being the lab Health and Safety Manager. He developed a health and safety course which all users of the labs are required to take. Doug enjoyed Chinese food and lunch time walks, and he built the house he lived in. Doug is survived by his wife and three children.

Photo by S. Johnson



NEW PUBLICATIONS

OPEN-FILE REPORTS (OFR)

NEW REPORT. [OFR 08-1](#), Ground Water Recharge in the New Jersey Highlands, Hoffman, Jeffrey L. and Mark A French, 2008, 10 p., 11 illus., 2 tables. \$5.00.

DIGITAL GEODATA SERIES (DGS)

NEW DATA. [DGS 09-1](#), Reservoir Storage and Related Diversions in the Passaic and Hackensack River Basins, 1898 to 2007.

NEW GIS DATA. [DGS 09-2](#), Coastal Plain Sediments with Potential to Form Acid (Sulfate) Soils.

GEOLOGIC MAP SERIES (GMS)

NEW MAP. [GMS 08-2](#), Surficial Geologic Map of the Branchville Quadrangle, Sussex County, New Jersey, Witte, Ron W., 2008, 2 plates size 40x52; 39x51, 3 cross-sections, 3 tables and 5 figures. \$20.00.

OPEN-FILE MAPS (OFM)

NEW MAP. [OFM 75](#), Bedrock Geology of the Salem and Delaware City Quadrangles, Salem County, New Jersey, Stanford, Scott D. and Sugarman, Peter J., 2009, scale 1 to 24,000, size 36x48, 2 cross-sections. \$10.00.

NEW MAP. [OFM 76](#), Surficial Geology of the Salem and Delaware City Quadrangles, Salem County, New Jersey, Stanford, Scott D., 2009, scale 1 to 24,000, size 36x49, 2 cross-sections. \$10.00.

DINOSAUR DAY AT THE NEWARK MUSEUM

By Helen L.L. Rancan

On Saturday, April 25, 2009, Survey Geologist Steve Johnson and Environmental Engineer Helen Rancan presented at the second annual "Dinosaur Day" at the Newark Museum. The free event included hands-on activities (fig. 1), inquiry-based workshops, demonstrations and activities in the geosciences for adults and children of all ages. Activities and displays included fossils on loan from the State Museum (visitors could make rubbings), a map of the bedrock of northern New Jersey, fossil specimens, a homemade dinosaur quilt, handouts of DEP's earth science information, rock and soil samples from around the state, a dinosaur computer game on loan from the Maryland Science Center



Figure 1. Dinosaur Day participant making a chalk rubbing of a fossilized dinosaur footprint. Photo by S. Johnson.



Figure 2. Helen Rancan, NJGS Engineer, referees a bean bag toss game that encouraged participants to throw an "asteroid" at the dinosaurs. Those who successfully "beaned" a dinosaur won a sticker. Photo by S. Johnson.

and a homemade bean bag toss called "Throw an Asteroid at the Dinosaurs" (fig. 2). At the bean bag toss children received dinosaur stickers. Other DEP information was also presented. In 2008, this event attracted 5,200 visitors to the museum. Because this year's Dinosaur Day was scheduled during the 100 year anniversary celebration of the museum itself, over 8,200 attended this one day event.



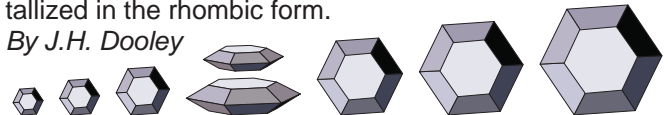
State Line Monument, located at the top of the Palisades, in Palisades Interstate Park, memorializes the eastern terminus of the New York-New Jersey boundary at Orangetown, Rockland County, NY and Alpine Boro, Bergen County, NJ. It lies 488 feet west of Station Rock which is located at the base of the Palisades on the west shore of the Hudson River. See "The New York-New Jersey Line War," page 6, for more information about Station Rock and the New York-New Jersey border disputes. Photo by Z. Allen-Lafayette



Earth Science Week (ESW) is October 11-17, 2009. This year's theme is **Understanding Climate**. Check out the [ESW website](#) for events and to order an ESW toolkit.

Chalcocite -- An important copper ore, chalcocite has been mined for centuries. It's high copper content (~80% by weight) and the relative ease at which copper can be separated from sulfur makes chalcocite a desirable and profitable commodity. Chalcocite is opaque and appears as black, blue black or gray with a metallic lustre. The chalcocite occurring in New Jersey most commonly crystallized in the rhombic form.

By J.H. Dooley



CROSSWORD ADITS



Pahaquarry Mine. The lower adit of this abandoned mine is gated to prevent hikers and mine enthusiasts, who might underestimate the danger of these old tunnels, from seeking entrance. *Photo by W. Marzulli*

ACROSS

1. Plane made by the Earth's orbit around the sun
4. Caused by rain wind or other atmospheric forces
10. Trick used to conceal, escape or evade
13. Suitable for drinking
15. Celestial body in orbit around the sun
16. Court writ
17. Copper carbonate
19. Edge
20. Jersey City neighbor

DOWN

2. Take as the rightful owner
3. Contend over
4. Institution devoted to procuring and displaying objects of lasting interest and value
5. Sun appears directly overhead at the equator
6. Underground
7. Material excavated from the earth for economic purposes
8. Latitude measurement of celestial bodies
9. Copper sulfide
10. Near vertical hole
11. Court of equity
12. Explosive
14. Horizontal tunnel
18. Copper

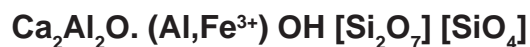


CORRECTION

In the last edition of **Unearthing New Jersey** we stated that the Trenton Water Power Canal was built by the Trenton Water Power Company (TWPC) in the early 1830's. The builder was actually the Trenton Delaware Falls Company (TDFC). In the mid-1840s, after TDFC went bankrupt, TWPC took over control of the canal.

LET'S PLAY: GUESS THE MINERAL

Here it is:



If you think you know this mineral, send your answer to:
njgsweb@dep.state.nj.us

The **New Jersey State Museum** is currently hosting **Rising Tide: Climate Change and New Jersey**, through January 23, 2010. The exhibit discusses global warming, sea level change, greenhouse gases, and the history of climate change in New Jersey extending back into the Pleistocene.



It is the tension between creativity and skepticism that has produced the stunning and unexpected findings of science.

Carl Sagan (1934-1996), astronomer

CROSSWORD PUZZLE ANSWERS. Across: (1) ecliptic, (4) meteoric, (10) subterfuge, (13) potable, (15) asteroid, (16) injunction, (17) malachite, (19) border, (20) Bayonne. **Down:** (2) claim, (3) dispute, (4) museum, (5) equinox, (6) subterranean, (7) ore, (8) declination, (9) chalcocite, (10) shaft, (11) chancery, (12) dynamite, (14) adit, (18) Cu.