

NC STATE UNIVERSITY



Compact Plan, February 6, 2007

Department of Civil, Construction, and Environmental Engineering (CCEE)

EXECUTIVE SUMMARY

The CCEE compact plan addresses significant proposals for action in the three years (2007-10) planning period and beyond. The four overarching objectives of the plan are:

- integrate the concept of *sustainability* into the Department's research and educational activities,
- pursue educational, research and extension initiatives that are critical to the state and the nation,
- improve the excellence of our graduate and undergraduate activities that in support of our constituents, and
- establish a "top five" status, consistent with the College of Engineering's goal of moving closer to the aspirant institutions pool.

As sustainability will become a central theme in CCEE research and educational activities, initiatives that are critical to the state and the nation will be emphasized in eight focus areas. These are Energy and the Environment, Coastal Engineering, Infrastructure Health Monitoring, Advanced Materials, Construction Engineering and Management, Transportation Systems, Natural Systems, and Informatics. These focus areas engage the College of Engineering (COE) focus themes and streamlining multidisciplinary initiatives in research and education under the sustainability initiative will position the department well within its peers in the coming decade. Beyond the focus on sustainability, the department intends to be actively engaged in initiatives that are critical to the state and the nation in the areas of Coastal Engineering, Construction Engineering and Management, Infrastructure Health Monitoring, and Advance Materials. The third objective encompasses new offerings and initiatives to improve student experience and better serve our constituents. These include creating immersion experiences for undergraduates in research but also calls for improving admission standards; integrating the department's Environmental Engineering program into a university-wide Environmental Science and Engineering initiative, creating graduate degrees in Environmental Engineering; participating in a campus-wide initiative to develop a Mechanics and Materials (M&M) graduate program; and, becoming involved in more international outreach/collaboration.

To pursue the outlined initiative and accomplish the plan objectives, the following actions items are advanced:

- Hire new faculty and staff with the capability to support the new sustainability theme of the Department.
- Build on existing CCEE Department strengths that have national and international recognition – transportation systems and materials, air quality, environmental systems, computer-aided engineering.

- Offer new course and undergraduate research immersion opportunities to improve the student experience and better serve our constituents. The CCEE Department will
- Raise admission standards.
- Integrate the Department's Environmental Engineering program into a University-wide Environmental Science and Engineering Program.
- Create graduate degrees in Environmental Engineering.
- Re-invigorate the research component of the Construction Engineering and Management program.
- Participate in a campus-wide initiative to develop a Mechanics and Materials (M&M) graduate program. and
- Increase international outreach and collaboration.

Resources needed for the implementation of the Plan and the theme of sustainability range from administrative support to funding personnel positions. The plan calls for funding:

- Fourteen tenure track faculty, four extension faculty, two teaching faculty to support the undergraduate program,
- several PhD fellowships to promote multi-disciplinary experimentation,
- numerous seed grants for matching funds,
- support for laboratory staff to upgrade and update laboratory facility for sustainability-related research, sensors, air quality, and,
- additional classroom, office, and laboratory space to accommodate the growth associate with the implementation of the plan.

In summary, the Compact Plan presents new and exciting cross-disciplinary activities among the different thrust areas, potentially transcending the traditional sub-area boundaries of civil engineering. The successful implementation of the proposed Plan will position the Department to progress toward a "top five" status and influence the direction for future research, instruction and practice in civil, construction and environmental engineering.

1.0 INTRODUCTION

The Department of Civil, Construction, and Environmental Engineering at NC State is one of the nation's largest civil engineering departments.¹ As with many such departments, it has two main purposes: 1) to make significant contributions to the state-of-the-art in civil, construction, and environmental engineering through nationally and internationally recognized research, and 2) to provide a rich portfolio of educational programs for the benefit of North Carolina, the nation, and the world.

Civil Engineering is the primary engineering discipline with the expertise to contribute to developing innovative infrastructure solutions. The Civil, Construction, and Environmental Engineering (CCEE) Department at NCSU not only has faculty in all of the related traditional civil engineering sub-disciplines but also has faculty who have worked extensively in contemporary areas such as climate change, coastal processes, environmental systems analysis, advanced materials, and planning and management. The CCEE department also has special strength in information technology, including high performance computing, which is important in developing innovative technologies for use in a broad set of complex infrastructure and environmental problems. As articulated in the department's new strategic plan, the *mission* of the department is to:

- Provide high quality undergraduate programs that continually incorporate advances in civil engineering science and technology;
- Offer post-baccalaureate educational programs that satisfy the increasing need for highly educated engineers in various specialty areas of civil engineering;
- Conduct research consistent with the responsibilities of a research institution to advance scientific understanding and to develop new technology for the solution of emerging problems and to support programs of graduate education; and
- Engage in extension and public service programs as a department at a land-grant university through the development of professional technical assistance and continuing education programs.

The *vision* is to be one of the best civil engineering departments, arguably in the world, and be recognized for the quality of the cutting-edge research and rich spectrum of high-quality educational programs provided by the faculty and staff. The department intends to undertake initiatives to expand the scope of research and teaching activities and to be actively engaged in the focus themes of the College of Engineering.

Outside trends affecting the department include: continued emphasis on quality by peer and aspirant institutions and growing student populations in competitive programs such as construction engineering and management and environmental engineering. There is also a sense of pressure from other academic institutions in North Carolina to establish civil engineering programs.

Status of Undergraduate and Graduate and Programs

The department's goal for the undergraduate program is to have each of the three accredited degrees be among the best in the country. Those degrees are: civil engineering; environmental

¹ Except where it obviously doesn't pertain, the word "civil" in this document implies all of the department's initiatives and activities in civil, construction, and environmental engineering.

engineering; and construction engineering and management. Their next ABET evaluation will be in 2011. The visitors in 2005 made the following recommendations: for the civil engineering program – better evidence of multi-disciplinary teams and an update to the objectives; for the construction engineering and management program – enhanced alumni surveys that provide better feedback; and for the environmental engineering program – more licensed faculty, more multi-disciplinary experiences, and updated objectives. The department needs to keep improving all three programs through curricular innovation, lab enhancements (especially in *sensors and instrumentation* as well as physical plant), and *immersion research experiences for undergraduates*. Undergraduate research is already present, but it has not been stressed. It needs to be given more emphasis. In addition, there is a need to improve standards for undergraduate admissions to bring NCSU test scores of incoming freshmen in line with scores at aspirant institution pool (Georgia Tech, Virginia Tech). The current trend at NC State shows increasing freshmen enrollment with a concurrent decrease in New Freshmen Average Total SAT score (see Figure 1). For reference, at GA Tech, new freshman average SAT in 2003 was 1336 and 25th - 75th percentile was 1270-1410 in 2005. VA Tech freshmen scores were similar to those of NCSU freshmen in 2002/2003 but have improved since while NC State’s have declined (see Figure 1). Focusing on the College of Engineering at NC State, the size of the incoming freshmen class increased from 1147 in 2003 to 1397 in 2006 while average SAT scores declined from 1262 in 2003 to 1233 in 2006.

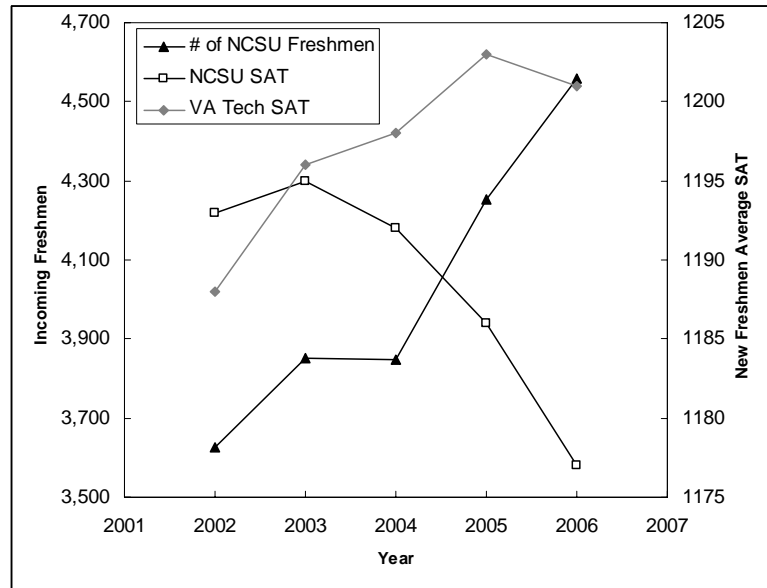


Figure 1. Historical Trend of Incoming Freshman Class Size and Average SAT Scores

The graduate program had an on-campus review in the fall semester of 2005. A number of recommendations were made ranging from increased space for graduate students, increased funding to improve diversity, and more cross-disciplinary activity. The department has embraced all of these recommendations. A few of the enhancement strategies involve college and university support and endorsement, such as more and better student office space, more computer resources, better labs, more TA funding, and expansion of the GSSP. A quote from the report is that: “the College and University administration needs to find ways of providing a more reliable source of funding for major equipment needs in order for programs to effectively compete with their peers.” The department looks forward to receiving that support. The department aims to increase the graduate program’s quality and size. Research expenditures are presently at \$7M per year (\$175k/faculty member) and total funding is at \$18M (\$450k/faculty member). The objective is to double these values. With university support and endorsement, including increased funding for staff, matching funds, and other empowering resources, the aim

is increase the number of graduate students by 50% (from the present level of 240 to 350 or more.)

University resources will be needed to accomplish the objective of the plan. These include equipment investments, maintenance and upgrades for existing labs, TA support to keep pace with the growing undergraduate student body, RA support to launch new initiatives, and additional faculty members including tenure track, teaching, and extension faculty.

Scope of Compact Plan

Consistent with the guidance provided to the Deans in the *Preliminary Guidelines for Preparing a Compact Plan – for Colleges: 2007-10*, the CCEE compact plan addresses “significant proposals for action in the three years of the 2007-10 planning period.” These include pursuing the theme of *sustainability*, engaging in multidisciplinary research and education endeavors related to the focus areas of the college of engineering, and introducing new initiatives in the undergraduate and graduate programs. Some of these proposals call for university funding, for either new or continuing activities. Others are efforts for which Executive Officer support and attention are desired.

2.0 PLAN OBJECTIVES

The compact plan is focused on achieving several overarching objectives. These are integrating the concept of *sustainability* into the department’s research and educational activities by engaging the department in the multidisciplinary activities in concert with the focus themes of the College of Engineering, and pursuing graduate and undergraduate-focused activities contributing to establishing a “top five” status – (consistent with the College of Engineering’s goal of moving closer to the aspirant institution pool, such as Georgia Tech, Virginia Tech, and the University of Illinois.)

The *sustainability* theme is new for the department and further elaboration is warranted here. Civil engineers use this term to describe the assurance of compatibility between mankind with the earth through technological innovation and education that stresses earth-care responsibility (i.e., creating preventive care physicians for the earth), especially in the context of the interplay between the built and natural environments. Built infrastructures need to be implemented in a sustainable and resilient manner. Engineering sustainability aims at minimizing adverse ecological and socioeconomic impacts; but if adverse impacts are unavoidable, then engineered resilience measures assure recovery as a part of the project plan. In pursuing sustainability research of national and international significance, North Carolina’s coastal, piedmont, and mountainous regions are used extensively as the initial focal point for the department’s research and educational activities. The *coastal region* is especially of interest because natural hazards play a prominent role and sustainability issues are complex. Description of the specific compact plan objectives is as follows:

i. Integrate Sustainability into Departmental Focus

Sustainability will clearly be a major theme for the foreseeable future, as it is today. The department aims at adopting this emerging theme and becoming a champion at large through consistent implementation and pursuit of research and education opportunities. The department is well positioned to engage this theme through performing advanced and high visibility research and attracting the very best students (pro-active, engineering-based problem solvers that can improve and sustain the health of the globe). Effectively and successfully adopting this theme

will be one of the important factors for keeping the department at the level, or ahead, of the best programs in the world. Under the sustainability theme, eight focus areas are emphasized. These are *Energy and the Environment, Coastal Engineering, Infrastructure Health Monitoring, Advanced Materials, Construction Engineering and Management, Transportation Systems, Natural Systems and Informatics*.

By engaging these sustainability initiatives, the department will be actively contributing to the focus themes of the College of Engineering, including Critical Infrastructure, Energy and the Environment, Transportation and Logistics, Bio-Engineering, and Advanced Materials. It should be mentioned that the CCEE faculty are currently engaged in a broad spectrum of research activities that are related to, or in concert with, the COE focus themes. Streamlining these activities and pursuing multidisciplinary initiatives in research and education under the sustainability initiative is the focus of this objective and the department will be prepared and would welcome the opportunity, to support sustainability as a COE-level initiative.

ii. Initiatives on Coastal Engineering, Infrastructure Health Monitoring, and Advance Materials

Beyond the initiative of focus on sustainability, the department intends to be actively engaged in development of initiatives that are critical to the state and the nation. These initiatives are in the areas of Coastal Engineering, Construction Engineering and Management, Infrastructure Health Monitoring, and Advance Materials. The CCEE faculty are currently engaged in a broad spectrum of research activities that are related to these area. Streamlining these activities for pursuing multidisciplinary cooperative initiatives in research and education campus wide will be the focus of this objective.

iii. Improve Quality, New Offerings, and Ranking

The objective is to pursue graduate and undergraduate-focused initiatives that will serve our constituents as well as improve the perceived program quality – reach “top five” status – consistent with the College of Engineering’s vision of moving closer to the aspirant institutions pool. This initiative includes creating immersion research experiences for undergraduates but also calls for improving admission standards; integrating the department’s Environmental Engineering program into a university-wide Environmental Science and Engineering initiative, creating graduate degrees in Environmental Engineering; re-invigorating the research aspects of the Construction Engineering and Management program; leading a campus-wide initiative to develop a Mechanics and Materials (M&M) graduate program; and, becoming involved in more international outreach/collaboration.

3.0 SUSTAINABILITY AND ITS INTEGRATION WITH COE THEMES

In the U.S., residential and commercial buildings account for ~ 40%, and the transportation sector for ~25% of energy usage, respectively. Civil engineers are intimately involved in the planning, design, construction engineering and management of the nation’s infrastructure, but design paradigms need to change if to make the nation’s infrastructure more sustainable and resilient. For the department, critical areas for research and educational opportunities include infrastructure for fuel-flexible and sustainable approaches to power generation, including high-efficiency and low-emissions gasification-based alternatives to combustion systems for co-production of electricity and other products (e.g., gasification of blends of coal and solid waste to produce electricity, methanol, and ammonia), wind, solar, biomass, hydro and tidal power

generation; microbial fuel cells (e.g.; electricity from biological wastewater treatment processes); prevention or management of emissions of criteria pollutants, hazardous air pollutants, and greenhouse gases; emission inventories; environmental impact assessment (including energy-efficiency, environmental impact of building materials); impact on and effects of climate change (including impact of rising sea level on coastal regions and protective structures, impact of climate change on water resources, impact of climate change on air quality, transportation, and emissions); green building design and construction; recycling or beneficial use of by-products of energy generation systems based on life cycle inventory and industrial ecology principles, and use of recycle materials to preserve earth natural resources.

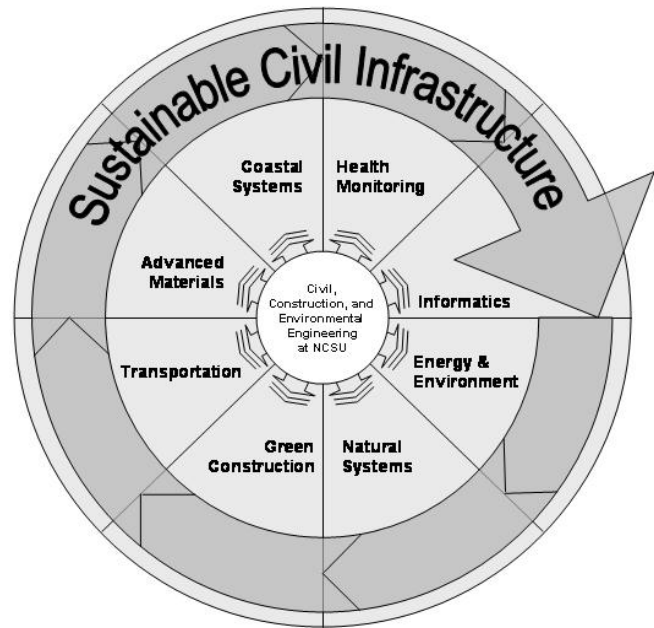


Figure 2. Thrust areas within CCEE Department, and their integration to achieve sustainable civil infrastructure

All civil engineering sub-disciplines in our department influence and shape the civil infrastructure, and have the potential to contribute to sustainable civil infrastructure planning, design, development and management (see Figure 2). We already have ongoing activities and strengths in the sustainability area within our department. With additional emphasis and growth in sustainability related sub-disciplines, we will be well poised to integrate many of the research, teaching and extension activities in each sub-disciplinary area to contribute collectively to a unifying civil infrastructure sustainability theme. Thus, the civil engineering department plans to enhance the following interrelated *thrust areas* (shown in Figure 2) with the aim to bring focus to *civil infrastructure sustainability*.

- **Energy and the environment:**

- All civil infrastructure development, construction and operation activities contribute significantly to energy consumption and environmental emissions. Examples include transportation systems and their impact on air pollutant emissions, near roadside air quality, storm water run-off, land-use, and so on, and construction practices and technologies and their impact on usage of materials, and generation of emissions and wastes (e.g., construction vehicles are a significant source of air pollutants from nonroad mobile sources, or construction practices can lead to adverse ecological impact in sensitive areas).
- Systematic and comprehensive assessment of infrastructures supporting energy generation facilities as well as energy consumption and environmental emission

- inventories are needed for enhancing the collective sustainability of the civil infrastructure systems.
- This thrust area forms the core for establishing the proposed unifying sustainability theme in the department.
 - **Coastal engineering:**
 - The coastal zone is by nature an ever changing environment. Landforms and ecosystems change from time scales of seconds to days to geologic eras. Such system presents unique problems to the engineering design window of 50 to 100 years. In addition, impact from coastal development is experienced at multi geospatial scales. Coastal engineering embraces this complexity and seeks to find sustainable and resilient engineered solutions for managing development within the coastal zone. Renewed focus on the coastal zone is driven by the tremendous imminent changes in the geomorphologic and eco-hydrodynamic coastal environments resulting from global climate change and the associated projected sea level rise and the subsequent impact that these changes will have on the 40% of the world's population living within 100 km of the coast. Locally, NC has over 300 miles of ocean shoreline and 4000 miles of estuarine shoreline. The 20 counties making up the coastal zone are experiencing expansive growth and development. NCSU, the COE, and the CCEE department are uniquely positioned within the UNC system to grow the coastal engineering program and broaden the scope of the Marine Science initiatives earmarked by the State. Opportunities exist to partner with the NCSU Center for Marine Science and Technology (CMST) as well as with the UNC Coastal Studies Institute (CSI) creating multi-disciplinary, multi-university teams to deliver research and education programs for the State. Under the umbrella of the sustainability theme within the department, coastal engineering has the opportunity to become integrated across the many specialty areas represented by NCSU CCEE department. The department has a responsibility to be a source of coastal engineering know-how and expertise for the state.
 - Global climate change and sea level rise as well as natural disasters are leading to geomorphic and eco-hydrodynamic change in the coastal regions.
 - Extensive and rapidly developing coastal regions, however, are contributing to a significant economic growth, e.g., NC, while adversely affecting sensitive natural ecological systems.
 - Coastal regions are highly prone to natural disasters, and debris from the resulting destruction pollutes the environment.
 - Urgent needs exist for coastal engineering and sustainable/resilient development planning and design considering fundamental coastal processes on multi-temporal and geospatial scales, Construction Engineering and Management, impact of construction approaches, advanced construction material, intelligent transportation system, energy & environmentally friendly practices, health monitoring of the infrastructure, and informatics for design and operation.
 - **Infrastructure health monitoring:**
 - Rehabilitation of deteriorating and aging civil infrastructure components, including bridges, roadways, buildings, water distribution pipe networks, sewer systems,

- foundation systems, tunnels, dams, waste disposal systems, power generation systems, etc.
- Monitoring and condition assessment of aging as well as new civil infrastructure systems for efficient retrofit, management, and operation (e.g., minimizing energy and natural resources consumption) to enhance sustainability.
 - Use of contemporary technologies in sensors and informatics for effective information assessment for sustainable engineering.
- **Advanced materials:**
 - Use of functionally superior (e.g., lighter but stronger) as well as environmentally safer (e.g., minimal pollutant emitting and energy efficient) construction materials to design and construct future civil infrastructure systems.
 - Study of the mechanics and multi-scale (nano-micro-macro) modeling of construction materials in infrastructure applications will contribute to improving the performance of components made from these materials.
 - In addition to strength and mechanics of advanced materials, study, for example, their energy/environmental effects, usability in Construction Engineering and Management and transportation systems to enhance civil infrastructure sustainability.
 - **Construction Engineering and Management:**
 - Construction practice and choice of construction materials affect, on the short-term as well as long-term, energy consumption, natural resources consumption and environmental emissions.
 - Considering green construction practice in conjunction with all other thrust areas is crucial to establish the future of sustainable engineering of civil infrastructure.
 - **Transportation systems:**
 - The transportation subsystem in the civil infrastructure greatly affects energy consumption and the environment.
 - Through improved choices in transportation materials as well as operations and logistics, the collective sustainability of civil infrastructure can be greatly enhanced.
 - Interdisciplinary research and education in areas such as transportation and air quality to quantify the real world impacts of transportation systems on the environment using sensors and advanced modeling methods.
 - Readily interfaced with all other thrust areas.
 - **Natural Systems:**
 - The effects of engineered civil infrastructure on the natural environment, e.g., soils, water resources, subsurface geology, ecology, atmosphere and climate, and coast, need to be understood and studied.
 - The design and implementation of civil infrastructure system must assess and consider the impacts on natural resources (e.g. soil depletion, water and air quality, water resources), energy and the environment.
 - Risk assessment and hazard mitigation of natural events including earthquakes, floods, land and underwater slides, avalanches and tsunamis. Such scope involves the utilization of appropriate design and analysis techniques to predict probability of

- occurrence, estimate the consequences of a given event, and assess and implement measures to protect civil infrastructure systems and minimize damage. Main thrust areas are focused on development of risk assessment and hazard mitigation methodologies, including use of advanced sensing systems; utilization of advanced materials; seismic retrofit approaches, utilization of new sensors to develop a better understanding of infrastructures performance during and after the event, performance of design and construction procedures for improved performance under the extreme events.
- Sustainability could be improved through effective use of, for example, advanced smart geotechnical and transportation materials that are capable of transmitting radio frequencies, rapid construction techniques while minimizing energy consumption, Construction Engineering and Management, infrastructures health monitoring, and informatics.
- **Informatics:**
 - Performance evaluation of sustainability (e.g., reduction in net energy consumption or green house gas emissions) of civil infrastructure systems is critical.
 - Geomatics (a recent thrust area in the department) and geospatial analysis provide the tools and methods for improving the observability of engineered and natural systems.
 - Assessment of sensor data, process modeling for performance estimation, and search for efficient choices will be enabled by informatics and computing techniques to facilitate the integration of the other thrust areas to establish the unifying sustainability theme.

Anticipated Benefits and Opportunities

The proposed plan to mainstream the sustainability theme within the civil engineering department offers numerous potential benefits not only to all aspects of the mission of the department, but also to the many focus themes being considered by the COE. This effort also opens up opportunities for collaboration in related and complementary initiatives being formulated by other departments, within and outside of COE. Ultimately, the unifying sustainable civil infrastructure theme that we envision is anticipated to position the department, the college, and the university on a world map of elite institutions of excellence in learning. The following are examples of specific anticipated benefits and opportunities:

- Open new and exciting research opportunities through the cross-disciplinary activities among the different thrust areas, potentially transcending the traditional civil engineering disciplinary boundaries.
- Overlap with and augment several initiatives from other departments, e.g.:
 - Interdisciplinary degree programs in proposed in the Geographic Information Science and Technology by the GIS Program.
 - Materials modeling initiative (Mathematics and others?).
 - Energy initiative (Physics and others?).
- Create contemporary instructional programs to maintain and enhance relevance of undergraduate and graduate education programs in civil engineering.
- Position the department to compete successfully in major national initiatives to establish new centers (e.g., ERC), graduate fellowship programs (e.g., IGERT, GAANN), undergraduate research internships (e.g., REU), etc.

- Play an active role in setting an example and influence the direction for future research, instruction and practice in civil infrastructure systems
- Become an international center for the future civil engineering research and training, and set the stage and direction for future civil engineering practice where all aspects of engineering are conducted with care and consideration of the natural environment and its sustainability

Contributions to COE Focus Themes

Table 1 summarizes the overlap of the proposed Civil Engineering Thrust Areas for Sustainability with COE focus themes that are being considered.

Table 1. Intersection of Departmental Sustainability Thrust Areas with COE Focus Themes

CCEE Thrust Areas for Sustainability	COE Focus Themes				
	Critical infrastructure	Energy & the environment	Transportation & logistics	Advanced materials	Bio-engineering
Energy & the Environment	X	X	X	X	X
Coastal Engineering	X	X	X	X	X
Infrastructure Health monitoring	X	X	X	X	
Advanced Materials	X	X		X	X
Construction Engineering and Management	X	X	X	X	
Transportation	X	X	X	X	
Natural Systems	X	X	X	X	X
Informatics	X	X	X	X	X

4.0 GOALS

To accomplish the plan objectives, the following major initiatives are identified for mainstreaming the concept of *Sustainability* into the department’s research, education, and extension programs, and for improving quality and ranking. Goals within the plan’s time horizon include:

4.1 Sustainability and Resilience

Mainstream the concept of sustainability into the department’s programs; become a national/international leader in sustainable civil infrastructure engineering. Pursue research opportunities that require multidisciplinary expertise and engage the COE focus themes through the department-identified thrust areas of *Energy and the Environment*, *Engineering for Coastal Regions*, *Monitoring the Health of Critical Civil Infrastructure*, *Advanced Materials*,

Construction Engineering and Management, Transportation Systems, Natural Systems, and Informatics.

4.2 Coastal Engineering

Implement initiatives in engineering for coastal regions beyond the initiative under the umbrella of Sustainability. The department has a responsibility to be a source of coastal engineering know-how and expertise for the State. Examples are context-sensitive development, environmental sustainability of coastal infrastructure, hazard mitigation (both natural and man-made) and emergency response.

4.3 Construction Program Partnerships

Find other partners on campus who share an interest in construction (academic and research programs such as mechanical engineering, architecture, business and the American Home initiative; and administrative units such as Design and Construction Services, Construction Management, and Facilities Operations). Find purposeful relationships with North Carolina government agencies that are the largest owners of constructed facilities in the state (e.g., the UNC System, and departments of Corrections, Administration, Cultural Resources, DEHNR) and those that are regulators of the design and construction process (Labor, Insurance, and various licensing boards) to help respond to their needs. Partner with other engineering and construction programs where common interests exist. Boost the department's research activities in construction. Identify areas to stress – such as error-free design, reduction in cost of changes, evaluation and refinement of contract procedures, evaluation of new materials, systems and fabrication processes, use of environmentally friendly technologies, information technology, project management, production scheduling – that resonate with the construction industry, partner programs, and the department's faculty, staff, and students.

4.4 Infrastructure Health Monitoring and Improvement

Provide a unifying context for the various technological research activities within the department. Focus on monitoring the health of critical civil infrastructure facilities (sensors, instrumentation, creation of observability, system identification, etc.)

4.5 Engineering of Advanced Materials

While the department has traditional expertise in the area of materials development and testing, the goal of the new initiatives is directed toward the analysis of system performance in terms of multi-scale testing and modeling with the aid of high-speed computing, development of new nano materials and technologies that improves infrastructure resilience and performance, create innovative and new performance metrics for materials to enhance the health of deteriorating infrastructures (advanced embedded materials, new uses for existing materials, new design paradigms), and optimization of critical infrastructure investment and asset management.

4.6 Program Quality and Ranking

This goal is focused on new offerings and initiatives to improve student experience and better serve our constituents. These include:

- ***Attract highly qualified students to undergraduate degree programs:*** Improve standards for undergraduate admissions to bring NCSU test scores of incoming freshmen in line with scores at aspirant institution pool (Georgia Tech, Virginia Tech).

- **Attract highly qualified students to graduate program:** At the graduate level, university fellowships are needed to improve recruiting opportunities for highly qualified graduate students (US residents and international applicants). Fellowship opportunities (full support for one or more years) are available at aspirant institution pool but few (such as COE Dean's Fellowship) are available at NC State.
- **Improve Research and Learning Experiences for Undergraduates:** Engage undergraduates in research-oriented activities; expand the emphasis on hands-on experiences; discuss and pursue ways to incorporate sensors and instrumentation into undergraduate curriculum. Engage the services of professors whose primary mission is top-quality education and who can also supervise undergraduate research.
- **Environmental Program Initiative:** To enhance visibility and opportunities for cross-departmental collaborations, integrate the department's environmental engineering program into a university-wide environmental science *and* engineering initiative. In addition, propose the offering of graduate degrees in Environmental Engineering.
- **Mechanics and Materials Graduate Program:** lead a campus-wide initiative to develop a mechanics and materials (M&M) graduate program. Twenty seven faculty members from Biomedical Engineering, Civil, Construction and Environmental Engineering, Materials Science and Engineering, Mechanical and Aerospace Engineering, Nuclear Engineering, Mathematics and Physics Departments are currently participating in this effort. About 40 graduate courses that include mechanics and materials topics are already offered at NCSU, enough to develop a graduate degree program.
- **International Outreach/Collaboration:** Emphasize partnerships with other programs across the globe, encourage these interactions through collaborative research; create exchange programs for faculty, students, and staff; and explore shared ownership of degree programs.
- **Laboratory Facilities and Space:** furnish the undergraduate and graduate teaching and research laboratory with state-of-the-art equipment that support research and education activities within the focus themes. Provide physical improvements to the laboratory and gain access to new space to accommodate the growth outlined in the plan.

5.0 ACTION ITEMS

The goals described in Section 4.0 translate into a specific set of action items described as follows:

5.1 Mainstreaming the Sustainability Theme

- **Description:** Open new and exciting educational, research, and extension opportunities through cross-disciplinary activities and build upon existing strengths within each sub-area under the unifying theme of sustainable civil infrastructure engineering.
- **Intended Impact:** Improve the health and vitality of the graduate and undergraduate programs and progress the department towards elite status.
- **Funding Requirements:**
 - Additional faculty (6 tenure track faculty) to bring new strengths and capabilities in the eight thrust areas
 - Extension faculty (2 extension faculty for the theme of sustainability)

- Support for visiting scholars, symposia, on- and off-campus activities, in-field sensors and instrumentation, and one or more extension specialists focused on sustainability
- \$200-\$300k/year for three years to fund graduate students fellowships and undergraduate student research support to help establish the programs

5.2 Coastal Engineering

- **Description:** Improve growth and establish new partnerships in coastal engineering research, education, and extension programs (outside the theme of sustainability).
- **Intended Impact:** Open new and exciting research and extension opportunities through multi-disciplinary activities in Marine Science and Coastal Engineering.
- **Funding Requirements:**
 - 3 tenure track faculty (1 NCSU, 1 CMST, 1 CSI).
 - PhD fellowships to promote multi disciplinary effort (2 per year for 3 years).
 - 2 extension (non tenure) positions

5.3 Construction Program Partnerships

- **Description:** Boost the department's research activities in construction. Identify areas to stress that resonate with the construction industry, partner programs, and the department's faculty, staff, and students. Increase the number of faculty from 2 to 5. Encourage additional faculty, in other areas, to focus their experimental work on the construction-related issues.
- **Intended Impact:** Increase the pre-eminence and visibility of the construction research, education, and extension activities. Enhance position as one of about 20 departments nationwide that have such an emphasis. Increase the critical mass of faculty in the area. Strengthen the ability to have an impact. Help the construction industry, which is heavily North Carolina- and NC State-based, to be a strong part of the economic development engine in the state. Enhance the cost effectiveness of State-owned constructed facilities and reduce life-cycle costs of ownership. Enhance the uniqueness of the department's identity.
- **Funding Requirements:**
 - 3 tenure track faculty
 - \$200-300k for three years to fund graduate students fellowships and events that will raise the visibility of the program. Faculty positions, through the college/university and/or through endowments (e.g., the Clancy Chair).

5.3 Infrastructure Health Monitoring

- **Description:** Advance the state-of-the-art in Health Monitoring of deteriorating and aging civil infrastructure components, including bridges, roadways, buildings, pipe networks, sewer system, waste disposal systems,

- power generation system, etc. Focus on sensors, instrumentation, observability, system identification.
- **Intended Impact:** Make the department more pre-eminent. Prepare it for high visibility in the coming decades. Attract the very best and brightest graduate students to the department. Improve the department's identity in this market niche. Capitalize on existing and growing strengths.
- **Funding Requirements:**
 - 1 tenure track faculty
 - \$100k for 2 years to support for experimentation with innovative ideas, matching funds, staff support in advanced sensor and instrumentation technology

5.4 Advanced materials:

- **Description:** Develop world-class expertise in materials multiscale testing and system modeling and strengthen the area of advanced materials by leading campus initiatives.
- **Intended Impact:** Enhance capabilities in multi-scale testing and modeling, development of smart construction materials, high-speed computing, computationally intensive modeling, simulation, etc. Capitalize on existing strengths. Make the department more pre-eminent. Prepare it for high visibility to improve ranking. Foster a world-class expertise in the development of new technologies.
- **Funding Requirements:**
 - 1 tenure track faculty
 - \$100k for 2 years to support for experimentation with innovative ideas, matching funds, staff support in advanced materials technology

5.5 Program Quality and Ranking

i. Improve Admission Standards for Entering Freshmen

- **Description:** Increase selectivity and bring admission criteria (e.g. entering freshman SAT scores) in line with aspirant institution pool.
- **Intended Impact:** Current admission criteria are not competitive with aspirant institution pool. Increased selectivity will improve rankings and quality of undergraduate student body.
- **Funding Requirements:**
 - No funding required but action by university administration is required

ii. Undergraduate Research and Teaching

* *Immersion Experience for Undergraduates*

- **Description:** Introduce undergraduates to research experiences.
- **Intended Impact:** Increase the number of undergraduates who pursue graduate degrees. Prepare the undergraduates for successful careers as graduate students. Improve the size and scope of the research program. Bring more research results into the undergraduate classrooms.

- **Funding Requirements:**
 - College/university funding, like REUs, for undergraduates to be interns in the summer and for-hire helpers during the academic year
 - Funding for renovation of laboratory space to level compatible with undergraduate research needs

*** Increase Teaching Staff**

- **Description:** Engage the services of professors whose primary mission is top-quality education.
- **Intended Impact:** Maximize the quality of the undergraduate program. Ease the pressure on tenure-track faculty responsible for all of the heavy undergraduate teaching loads. Increase the pre-eminence and visibility of the undergraduate research program. (The undergraduate research participants could be supervised in large measure by such individuals). Enhance the uniqueness of the department's identity.
- **Funding Requirements:**
 - \$150k / year of permanent funding to hire Teaching Staff.

iii. University Fellowships for Graduate Students

- **Description:** Create a university fellowship program that will attract highly qualified graduate applicants to NC State University
- **Intended Impact:** Fellowship program will help recruit highly qualified graduate students (U.S. citizens and international applicants) to NC State University
- **Funding Requirements:**
 - \$25K/year salary and fringes plus tuition per fellowship.

iv. Environmental Engineering and Science Program Initiatives

*** Create MS and PhD Degrees in Environmental Engineering**

- **Description:** Improve the visibility of the environmental engineering program by creating a separate identity as many major civil engineering programs have done.
- **Intended Impact:** Create a clear, visible, image to attract top applicants.
- **Funding Requirements:**
 - Staff and faculty time, and university endorsement.

*** Integrate Environmental Science and Engineering**

- **Description:** Fully integrate the environmental engineering program into on-campus activities in environmental science and engineering
- **Intended Impact:** The lack of coordination across campus means that NC State is not presenting its true strength either internally or externally. Weak coordination also weakens our competitiveness in major cross disciplinary proposals.
- **Funding Requirements:**

- Staff and faculty time, and strong university commitment. University resources to strengthen the coordination and publicity of environmental programs across campus

v. Mechanics and Materials Graduate Program

- **Description:** Create and lead a campus wide collaborative research and graduate program in mechanics and materials (M&M)
- **Intended Impact:** Enhance multi-disciplinary research and instruction collaborations in mechanics and materials across campus.
- **Funding Requirements:**
 - Staff support for administering the M&M graduate program.

vi. International Outreach

*** Create Collaborative Research**

- **Description:** Develop collaborative research with universities around the globe.
- **Intended Impact:** Make the department more pre-eminent. Prepare it for high visibility in the coming decade. Attract the very best and brightest graduate students to the department. Capitalize on existing and growing strengths.
- **Funding Requirements:**
 - \$100-200k to support travel, visiting scholars, international exchange programs. Work with NCSU Office of International Programs to send “ambassadors” to universities in key areas around the globe.

*** Develop International Exchange Program**

- **Description:** Develop exchange programs with universities around the globe.
- **Intended Impact:** Make the department more pre-eminent. Prepare it for high visibility in the coming decade. Attract the very best and brightest graduate students to the department.
- **Funding Requirements:**
 - \$100k per year for three years, primarily for travel and sponsoring international visitors, would be extremely helpful. The more important need is for college and university endorsement and support for such activities. Existing relationships (e.g., the new NC State partnerships with Chinese universities, the Prague program) can be used as the basis for cultivating such programs.

vii. Laboratory Facilities and Space:

- **Description:** Upgrade laboratory facilities and acquire space to accommodate growth.
- **Intended Impact:** Enhance student experience and attract the very best and brightest graduate students to the department.
- **Funding Requirements:**

- \$100-200k per for three year to furnish the undergraduate and graduate teaching and research laboratory with state-of-the-art equipment and perform physical improvements.
- Access to new space to accommodate the growth outlined in the plan.

6.0 METRICS OF SUCCESS

Matrices that will indicate the success of the compact plan initiatives will include (not in a specific order): rankings (both undergraduate and graduate), student quality, awards won by students, applications from outstanding high school students who presently choose to go to out of state top ten schools, participation rates for students in undergraduate research, REU funding obtained by faculty members, graduation rates; accolades from parents, visibility of departmental faculty at the national and international level; research support levels, and the papers, patents, and other contributions made by the faculty and students.