

## **New Brunswick Strategic Planning Proposal**

### **BINDING THE RUTGERS NEW BRUNSWICK UNDERGRADUATE COMMUNITY THROUGH THE RARITAN RIVER INITIATIVE**

**Proposal Initiator:**

Oscar Schofield

**Primary Contact Name and Phone Number:**

Oscar Schofield, 1-848-932-3265

**Primary Contact Email Address:**

oscar@marine.rutgers.edu

**Primary Strategic Priority/Foundational Element/Integrating Theme Addressed**

Transform the Student Experience

**Proposal Abstract**

For Rutgers students the Raritan River is a problem, a physical barrier separating campuses experienced primarily through the windows of a bus. We propose to transform the Raritan Basin into an academic solution, an interactive field laboratory that enhances the student experience by linking science, engineering, and humanities programs through interdisciplinary classes, projects and activities that take place not only on the banks of but actually on and in the Old Raritan and its tributaries.

This will be accomplished by developing a physical, cyber and social infrastructure that will put students and faculty on and in the river in boats and autonomous vehicles, enable them to collect and analyze physical, chemical, biological and other data about the river basin, and enable them to easily share these data with others. Although this infrastructure will initially emphasize scientific exploration of the physical and biological riverine ecosystem, once built, it will equally support field experiences relevant for the social sciences and humanities: investigation of the social or historical role of the Raritan for NJ and the region could then include direct experience of the river.

Our University team proposes to: 1) develop a permanent presence on the Raritan by leveraging existing partnerships between Rutgers athletics and marine sciences; 2) outfit this Raritan presence with an extensive pool of open access instruments and the cyber infrastructure to use them effectively; 3) develop a social, open curriculum and virtual portal to support use of the river across the entire Rutgers New Brunswick community.

***Why the Raritan Initiative?*** Studies show that students gain disciplinary knowledge when engaged in trying to solve meaningful problems rather than just historically reviewing synthetic efforts in the classroom. This has often been illustrated in science education which is most effective when students engage in research by using instruments to collect and analyze data, develop models to explain what they find, and refine and adjust those models through further observations. National Research Council studies have shown essential elements of inquiry include: 1) asking questions; 2) framing hypotheses; 3) gathering and interpreting evidence; and 4) revising explanations to fit data. Factual knowledge is not as important as critical thinking skills, including: 1) knowing generating, evaluating, and applying scientific evidence and explanations to the natural world; 2) understanding the development of scientific knowledge; and 4) participating in scientific practices and discourse. Often these are difficult experiences to capture in the class room, however exploration in nature has proven to a particularly effective means to focus students on understanding what we “don’t know” and then designing approaches to better understand the processes of interest. In an effort to transform undergraduate education at Rutgers we propose to develop the infrastructure and curriculum to turn the Raritan River basin into an integrated field laboratory to enhance the undergraduate experience in New Brunswick. This model would be readily expandable to Rutgers Newark and Camden both of which are also near urbanized rivers.

***What is the Raritan Initiative?*** The Raritan Initiative will develop an integrated presence in the river and the adjacent watershed coupled to an extensive web-based network to facilitate the study of the evolving status of the Raritan in a highly urbanized setting. The goal is to have students learn how to sample and synthesize data to create knowledge about complex environmental processes in space and time, identify gaps in knowledge and then as a Rutgers community design new approaches and instruments that would facilitate better understanding of their local environment. Specifically the Raritan Initiative will:

- advance understanding of the factors underlying the physical, chemical, and biological structure of the river with a view to its global implications and sustainability,
- understand how human activity has altered the river while simultaneously appreciate how the river in turn historically shaped the human activity
- facilitate the design of system sampling techniques and the associated sensors required and,
- formulate the strategies and approaches for making new measurements and the design of new sensors to be used in the field.

The Raritan Initiative will be enabled through infrastructure that will include sensors on boats, robots and support structures that can place students and instructors safely on the river and its tributaries and then deposit their individual data collections in the field to a robust web-based knowledge environment that facilitates access to, analysis of, and interpretation of existing and student-generated data on the basin. The goal would be to create a social network of faculty and student learning communities to encourage and support effective fieldwork on the basin. This infrastructure will enable field trips by introductory classes, field research in advanced classes, and independent student research projects on the river and its tributaries and drainage basin in RU programs in Marine Sciences; Environmental Science; Ecology, Evolution, & Natural Resources; BioEnvironmental Engineering; Geography; Rutgers Film Bureau; and Civil & Environmental Engineering. This infrastructure will also potentially enhance coursework in History and Social Sciences as historical human layers on the Raritan’s story illustrating two centuries of urbanization linking the feedbacks between the river to human society.

The proposed program arises out of recognition of the value of field experience to knowledge generation by directly participating in scientific practice. The project will support learning goals in which: Students will be able to analyze a river basin ecosystem in terms of the dynamic natural physical and biological processes acting to shape it. Students will be able to analyze, explain, and predict how human activity has affected natural and physical processes to produce the current state of a river basin ecosystem. Students will be able to access existing and collect novel data on a river basin ecosystem and analyze that data to develop and test models about the past and future behavior of the basin and the effect of human activity

on it. Students will apply their knowledge of the physical, biological, and human processes affecting river basins to help remediate a local river landscape. The proposed project expands existing activities in science and engineering disciplines at Rutgers—New Brunswick into a program of fieldwork integrating education and research around a local river basin. Given that many American colleges and universities are located near and even on rivers, this project thus has the potential for extensive dissemination throughout the nation and thus increasing the national prominence of Rutgers. This model will be directly applicable to our partners in the Big Ten.

***Why the Raritan River?*** The Raritan River, which drains 1100 square miles of central Jersey into Raritan Bay, is the largest drainage system located entirely within New Jersey, including portions of seven counties and containing 100 municipalities. It ranges in elevation from sea level to ~1400 feet. The topography, steeply sloped with incised stream valleys in the north and more gently sloped in the south, relates to the underlying geology of the Highlands, Piedmont, and Coastal Plain Provinces. The Highlands (northwest) contains soils weathered from bedrock and glacial deposits that are generally shallow and stony with frequent rock outcrops. The Piedmont (central) contains sedimentary rock with gently rolling terrain, dissected by broad winding river valleys. The Coastal Plain (southwest) consists of sandy aggregates with a wide variety of drainage conditions. Human intervention in the basin extends back thousands of years. Early Leni Lenapex practiced garden agriculture involving localized land clearing with consequent soil disturbance and alterations of the natural vegetation. European settlers cut much of the native forest to grow crops for nearby New York and Philadelphia. Although New Brunswick in the tidal basin has been a major urban center for over 200 years, the upper basin was largely rural until the mid-20<sup>th</sup> century; rapid development after WWII has generated the current 1.2 million inhabitants. While the upper basin in the Highlands is largely unpolluted—containing major drinking water reservoirs at Spruce Run and Round Valley—industrial development within the lower basin has left a legacy of 24 Superfund sites within a few miles of the river ([www.blueraritan.org/data/superfund.php](http://www.blueraritan.org/data/superfund.php)). Thus the Raritan provides a diverse landscape with a variety of local ecosystems more or less modified by human intervention over hundreds of years. The Raritan basin provides a varied landscape with a broad range of rich and complex opportunities for undergraduate fieldwork in environmental disciplines.

Additionally, the Raritan is currently a conspicuous feature in the lives of Rutgers undergraduates in New Brunswick. Students rarely have the opportunity to go on the river, and their main experience is that the Raritan is a barrier that carves up the New Brunswick campus. This is generally a negative view, which is a missed opportunity as the river represents potentially an ideal urbanized field laboratory that could enable interdisciplinary education programs that would span numerous academic departments ranging from Marine Science to Civil Engineering to History. This proposed education initiative would make the Raritan a unifying feature for a diverse undergraduate body across Rutgers campus and promote dialogue and collaboration between a wide range of Department teaching efforts.

***Strategic Approach.*** This project will integrate diverse institutional efforts into a coherent program of fieldwork across the disciplines focused on the Raritan. This program will be based upon and thus grounded both in the pedagogy of these disciplines and in the research projects of the participating RU faculty. Curricula from across disciplines will be cross referenced and a teaching curricula digital teaching library of materials will be gathered as a resource for teaching faculty across campus. The cross-referenced curricula will span Humanities and Science Departments. This will over time provide a common rich narrative for all courses to draw from. These efforts will provide the basis for the development of a faculty learning community that works to enrich specific courses and associated fieldwork experiences in the Raritan River basin. Learning goals and annual research foci will be developed during an annual face-to-face faculty symposium and through virtual interactions each summer. Following an initial event in which participants are oriented to the larger curricular goals of the project, faculty will meet regularly to attend lectures/seminars on specific educational topics, share experiences, describe new data or methods of analysis, investigate ways in which the electronic

infrastructure can best be used, and build interdisciplinary connections. Social network tools developed by this Initiative will act as the vehicle for most virtual interactions combined with other social networking tools (Facebook, Twitter, etc). By working together, faculty will develop fieldwork interactions in which, for example, sensor development, and design historical analyses of industrialization along the river provide explains the distribution of specific pollutants that in turn provides insight into microbial, plant, and animal diversity in specific locations in the basin. This will inform departmental courses across campus.

These courses will be complemented with research courses, open to all students, which will build an academic community across Department. These courses will be based on a cognitive apprenticeship model (“watch one, do one, teach one”). In this model the undergraduate community decomposes a large problem (example, “What is the impact of tributary damming on the Raritan ecology?) into small-scale problems that can then be addressed by focused teams of students over the course of the school year. Students based on their experience will assume various roles (mentor-worker-watcher). These 1-2 credit research courses which then allow the students to take the courses an unlimited number of times during their tenure at Rutgers. These teams will design and conduct field research (see below). Student teams, at the end of the year, reassemble their focused smaller efforts to address the larger original problem posed to the entire cohort. This approach grows out of a successful teaching model developed in the Marine Sciences that integrates undergraduates as a community and as individual researchers in this mode. This course, now ranging from 50-70 students per term (ranging from freshmen to seniors), piloted an underwater autonomous glider from New Jersey to Spain, the first robotic crossing in history, while documenting the expedition in a one-hour PBS special. This will provide a means of students taking courses in specific majors to develop a sense of community with the students from other departments. The student research will be documented by undergraduate from the Rutgers Mason Gross Film Bureau which over time will create a rich digital library of past student efforts. Finally to engage undergraduate students in Engineering an annual robotic competition will be held in the River. The competition will require Rutgers student teams to successfully complete an in-water challenge defined by the faculty community each (based on specific robotic capabilities, sensor capable of making critical measurements, etc.). The engineering teams will be provided a fixed budget for developing the product of interest. The students will be able to take advantage of the Makerspaces spaced out on several campuses across New Brunswick campus. Results of all the student efforts will be celebrated at a Raritan festival prior to graduation each spring. Our vision is this would become a University wide celebration of community.

***Infrastructure to support the Approach.*** In order to accomplish these goals, the Raritan initiative will develop an infrastructure to effectively use the Raritan River basin as an environmental fieldwork laboratory for both demonstration of scientific principles and the collection and analysis of scientific data.

*Physical infrastructure:* Effective use of the basin requires the ability to actually put individual students and classes safely on the river and its tributaries. This is made possible at by the proximity of the Class of 1914 boathouse to students across New Brunswick. The boathouse is operated by Rutgers Recreation and is home of the Rutgers Crew teams ([www.sportclubs.rutgers.edu/Content/Boathouse.asp](http://www.sportclubs.rutgers.edu/Content/Boathouse.asp)). It provides floating docks, and a node for internet connectivity for remote assets deployed in the river and to the University. It provides the platforms that allow the deployment of autonomous moored, drifting, propeller and buoyancy platforms.

We propose three different ways to physically access the river and its tributaries. 1) The Caleta, an ocean-going research vessel which can carry ~10 passengers, is currently used by Marine Sciences for fieldwork; since she is technically considered a boat-for-hire for educational use (46CFR 15.605), she requires a licensed captain as operator. This boat now located at the Rutgers field station in Tuckerton New Jersey and rarely used, so for the Raritan Initiative will be moved to campus permanently. During winter it will be stored in the Rutgers Coastal Resource Center and managed by Coastal Ocean

Observation Laboratory (COOL), which employs a captain full time on New Brunswick campus. 2) Individual research students and some advanced classes will use canoes and kayaks that provide access to shallow parts of the river near banks and in reed beds, to tributaries, and to the shallow main channel above the New Brunswick railroad bridge and extending into the upper basin. Vessels will be outfitted with a range of small sensors making them science-sampling platforms. 3) The Raritan Initiative will also pursue acquiring a pontoon boat capable of supporting a class of 20 students. The pontoon boat, anchored/locked in river could provide an instrumented platform that would be a low cost platform (after initial purchase) to serve as many as 3 classes/day on the Raritan for low cost. The pontoon, managed by the COOL group providing infrastructure management experience and instrument pool, would provide a permanent presence in the river enabling a unique river network enabling the development of a sustainable test range for sensor-platforms being developed by engineering undergraduates. These resources could be integrated to the proposed Coastal Resource Center allowing a sustained means to leverage staffing costs and a pool of cutting edge sensors need for characterizing aquatic systems making this a resource available to all faculty across New Brunswick campus.

*Electronic infrastructure:* A major mechanism to integrate and unify our activities in the basin involves development of a web-based knowledge environment (called here the Raritan Environmental Network, REN) to collect and integrate existing physical, biological, and human data on the basin; to support the storage, analysis, and integration of new information about the basin collected by student's laboratory class work and individual research projects; and to enable and foster social interaction among the student and faculty participants. REN will build on and use the expertise of a number of Rutgers partners: the GIS capabilities of the Center for Remote Sensing and Spatial Analysis at Rutgers SEBS (<http://crssa.rutgers.edu/>), the COOL (<http://rucool.marine.rutgers.edu/>) and COSEE NOW (<http://coseenow.net>) networks of Rutgers marine sciences, and cyberinfrastructure skills provided by the Department of Civil and Environmental Engineering at Rutgers. Additionally, the Coastal Resource Center has the Rutgers Discovery Institute as a partner providing a deep University resource as a partner. The network will make significant use of easy-to-use visual analysis software tools to organize, analyze, and interpret data on the river basin. It will leverage existing large investments of NSF for Ocean Observatory Initiatives developing web-based learning tools and software. Data storage, preservation and dissemination on the REN will be performed using a service oriented architecture (SOA) custom designed for this project, but which leverages existing off-the-shelf components. These strategies will enable the Raritan initiative to 1) reduce cost by leveraging distributed data repositories, 2) facilitate data sharing by employing standard data formats common to the hydrologic domain and 3) supported by the NSF, and improve the state of knowledge regarding data infrastructure necessary for creating comprehensive repositories of information describing environmental systems.

***How does the Raritan Initiative align with the University Strategic Plan?*** The Rutgers Strategic plan clearly identified improving the student experience as a top priority in part because the overall quality of students' experience at Rutgers is rated lower than at comparable AAU institutions. Feedback from the student body urged the need to deliver academic programs and cultivate more personalized student and research communities to create a more intimate learning environment. The Raritan Initiative will directly address this by deploying students directly in the field and fuel the spirit of the camaraderie by developing a dynamic web-based social-research community allowing students from across disciplines to interact, collaborate, compete, explore, and learn while delving into their local environment. The goal is to help the Rutgers regain the warmth of that "noisy college town on the banks of the old Raritan" as is celebrated in the Rutgers alma mater, a warmth that will tug at the heart and intellect of Rutgers undergraduates for decades after their time on this great campus.

***What are the additional themes, priorities, and elements addressed?*** This project will provide a sustained infrastructure in an aquatic environment, which will enable a wide range of science and engineering skills of Rutgers Marine Sciences, Computer Sciences, and WinLab. This infrastructure

investment on campus represents an investment to transform the University by integrating the research, education and service mission of Rutgers. This initiative will build a coherent and integrated link between the science and humanity communities on campus. It will facilitate an inclusive, diverse and cohesive culture among collaborating programs, faculty and students. It will help build student skills and awareness to create a sustainable world linked to other proposals to develop a Coastal Resource Center on New Brunswick campus. Finally the program will increase student community while also providing a firm foundation for our students to be ecologically and environmentally literate enabling them to be more involved citizens and effective leaders irrespective of the final career trajectories after Rutgers.

***Which Departments are currently involved in the Raritan Initiative?*** This initiative grows out of a grass root effort that has been developing at New Brunswick over the last 5 years. The evidence of this is evidenced by expanding courses trying to develop a field presence throughout the Raritan watershed. Current partners that would benefit from the Raritan Initiative:

*Rutgers Recreation.* It is important to emphasize that this project is only made possible by a collaboration with Rutgers Recreation (<http://www.rutgers.edu/campus-life/recreation>); we believe that this will be the first such academic collaboration by a recreation unit at any American university. Rutgers Recreation will provide water safety and boating safety instruction for individual students who use canoes/kayaks and water safety experts for any class trips using canoes/kayaks. These will be stored at and made available to the students at the Rutgers boathouse. This will unify the active partnerships between the recreation and the academic life of Rutgers undergraduates.

*Rutgers Academic Departments.* A range of existing educational efforts across Rutgers will be complemented and expanded with the proposed Raritan Initiative. Currently the following Departments have a range of educational and research efforts being conducted in the Raritan River watershed. These Departments include Animal Sciences, Biology, Chemistry, Civil Engineering, Computer Sciences, Computer Sciences, Ecology and Evolution, Film Bureau, History, Human Ecology, Marine Sciences, and Mechanical Engineering. As the program matures we expect it will draw in a larger number of Departments.

***Desired outcome:*** We believe that the Raritan Initiative can propel Rutgers to become the leading environmental teaching and research University in America by explicitly linking the science with human activity (past, present and future), technology development, student recreation and university community.

***Anticipated resources to initiate the Raritan Initiative.*** Anticipated resources are for the initial investment for the teaching resources. These resources include the purchase of the mooring site and equipment to deploy upon a mobile floating pontoon laboratory and improved docking abilities at the Rutgers boathouse. Additionally there will be an initial investment in the equipment, and the development of the online digital databases and cyberinfrastructure backbones. An investment to support the initial funding of the faculty and undergraduate symposia would also be required. The initial investment is estimated to be 2 million dollars. This leverages a larger commitment of existing resources that includes the permanent relocation of the Rutgers Research Vessel Caleta to the New Brunswick campus to housed in the Coastal Resource Center, the focused equipment pool investment of the Center of Ocean Observing Laboratories, the leverage educational cyberinfrastructure developed through the Ocean Observatory Initiative. Management of marine resources could be leveraged on the management capabilities of the Marine Science Center of Ocean Observing Laboratories (manages on average 2 million in external grants support annually). After initial investment, the ongoing sustained funding would be supported through the existing teaching financial models, external fund raising and the completion through foundation and federal support. For the initial investment of an endowed Chair, the Raritan Initiative can provide a university wide focus for New Brunswick campus and provide a model for other Universities.

## **Proposed Measures to Mark Progress and Determine Success**

We propose to monitor the impact of this infrastructure development project to be evaluated in terms of a range of metrics. Our initial list of metrics that might be the initial list for evaluation are listed below however believe that reviews should be flexible as we believe this initiative will grow in scope significantly requiring an evolving review structure. Therefore we believe that an overseeing board of Deans, faculty, New Brunswick civic leaders, and corporate partners should review initiative. Initial thoughts of metrics of the initiative success could be:

- Number of faculty each year making use of the new infrastructure.
- Number of and programmatic affiliations of courses (and student numbers) that use the infrastructure each year: take river tours, use the instrumentation, etc.
- Number of and programmatic affiliations of new courses that are developed due to the presence of the new infrastructure.
- Number of and disciplinary affiliations of independent student research projects each year that are enabled by the new infrastructure.
- Types of interdisciplinary courses, research projects, or events made possible each year by the new infrastructure.
- Number of and type of novel events (special activities other than course or research project) each year made possible by the new infrastructure.
- Amount and nature of data and images loaded onto the web site developed to support the Raritan project.