NORTH CAROLINA BIOPHARMA MANUFACTURING LABOR MARKET ANALYSIS — *Greater Charlotte*

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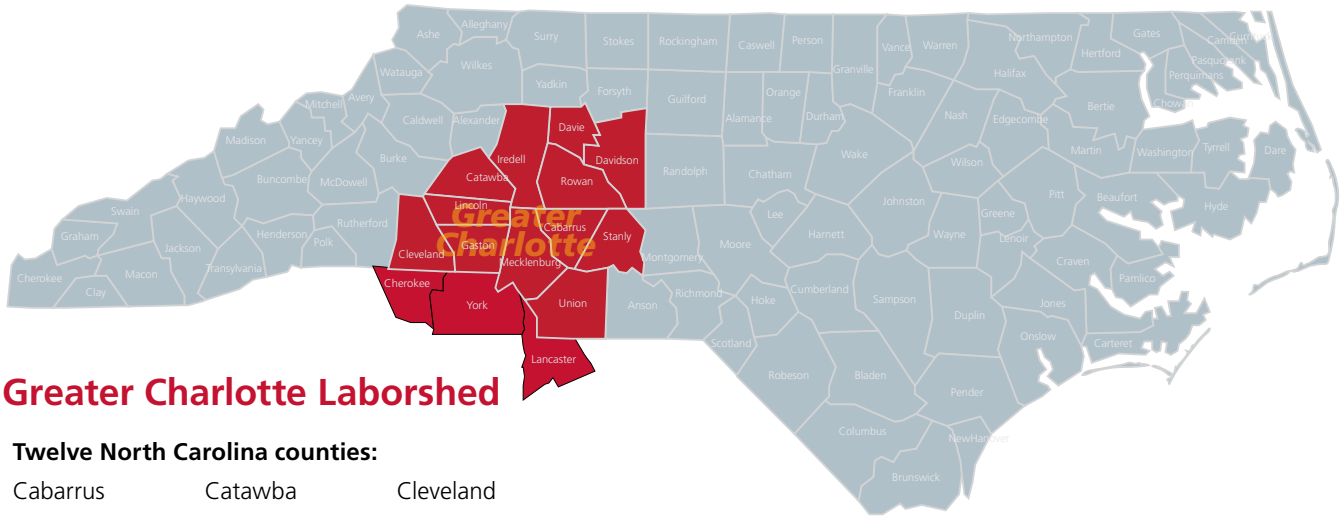

Greater Charlotte Laborshed

Twelve North Carolina counties:

Cabarrus	Catawba	Cleveland
Davidson	Davie	Gaston
Iredell	Lincoln	Mecklenburg
Rowan	Stanly	Union

Plus three South Carolina counties:

Cherokee	Lancaster	York

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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 2

2. INTRODUCTION 4

2.1 Background 4
2.2 Organization 4
2.3 Methodology 4
2.4 Project and Labor Requirements 5
2.5 Geographic Scope 6
2.6 Data Gathering 6
2.7 Data Limitations 7

3. THE SUPPLY OF EXISTING BIOPHARMA MANUFACTURING LABOR 8

3.1 Life Sciences Industry Profile 8
3.2 Biopharma Manufacturing Occupations 9
3.3 Existing Biomanufacturing Skill Base 10
3.4 Manufacturing/Production Labor 11
3.5 Quality Assurance/Quality Control Labor 12
3.6 Process Development Labor 13
3.7 Plant Operations Labor 13

4. THE SUPPLY OF EMERGING BIOPHARMA MANUFACTURING TALENT 14

4.1 Emerging Biopharma Manufacturing Skill Base 14
4.2 BioWork Enrollment and Course Completions 14
4.3 Biopharma Manufacturing Curricula 14
4.4 Community College Enrollment 15
4.5 Undergraduate Degrees 16
4.6 Graduate and Ph.D Degrees 18

5. CONCLUSIONS 19

REFERENCES 20

1. EXECUTIVE SUMMARY

Biggins Lacy Shapiro & Co, (BLS & Co), a New Jersey-based site selection and economic development consultancy, was engaged by the North Carolina Biotechnology Center and its economic development partners in and around Charlotte, N.C. (Greater Charlotte), to gauge the capability of the region's labor force to sustain significant biopharmaceutical manufacturing plant investments.[1] It is our conclusion that the Central Piedmont regional labor market possesses the necessary skills, if not the direct experience, to support a number of biopharma manufacturing plants. Scale-up of the first plant, in particular, should be managed at pace that would enable the recruiting, training and development staff to understand and adjust to local market conditions and to assimilate new employees.

Our analysis adopts a site selector's perspective and was designed around the types of information that clients typically want to understand before making an important location decision. Our methodology borrows from site selection engagements and labor market assessments performed on behalf of corporate clients and refined over years of practice. This approach includes:

1. Creating a "proxy" project and associated labor requirements. The basis for this analysis was a fully integrated, GMP compliant, biologics manufacturing plant producing an existing, approved, cell-based drug. The plant will ramp-up staffing over a 2-year period. Our hiring standard is based on 15 potential applicants for each available position (15:1 hiring ratio).
2. Defining the geographic boundaries of the labor market (the "laborshed"). This constituted a 15-county region in the Central Piedmont comprising an approximately 45-minute commuting distance around principal employment nodes in Mecklenburg, Gaston, Rowan and Cabarrus Counties.
3. Quantifying and assessing the availability of experienced manufacturing talent in the laborshed and new workforce entrants who will replenish this pool. To do so we identified the most relevant occupations in key functional areas of a biologics plant: 1] Manufacturing/Production; 2] Quality Assurance/Quality Control; 3] Process Development; and 4] Plant Operations and Support. We also attempted to align these functions with the various degree programs at North and South Carolina's community colleges and universities. Data was gathered via interviews with human resources officials and managers at local plants, instructors at community colleges and universities and economic developers. We also accessed federal and state occupational and academic data bases, among other secondary information sources.
4. Inferring from these data the depth and breadth of the regional labor market and its ability to sustain our project.

Our findings address each of the plant's most important functions:

Manufacturing/Production

As the pool of potential applicants far exceeds our annual hiring requirement, BLS & Co believes that the Charlotte labor force should be large enough to staff and maintain the manufacturing/production functions at a large biologics facility. However, the lack of any sizeable biopharma manufacturing activity in the Charlotte area at this time means attracting operators and technicians specifically skilled or experienced in biomanufacturing processes will be challenging, particularly for that first plant.

We project approximately 5,800 potential applicants for the 140 manufacturing/production positions requiring previous experience. As these jobs would be filled at the rate of 70 per year, the potential labor supply, including those with skills that could be transferable to biologics or pharmaceutical manufacturing, would more than exceed the target 15:1 hiring ratio.

To fill the "slots" available to 30 or so less experienced employees only eight BioWork course completers are produced annually in Greater Charlotte. However, the staffing of these production positions is expected to benefit from the new AAS in Biotechnology (and bioprocess area of concentration) program at Rowan-Cabarrus Community College.

Quality Assurance/Quality Control

BLS & Co projects a potential applicant pool of approximately 1,500 persons in Greater Charlotte for the 90 experienced staffers to be hired into the QA/QC organization during the two year ramp up period. This represents almost 3x the number of applicants needed to achieve our desired hiring ratio. Local employers report generally favorable results recruiting experienced biologists, microbiologists and most chemists. As reported elsewhere, it can be difficult to attract and retain experienced analytical chemists.

The community colleges and universities are expected to produce more than 600 prospective QA/QC employees to satisfy a need for just 5 inexperienced new hires per year.

[1] In the report that follows we use the terms "biopharma" "pharma" and "biologics" interchangeably.

Process Development

The Charlotte area's supply of chemical and industrial engineers is more than adequate to staff process development positions. Locally, many experienced chemical engineers can now be hired out of the automotive and paper sectors. However, it can be significantly more challenging attracting and retaining good Mechanical and Electrical Engineers in Charlotte, as elsewhere.

BLS & Co projects a potential supply of more than 1,300 experienced process development employees within the Charlotte laborshed. This is significantly greater than the 210-person applicant pool that results from our desired hiring ratios. We also estimate that area colleges and universities can supply an annual allotment of approximately 30 graduates to satisfy the need for six inexperienced process development staffers.

Plant Operations

The hiring margins for instrumentation and control technicians, process technicians and automation engineers in Greater Charlotte are thinnest of any biomanufacturing occupation we have tested. These findings are consistent with those we have experienced in the Triangle, the Triad and Eastern North Carolina. Nonetheless, the data indicate that the area's appears supply of these skills will be sufficient to accommodate a new biomanufacturer. BLS & Co projects a potential supply of about 480 experienced plant operations employees within Greater Charlotte. As our needs are 20 such employees per year we anticipate being able to meet our 15:1 hiring standard.

Summary

The table below provides a synopsis of our project's talent requirements and prospective sources of qualified and inexperienced workers that have the potential to meet this demand in Greater Charlotte.

Summary of all Sources of Labor: Greater Charlotte

Function	Total Hires	Annual Hires	Target Yield @ 15:1 Ratio	Projected Annual Supply	Source of Supply
Existing Biopharma Manufacturing Labor					
Manufacturing/Production	140	70	1,050	5,827	Labor Force
QA/QC	90	45	675	1,536	Labor Force
Process Development	28	14	210	1,321	Labor Force
Plant Ops/Manufacturing Support	40	20	300	414	Labor Force
Emerging Biopharma Manufacturing Labor					
Manufacturing/Production	60	30	—	8	BioWork and Community Colleges
QA/QC	10	5	—	621	Community Colleges & Universities
Process Development	12	6	—	30	Universities
Plant Ops/Manufacturing Support	0	0	—	478	Community Colleges & Universities

2. INTRODUCTION

2.1 Background

This report constitutes Biggins Lacy Shapiro & Company's (BLS & Co's) analysis of the market for biopharmaceutical manufacturing labor in the Charlotte region; an assessment made from the perspective of a site selector. As practiced by a site selection firm, labor market analyses typically attempt to quantify the availability and quality of the workforce for an established skill set(s) and at a given price point, or wage. Clients use this information to choose between competing destinations for a new project (e.g., a new distribution center or manufacturing plant), and/or to help them understand how large they might grow in an existing market without jeopardizing their continued access to qualified labor at affordable wages.

This analysis was inspired by the desires of those at the North Carolina Biotechnology Center and its economic development partners in and around Charlotte to understand if local industry and the area's extensive post-secondary educational infrastructure have developed a sufficient number of experienced employees and prospective workforce entrants to attract a significant biopharma manufacturer to the region. This report focuses mainly on the workforce metrics that a new employer would want to understand before making a location decision.

Why this concern about labor markets? In a 2001 survey by Site Selection Magazine 74% of corporate executives said finding available, skilled labor was their biggest challenge and that "labor, whether in a growing or declining economy, still plays a crucial role in corporate location decisions."[1] However, labor markets in many areas of the United States are at risk due to slowing growth and troubling skill shortages. According to recent studies by the US Bureau of Labor Statistics, the nation's labor force is projected to grow by only 1% per year, compared with 2.6% during the periods of peak growth in the 1970's. Over the longer term the Bureau envisions that growth of the nation's labor force will come to a standstill. Such trends signal that employers will have to learn to do more with less. However, a 2006 survey by the Conference Board and the Society for Human Resources Management warned that the workforce is wanting: fully 70% of recent US high school graduates had substandard skills and college graduates were thought to be just adequately prepared to enter the modern workforce.[2]

It is clear that employers cannot, and do not, take the availability of a skilled workforce for granted when making a location decision. It should be equally apparent that any area or region that can boast of an abundance of experienced and skilled workers and the infrastructure to grow and resupply this valuable resource will have an advantage in the global competition to attract good jobs and investment.

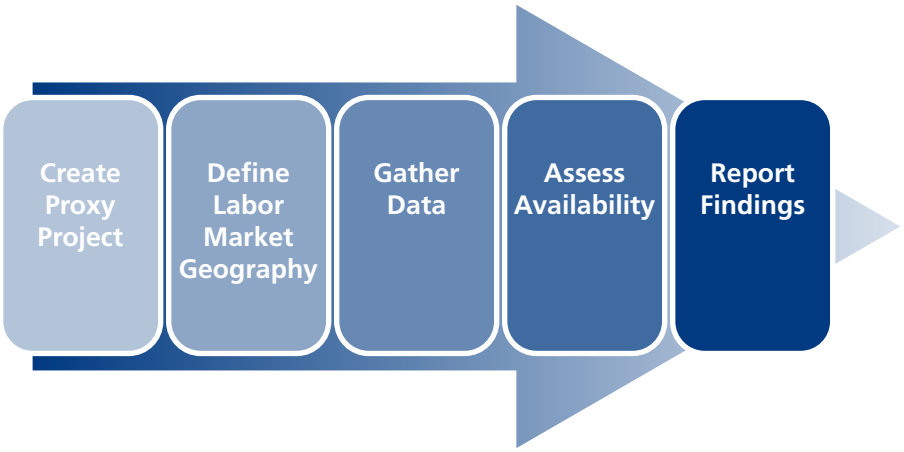
2.2 Organization

This report is organized around the labor requirements of a 400-employee biopharma manufacturing plant, as described in more detail below. For each key function in such a plant (e.g., manufacturing, quality control), we have attempted to quantify the available pool of experienced, skilled workers and the "pipeline" of new talent being produced annually by North Carolina's and South Carolina's community colleges and universities.

2.3 Methodology

Our approach to this engagement included the following key activities:

- Creating a "proxy" project and labor requirements
- Defining the spatial dimensions of the labor market (the "laborshed")
- Assessing the availability of experienced biomanufacturing labor and new workforce entrants
- Reporting findings and making conclusions as to the ability of a new biomanufacturer to compete for its fair share of labor; e.g., to achieve a sustainable labor pool.



2.4 Defining the "Proxy" Project and Labor Requirements

This engagement is somewhat unique from labor market analyses that BLS & Co undertakes on behalf of its corporate clients. Without a predefined project requirement including numbers and types of positions, skills, attributes, etc., there can be no context for an assessment of Greater Charlotte. The solution was to create our own "proxy" project, a realistically-drawn fictional entity that will enable us to perform a market-based assessment of the region.

Our fictitious project was designed with the active input of a panel of industry, economic development and academic experts assembled for this study by the North Carolina Biotechnology Center. A fully-integrated plant (fermentation thru fill/finish) was deemed well-suited to our purposes. Project employment was pegged at the high end of the spectrum, reflecting the prospect demographic that has been encountered most frequently by local economic developers. The distribution of the workforce is typical of the life science manufacturing operations known to our panelists (and later verified by BLS & Co during field interviews with local employers). This profile is summarized below:

Type of Facility	• Fully integrated biologics plant • Manufactures approved, cell-based drug
Employment	• Approximately 400 at full buildout • 2-year ramp-up
Workforce	• 50% Manufacturing/ Production • 25% QA/AC • 10% Process Development • 10% Plant Operations • 5% Other [management, etc.]

Following are brief position descriptions for key functions within our project:[3]

- *Manufacturing/Production:* Combines technical knowledge with procedural accuracy in diverse areas from cell development (for biomanufacturing) to sterilization and chemical mixing (for traditional drug making); also focuses on product finishing and packaging tasks. Representative positions include:
  - *Process Technician:* High School Diploma and relevant experience/training
  - *Formulation/Fill Technician:* High School Diploma and relevant experience/training
  - *Packaging Technician:* High School Diploma and relevant experience/training
- *QA/QC:* Plays a central role by ensuring products and production processes meet stringent federal manufacturing standards. Representative positions include:
  - *Quality Control/Assurance Technician:* 2-year Associates degree
  - *Quality Control Associate:* B.S. degree
- *Process Development:* On hand R&D staff to make improvements and modifications to existing production processes and identify possibilities for extending production technologies and applications.
  - *Process Development Associate:* 2-year Associates degree & experience
  - *Process Development Scientist:* MS & experience or PhD
- *Plant Operations:* Maintenance workers to ensure the smooth and continuous functioning of highly complex machinery.
  - *Maintenance Technician:* High School Diploma and trade certification
  - *Instrumentation Technician:* 2-year Associates degree

Based on our conversations with area employers and BLS & Co's previous project experiences, compensation and benefits at our proxy plant have been pegged at the market median (50th percentile) in Greater Charlotte. We also assume a 15:1 hiring ratio, meaning that employers will make one hire for every 15 qualified applicants, this too is based on project experience and our local interviews. Finally, our manufacturing clients have always voiced a preference for a non-union labor environment whenever attainable. As North Carolina's workforce has among the lowest rates of unionization in the country (2.0% of the private-sector workforce vs. 7.5% nationally), this is not expected to present any serious hiring challenges.

2.5 Defining the Geographic Scope

It is important at the beginning of this analysis that we determine the boundaries of the targeted geography to be investigated. For the purposes of this study we defined the Charlotte biomanufacturing laborshed as that area approximating a 45-minute driving distance from three Charlotte area life sciences employment nodes along I-77 and I-85:

- Charlotte
- Huntersville
- Concord/Kannapolis

It has been our experience that a 45-minute drive is often the maximum distance that a nonexempt (hourly) worker will travel for a desirable job paying the median wage in an area. We constructed a customized polygon that encompasses this drive zone. To facilitate the collection of occupational data we included every county associated with this polygon. This same approach was employed in our labor market analyses of the Triangle, Triad and Eastern North Carolina. In the Charlotte region the result is a 15-county area comprising the North Carolina counties of:

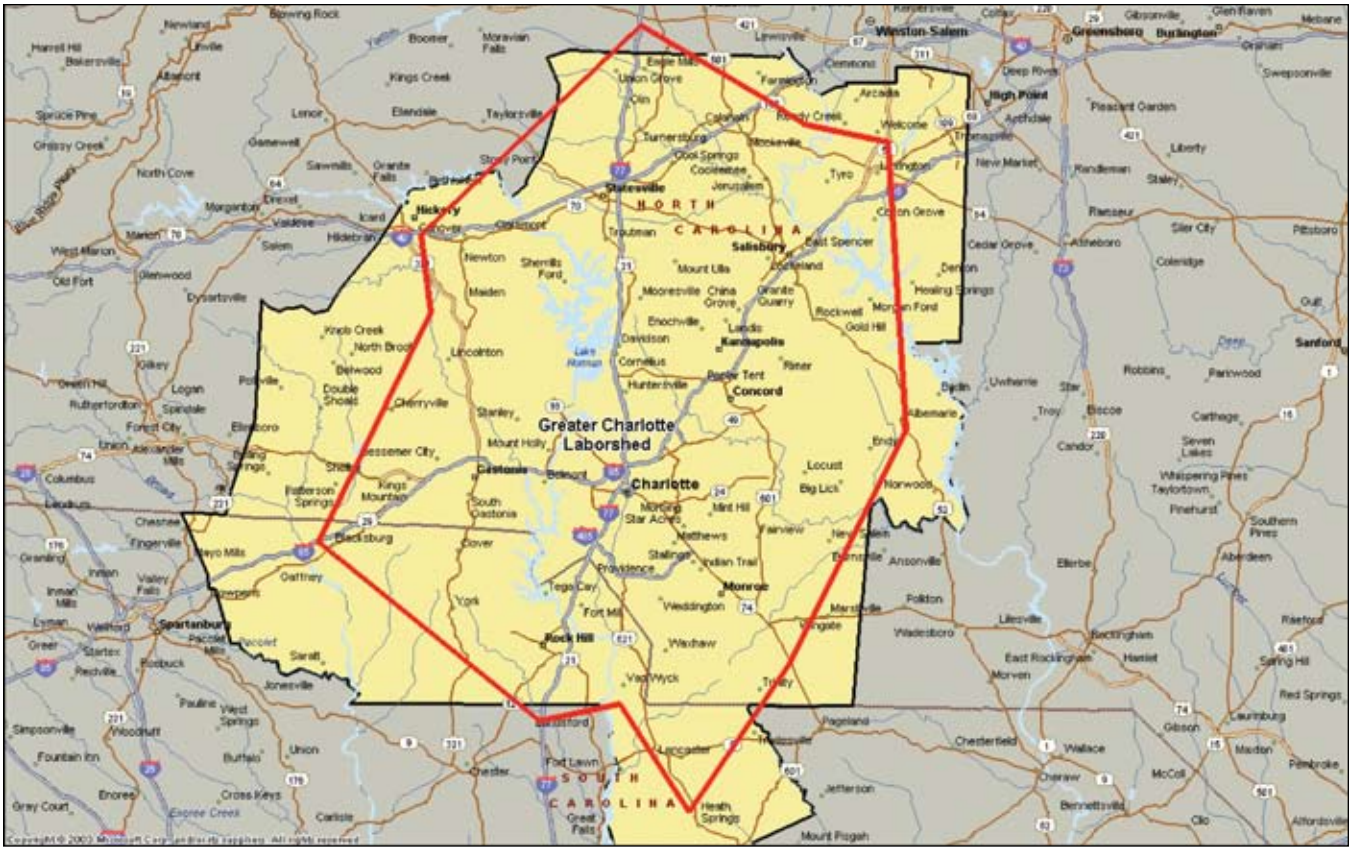
- Cabarrus
- Cleveland
- Davie
- Iredell
- Mecklenburg
- Stanly
- Catawba
- Davidson
- Gaston
- Lincoln
- Rowan
- Union

And the South Carolina counties of

- Cherokee
- York
- Lancaster

Davidson and Davie Counties are close enough to High Point also to be considered as part of the Triad laborshed, which was profiled earlier. The map below depicts the counties included in this laborshed (lightly shaded) and our customized 45-minute polygon as an overlay in red:

Projected Laborshed:



2.6 Gathering the Data

For this analysis our data gathering included:

- Primary research, including field interviews with employers, recruiters, academics and economic development officials in and around Charlotte; and
- Secondary research, including data describing occupations and academic curricula characteristic of the biopharma manufacturing sector in the regional laborshed. Much of the labor market data needed for this assignment are available from the major federal data sources (e.g., the Census Bureau, the Bureau of Labor Statistics) as well as the North Carolina Department of Labor, the University of North Carolina system, the North Carolina Community College System, the South Carolina Commission on Higher Education, the South Carolina Department of Employment Security and others.

Using these resources BLS & Co began assessing the Charlotte labor market.

2.7 Data Limitations

As is common during these types of engagements, the data sources presented a number of analytical challenges, the most significant of which was the lack of county-level occupational employment data for many of our targeted occupations (more fully described in Section 3.2), in the three counties that comprise South Carolina's portion of our labor shed. These data were suppressed by the South Carolina Department of Labor because their disclosure could reveal confidential information about certain major employers in the region. As a result, BLS & Co has chosen derive its estimates of the Charlotte region's *existing* biomanufacturing workforce from the detailed occupational data that we have been able to aggregate for the twelve counties in North Carolina and then to increase this amount by an additional 12% to reflect the share of the Charlotte region's civilian labor force that can be attributed to Cherokee, Lancaster and York counties in South Carolina. Our abilities to project the emerging biomanufacturing workforce (those graduates produced every year by North and South Carolina's community colleges and universities) were unaffected by these data limitations.

Other data management issues that arose during this study, and also during the prior analyses in the Triangle, the Triad and Eastern North Carolina, include the following (none of which would be considered detrimental to a study of this nature):

- The occupational data are reported by place of work, because place of residence data (which would have been preferred) are not available at the county level. We anticipate little impact from this decision to base our "headcount" on where employees work and not where they live. For example, our earlier interviews with employers in the Triangle and the Triad indicated that few recruited biomanufacturing workers from outside their respective regions to any significant degree.
- We faced some challenges gathering university enrollment and graduation data. The data bases of the University of North Carolina system and of the South Carolina Commission on Higher Education are very comprehensive but do not report the county of residence of graduating students at the curriculum level. To approximate these data BLS & Co used the distribution of student residences reported at the individual university level.
- We conducted interviews with seven contract medicine makers, manufacturers of nutritional supplements and medical device manufacturers in Greater Charlotte and also with area educators, recruiters and economic development officials. A staple of labor market analyses as practiced by BLS & Co, these conversations were very fruitful and yielded good information regarding current employment, hiring experiences, turnover, job training, etc. However these discussions cannot substitute for scientifically-controlled "surveys" as the sample size is too small and not every respondent was prepared, or willing to answer all of our questions.

3. THE SUPPLY OF EXISTING BIOPHARMA MANUFACTURING LABOR

3.1 Life Sciences Industry Profile in Greater Charlotte

Not regarded as a traditional center for biologics or pharmaceutical manufacturing, the Charlotte region can boast of a sizeable medical device/equipment cluster and is home to several notable manufacturers of pharmaceutical preparations and nutritional supplements. Prominent life sciences employers include:

- Actavis, Inc. (topicals and liquid preparations);
- CEM (laboratory equipment);
- Diagnostic Devices (medical devices);
- FMC Lithium (chemicals);
- Greiner Bio-One (laboratory equipment); and
- Solectron (devices)

Recent announcements include Biotage LLC's commitment to move 30 jobs and a medical instrument repair depot and customer contact center to Charlotte from Virginia, and LabCorp's agreement to operate a 40,000 square foot biorepository at the new North Carolina Research Campus in Kannapolis. The facility will store human biological samples for academic centers, research organizations, healthcare providers and biotechnology companies.

The Research Campus is perhaps the centerpiece of the region's efforts to further define and grow its life sciences sector. Planned is a $1 billion, 350 acre technology park that recently opened with three core buildings and is intended to host biotechnology and healthcare companies and academic institutions including research centers of the University of North Carolina system and a biotechnology training facility to be operated by Rowan- Cabarrus Community College. However, the park has had a difficult time getting established. Funding issues cost the campus a major tenant – PPD, Inc. which had anticipated adding as many as 300 new jobs in the Charlotte area, and UNC's new Nutrition Research Institute faces job losses after more than $1 million was sliced from its budget in 2009.

Some momentum was regained in mid-2009 when construction began on RCCC's new building, where the school intends to offer Associate degrees in Biotechnology and Agricultural Biotechnology as well as continuing education. Another recent, positive development was the decision by Congress to begin funding a new US Department of Agriculture Human Nutrition Center at the Research Campus. The Center would be one of seven such facilities operated by the USDA nationwide and would spearhead efforts to use biotechnology to help fight obesity, diabetes and cancer by focusing on individual health and nutrition.

The North Carolina Biotechnology Center surveyed biopharmaceutical companies as part of its 2003 and 2007

Table 1: Employment from "Windows on the Workplace," 2007: Greater Charlotte

					Projected	
		2002	2007	% Change '02-'07	2010	% Change '07 - '10
Biomanufacturing Total						
	Statewide	4,415	5,933	34.4%	6,442	8.58%
	Charlotte	0	0	0.0%	0	0.00%
Traditional Pharmaceutical Manufacturing						
	Statewide	8,808	9,424	7.0%	—	—
	Charlotte	188	257	36.7%	—	—
Pharma Manufacturing Service Provider						
	Statewide	2,374	2,286	-3.7%	—	—
	Charlotte	78	160	105.1%	—	—
Total Statewide		15,597	17,643	13.1%	—	—
Total Charlotte		266	417	56.8%	—	—

Source: North Carolina Biotechnology Center, 2008

"Windows on the Workplace" training needs assessments. It's most recent effort found that biopharma manufacturing (large molecule, cell-based drugs) has yet to impact the regional labor market, while traditional pharmaceutical employment and jobs at pharmaceutical manufacturing service providers, though relatively few, grew more rapidly than the statewide averages between 2002 and 2007.

3.2 Biopharma Manufacturing Occupations

A key objective of this study is to quantify the supply of existing, experienced talent with skills relevant or transferable to biopharma manufacturing in Greater Charlotte. BLS & Co's methodology is based on occupational data rather than industry or sectoral data. The sector approach would have required using North American Industry Classification System (NAICS) codes, the standard system of classifying industry adopted by the federal government. The limitations of NAICS codes are two-fold: 1] the System does not recognize "Biotechnology" or "Biomanufacturing" as industrial sectors; and 2] the System does not discriminate between scientific, manufacturing, administrative jobs, etc.

To address these omissions we resorted to The US Bureau of Labor Statistics Standard Occupational Classification (SOC) system, and SOC codes for occupational employment and wage data. The SOC system is the occupational classification system used by all federal statistical agencies. It consists of 801 detailed civilian occupations organized into 22 major groups. Excluded are military occupations, which are not covered in the Bureau of Labor Statistics survey. Because the SOC system does not distinguish biomanufacturing jobs from other technical and scientific occupations we turned to the work performed in 2006 by the San Diego Workforce Partnership, and in particular, its "crosswalk" between SOC codes and another, well-regarded occupational classification system developed by the Radford Biotechnology Survey.

In cooperation with North Carolina Biotechnology Center staff this crosswalk allowed us to narrow our focus considerably by eliminating occupations that had little or no relevancy to biopharma manufacturing and by enabling us to "drill down" to very specific *6-digit* occupational codes for those jobs that were deemed appropriate to our proxy project. This approach has resulted in the identification of the following SOC codes and occupations as those most frequently found in a biopharma manufacturing plant. Please notice that the functions have been aligned with those used to characterize the distribution of the workforce in our proxy project in Section 2.4:

Biopharma Manufacturing Occupations

Function	SOC Code	SOC Description
Manufacturing/Production	19-4021	Biological Technicians
	19-4031	Chemical Technicians
	51-1011	Supervisor/Managers of Production/Operating Workers
	51-4011	Computer Controlled Machine Tool Operators
	51-8031	Waste Treatment Plant/System Operators
	51-8091	Chemical Plant/System Operators
	51-9011	Chemical Equipment Operators/Tenders
	51-9012	Separating, Filtering, Clarifying, etc. Machine Operators
	51-9111	Packaging and Filling Machine Operators/Tenders
Quality Assurance/Quality Control	13-1041	Compliance Officers, Except Agriculture/Construction
	17-2199	Engineers, All Other
	19-1021	Biochemists and Biophysicists
	19-1022	Microbiologists
	19-1029	Biological Scientists, All Others
	19-1099	Life Scientist, All Others
	19-2031	Chemists
	19-4099	Life, Physical, Social Science Technicians, All Others

Function	SOC Code	SOC Description
	29-2012	Medical and Clinical Laboratory Technicians
Process Development	11-3051	Industrial Production Managers
	17-2031	Biomedical Engineers
	17-2041	Chemical Engineers
	17-2112	Industrial Engineers
	17-2131	Materials Engineers
Plant Ops/Manufacturing Support	17-3023	Electrical and Electronic Engineering Technicians
	17-3026	Industrial Engineering Technicians
	51-4012	Numerical Tool and Process Control Programmers
	51-4012	Numerical Tool and Process Control Programmers

3.3 Existing Biopharma Skill Base

The BLS & Co approach yields approximately 24,000 persons in 2008 in Greater Charlotte who are employed in occupations that are relevant and transferable to a biopharma manufacturing plant (see Table 2).

Charlotte has experienced an overall decrease of approximately 17% in the size of the potential biomanufacturing labor pool between 2000 and 2008. This is consistent with national and state-wide manufacturing trends and is comparable to the 10% drop that occurred in Eastern North Carolina over the same period. Epitomizing this trend is the loss of over 4,300 jobs at Pillowtex Corporation, which closed its Kannapolis plant in 2003. It is at the old Pillowtex site that the new North Carolina Research Campus is now rising.

Comparable to our findings in the Triad, hiring standards appear to be generally less rigorous among some of Charlotte's contract manufacturers, medical device and laboratory equipment suppliers when compared to biologics and traditional pharma manufacturers in the Triangle and in Eastern North Carolina. In fact, none of the seven local companies interviewed for this assignment required more than a high school diploma and perhaps some prior industrial experience as a condition for employment in a

Table 2: Employment by Biomanufacturing Occupation, 2000 – 2008: Greater Charlotte

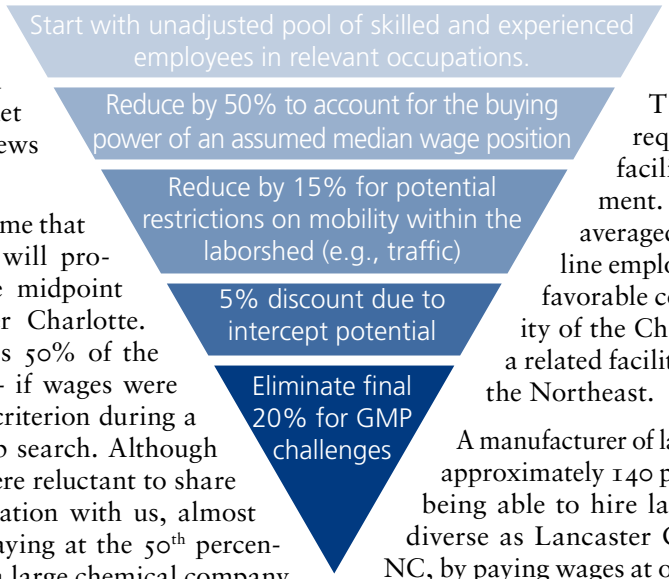
	Year 2000			Year 2008			Change 2000 – 2008		
SOC Description	Charlotte	State of NC	U.S.	Charlotte	State of NC	U.S.	Charlotte	State of NC	U.S.
Manufacturing/ Production	17,760	65,550	1,664,580	15,210	64,670	1,562,360	-14.4%	-1.3%	-6.1%
QA/QC	4,120	22,460	739,120	4,010	20,860	761,160	-2.7%	-7.1%	3.0%
Process Development	4,120	14,590	439,740	3,450	13,650	423,170	-16.3%	-6.4%	-3.8%
Plant Ops/ Manufacturing Support	2,940	10,380	332,250	1,210	5,900	254,670	-58.8%	-43.2%	-23.3%
Total	28,940	112,980	3,175,690	23,880	105,080	3,001,360	-17.5%	-7.0%	-5.5%

Source: North Carolina Department of Labor - Occupational Employment Statistics (OES), and Equal Opportunity Employment Commission (EEO) 2000 Data.

* Derived using multiple data sources - Claritas, EEO and OES.

production or manufacturing position. And, while some featured a GMP or GMP-like culture, none resembled the sterile environments found in a modern vaccine plant or biologics facility.

In the following section we will address how much of this labor force is available for each functional area of our proxy plant. With the assistance of our consulting partner, Wadley Donovan Gutshaw Consulting, we've designed the following methodology to derive a market-driven estimate of the availability of biomanufacturing worksite skills in Greater Charlotte:



These sequential adjustments are based on what we learned about the region's labor market dynamics during our interviews with area employers:

1. As a starting point we assume that our proxy manufacturer will provide compensation at the midpoint of the market in Greater Charlotte. Doing so effectively prices 50% of the market out of our reach - if wages were the sole decision-making criterion during a prospective employee's job search. Although several local employers were reluctant to share wage and benefits information with us, almost all made a point about paying at the 50th percentile. The one exception is a large chemical company, self-characterized as a "premium employer," seeking years of prior experience and (for its manufacturing positions) Associates degrees whenever possible.
2. There was relatively little concern among employers that Charlotte area congestion that could limit a prospective employee's willingness to commute. We have thus estimated that 10% of potential applicants would be disinclined to accept a particular job due to the adverse impact on their commute.
3. We eliminated another 5% based on the likelihood that they would pass-up a job at our proposed plant for another, equally attractive opportunity closer to home.
4. We made our final adjustment (20%) based on the perceived attractiveness of a job in the biopharmaceutical manufacturing industry. During our interviews elsewhere in North Carolina employers cited the challenges of working in an aseptic environment as one of the most significant disincentives to employment at their plant.

This methodology results in an accessible pool of almost 8,200 (out of 23,900) experienced and skilled employees capable of assuming positions in a biomanufacturing facility. The results for each function in our proxy plant follow.

3.4 Manufacturing/Production

As the pool of potential applicants far exceeds our annual hiring requirement, BLS & Co projects that the Central Piedmont labor force should be adequate to sustain the manufacturing/production functions at a large biologics facility. For example, paying competitive but not market leading wages a maker of topical medicines was able to hire 150 qualified employees in 2008, most for production positions. The H/R Director at the plant reported receiving an "overwhelming" response to an advertisement for the positions on the Charlotte Observer's recruiting website. The compounding positions required caps and masks, but the facility was not a sterile environment. Turnover at the company has averaged less than 8% per year among line employees. The H/R Director drew favorable comparisons between the quality of the Charlotte workforce and that of a related facility operated by his company in the Northeast.

A manufacturer of laboratory equipment employing approximately 140 persons in production reported being able to hire large numbers from places as diverse as Lancaster County, SC and Kannapolis, NC, by paying wages at or somewhat below the market median (approximately $11.50/hour to start).

The two chemical companies in our interview sample paid significantly above the wage midpoint (around $15 to $16 per hour to start, ranging as high as $23 per hour) but also sought to hire a more experienced workforce (up to 10 years prior experience, and/or an Associate Degree). Both reported little difficulty attracting or retaining production employees, even prior to the recession.

BLS & Co projects approximately 5,800 potential applicants for the 140 manufacturing/production positions requiring previous experience. As these jobs would be filled at the rate of 70 per year, the potential labor supply, including those with skills that could be transferable to biologics or pharmaceutical manufacturing, would more than exceed the target 15:1 hiring ratio. However, we caution that due to the absence of any measureable biopharma manufacturing in the Charlotte area at this time, the actual supply of operators and technicians specifically skilled or experienced in biomanufacturing processes will be much tighter. The table below summarizes the requirement and the derivation of labor supply:

MANUFACTURING/PRODUCTION LABOR SUPPLY DERIVATION	
Number Required:	100 per year
Number with Experience:	70 per year (70%)
Number without Experience	30 per year
Total Experienced NC Pool:	15,210
Wage Adjustment:	- 7,605
Commute Adjustment:	- 760
Intercept Adjustment	- 342
Attractiveness Adjustment:	- 1,300
	5,203 prospective experienced applicants in NC
	+624 projected applicants from SC
Final Yield:	5,827 total applicants
Target Yield at 15:1 hiring ratio	1,050 per year

3.5 Quality Assurance/Quality Control

Among local employers interviewed by BLS & Co., approximately one-half staffed their QA/QC departments with Biologists and Chemists, the rest treated their quality departments as an adjunct to the manufacturing function and staffed these positions with persons promoted from the production line (and rarely required more than a high school diploma). Those companies hiring professionals with 4-year or advanced degrees are generally satisfied with the supply of talent, though Analytical Chemists can be difficult to recruit, particularly if an employer is not well known.

BLS & Co projects a potential applicant pool of approximately 1,500 persons in Greater Charlotte for the 90 experienced staffers to be hired into the QA/QC organization during the two year ramp up period. This represents almost 3x the number of applicants needed to achieve our desired hiring ratio.

QA/QC LABOR SUPPLY DERIVATION	
Number Required:	50 per year
Number with Experience	45 per year (90%)
Number without Experience	5 per year
Total Experienced Pool:	4,010
Wage Adjustment:	- 2,005
Commute Adjustment:	- 200
Intercept Adjustment	- 90
Attractiveness Adjustment:	- 343
	1,372 prospective experienced applicants in NC
	+164 projected applicants from SC
Final Yield:	1,536 total applicants
Target Yield at 15:1 hiring ratio	675 per year

3.6 Process Development

The Charlotte area boasts a more than adequate supply of Chemical Engineers to staff process development positions according to employers interviewed by BLS & Co for this assignment. Locally, many experienced Chemical Engineers can now be hired out of the automotive and paper sectors, while Charlotte employers report being able to easily recruit engineers up and down the East Coast, due in no small part to the overall attractiveness of the Charlotte metro area as a place to raise a family. However, it is significantly more challenging to attract and retain good Mechanical and Electrical Engineers in Charlotte. Employers interviewed in the Triangle and the Triad and also in Eastern North Carolina reported similar difficulties recruiting experienced ME's and EE's. As noted in Section 3.2, we have not included Mechanical and Electrical Engineers in our profile of core biomanufacturing occupations.

BLS & Co anticipates a potential supply of more than 1,300 experienced process development employees within the Charlotte laborshed. This is significantly greater than the 210-person applicant pool that results from our desired 15:1 hiring ratio, based on 14 such experienced hires per year during the 2-year ramp-up period.

PROCESS DEVELOPMENT LABOR SUPPLY DERIVATION	
Number Required:	20 per year
Number with Experience	14 per year (70%)
Number without Experience	6 per year
Total Experienced Pool:	3,450
Wage Adjustment:	- 1,725
Commute Adjustment:	- 172
Intercept Adjustment	- 78
Attractiveness Adjustment:	- 295
Final Yield:	1,180 prospective experienced applicants in NC +146 projected applicants from SC 1,321 total applicants
Target Yield at 15:1 hiring ratio	210 per year

3.7 Plant Operations

Consistent with our previous analyses of the Eastern North Carolina, Triangle and Triad labor markets, the hiring margins for instrumentation and control technicians, process technicians and automation engineers in Greater Charlotte are thinnest of any biomanufacturing occupation we have tested. Among employers seeking more than just "handymen" such as those who employ skilled machinists, electricians and instrumentation mechanics, respondents reported some supply shortages and/or a lack of adequate experience. The situation was even more challenging five years ago when the local economy was firing on all cylinders.

Nonetheless, the data indicate that the area appears to have a supply of these skills that will be sufficient to accommodate a new biomanufacturer. BLS & Co projects a potential supply of about 480 experienced plant operations employees within Greater Charlotte. As our needs are 20 such employees per year we anticipate being able to meet our 15:1 hiring standard.

PLANT OPERATIONS LABOR SUPPLY DERIVATION	
Number Required:	20 per year
Number with Experience:	20 per year (100%)
Number without Experience	0
Total Experienced Pool:	1,250
Wage Adjustment:	-625
Commute Adjustment:	- 63
Intercept Adjustment	- 28
Attractiveness Adjustment:	- 107
Final Yield:	427 prospective experienced applicants in NC +51 projected applicants from SC 478 total applicants
Target Yield at 15:1 hiring ratio	300 per year

4. THE SUPPLY OF EMERGING BIOPHARMA MANUFACTURING LABOR

4.1 The Emerging Biopharma Manufacturing Skill Base

Greater Charlotte's emerging biopharma skill base is represented by enrollees and recent graduates from the state and region's community colleges and university systems (both public and private). Each county in the region has, or shares, a community college. Charlotte's notable institutions of higher education include Barber-Scotia College, Belmont Abbey College, Catawba College, Davidson College, Gardner Webb University, Johnson C. Smith University, Lenoir-Rhyne College, Livingstone College, Pfeiffer University, Queens University, the University of North Carolina at Charlotte (UNCC) and Wingate and Winthrop Universities in South Carolina.

4.2 BioWork Enrollment and Course Completions

Three institutions in the region (Gaston College, Rowan-Cabarrus Community College and South Piedmont Community College) have offered BioWork, a 128-hour fundamentals course providing entry-level training for the life sciences manufacturing industry designed by the North Carolina Biotechnology Center. Because BioWork has only limited barriers to entry it is available to job seekers with lower levels of education. The majority of BioWork students come from low-paying industries such as retail sales, food service and healthcare support. Many also have been displaced from traditional manufacturing sectors, such as textiles (including former Pillowtex employees).[4] The BioWork program at RCCC is presently inactive, pending an expected increase in demand once the economy improves. To the best of our knowledge nearby York Technical College, in South Carolina, does not offer a short-course that is comparable to BioWork.

Earlier we projected that our plant would need to hire 70 experienced manufacturing/production employers each year for two years. To fill the "slots" available to 30 or so less experienced employees a plant operator could turn to the 22 BioWork course completers produced annually in Greater Charlotte as depicted in Table 3, below.

Table 3: BioWork Enrollees and Graduates, 2004-2008: Greater Charlotte

Community College	2004-2008 Average Enrollment	2004-2008 Average Annual Completions*
Rowan-Cabarrus CC	19	18
South Piedmont CC	2	2
Gaston College	2	2
Total	**23**	**22**

Source: North Carolina Community College System Data Warehouse

*Note: Completions based on average 94% reported at Wake Tech and Wilson CC

However, our interviews with several BioWork observers revealed that on average only 40% to 50% of course completers take jobs within the biopharmaceutical industry. Thus, we discounted the estimated annual supply of BioWork completers in the Charlotte region to approximately eight per year, an insufficient number to accommodate our plant's needs (and even less so if another major biomanufacturer were to be in the job market at the same time). However, it bears mentioning that employers in the region are not limited to just these three colleges, thus the potential BioWork pool, which averages approximately 840 enrollees per year system-wide, can be considerably larger.

4.3 Biopharma Manufacturing Curricula

Neither is the emerging labor pool limited to BioWork graduates. To quantify the potential supply of Associates degree candidates and new undergraduate, graduate and doctoral degree holders BLS & Co and the staff of the Biotechnology Center identified the academic curricula most relevant to biopharma manufacturing.

We used the US Department of Education's Classification of Instructional Program (CIP) coding system, the Radford Biotechnology Study and the work performed by the San Diego Workforce Partnership to develop our inventory of educational programs. This list includes only those codes for which North and South Carolina's community colleges and universities reported enrollment between 2005 and 2008:

Biopharma Curricula

Function	CIP Code	CIP Description
Manufacturing/Production	A21080	Industrial Pharmaceutical Technology (AS)
	A50110	Chemical Process Technology
	A50440	Bioprocess Manufacturing Technology (AS)
Quality Assurance/Quality Control	A20100	Biotechnology (AS)
	A20140	Environmental Science Technology (AS)
	A20180	Industrial Laboratory Technology (AS)
	260101	Biology/Biological Sciences
	260202	Biochemistry
	260204	Molecular Biology
	260502	Microbiology
	261102	Biostatistics
	261201	Biotechnology
	400501	Chemistry
Process Development	140701	Chemical Engineering
	143501	Industrial Engineering
Plant Ops & Manufacturing Support	A35100	A/C, Heating and Refrigeration Technology (AS)
	A40240	Industrial Engineering Technology (AS)
	A50100	Biomedical Equipment Technology(AS)
	A50190	Facility Maintenance Technology (AS)
	A50240	Industrial Maintenance Technology (AS)
	D50170	Facility Maintenance Worker (AS)
	150612	Industrial Technology/Technician
	150613	Manufacturing Technology/Technician
	150699	Industrial Production Technologies/Technician

4.4 Community College Enrollment

BioNetwork is a statewide initiative of the North Carolina Community College System that provides specialized training and equipment to develop the state's workforce for the biotechnology and pharmaceutical industries. In Greater Charlotte Gaston College has had the most established biotechnology program, and presently offers an Associate in Applied Science degree (AAS) in Biotechnology. Central Piedmont Community College offers a similar curriculum in cooperation with Gaston College (a so-called "1+1" program) and Cleveland Community College offers a biotechnology track to students training for work as lab technicians.

As noted earlier, Rowan-Cabarrus Community College (RCCC) hopes to soon take occupancy of its new building (with a simulated aseptic suite) on the North Carolina Research Campus in Kannapolis. In anticipation of that event the school has begun to offer its own AAS in Biotechnology, with bioprocessing options. Until recently this degree was provided via a 1+1 agreement with Gaston College. During the fall semester of 2009 approximately 100 students enrolled in the biotechnology program, many of whom were dislocated workers whose tuition was reimbursed by the NC Department of Employment Security. RCCC also offers an AAS in Industrial Engineering Technology with a bioprocessing concentration.

The community colleges serving the 15-county Charlotte region (including York Technical College in Rock Hill, SC) enroll an average of 520 students per year in biopharma manufacturing disciplines. Our research reveals that a significant number of these enrollees will not complete their degrees in a timely manner, if at all. Among this group are those who will leave college for a new job and

fail to complete their degree requirements. Others work full-time while in school and thus may take many years to achieve their degrees. Employers interviewed by BLS & Co have reported relatively high levels of satisfaction with these non-degree "dropouts," thus the number of students potentially available to industry should not be limited to those who have completed their degree requirements. Below we have chosen to reflect Associates degree enrollees rather than graduates in the pool that can satisfy our project's allowance of inexperienced labor.

Based on these data BLS & Co estimates that Charlotte's community colleges will be able to produce the following annual supply of inexperienced new hires:

- Approximately 8 prospective production employees, based on the projected number of BioWork completers to satisfy our project's appetite for 30 inexperienced new hires per year
- 88 prospective QA/QC employees to meet a need for just 5 inexperienced new hires per year; and
- 432 prospective plant operations personnel, all of whom will likely require additional experience to be considered qualified for positions.

4.5 Undergraduate Degrees

Although some employers fill manufacturing jobs with candidates possessing 4-year degrees this is not the norm. Generally, the undergraduates receiving biopharmaceutical-related degrees find themselves in process development and quality control positions, depending on the types and amount of industry experience they also have been able to attain. For these jobs the annual output of North and South Carolina's public and private universities is more than ample to fill our project's requirements.

Employers who agreed to speak with BLS & Co. reported success hiring biologists and chemists from the small Division II and Division III schools in the area, such as Gardner-Webb University and Belmont Abbey, in addition to NC State and Appalachian State Universities. While NC State University and other nearby schools (e.g. Clemson and Virginia Tech) are a good source of new engineering talent.

Another educational asset nearby is the new Biomanufacturing Education and Training Center (BTEC) at NC State University. In our earlier report on the Triangle labor market, local employers lauded BTEC for the quality of its engineering grads and for the hands-on training offered on its 300 liter bioreactor and in its aseptic suites. BTEC expects to be able to graduate approximately 100 students in the Biomanufacturing minor once classes are fully subscribed. The Center is now graduating more Chemical Engineering students with Biomanufacturing minors than industry is able to absorb in the Raleigh Durham market. Therefore, as a statewide asset, BTEC will also benefit the Charlotte labor market.

As employment outcome data were hard to come by BLS & Co defined the emerging labor pool as those graduating students whose permanent address is in Greater Charlotte, as well as those graduating from colleges in the Charlotte region but actually residing elsewhere. Based on these parameters, Table 5 below indicates that public colleges of North Carolina and South Carolina plus the region's 11 private schools (e.g., Barber-Scotia College, Belmont Abbey College, Catawba College, Davidson College, Gardner Webb University, Johnson C. Smith University, Lenoir Rhyne College, Livingstone College, Pfeiffer University, Queens University and Wingate University), produce more than 600 biomanufacturing-related graduates per year for Charlotte employers.

Table 4: Selected Associate's Degree Enrollment: Students from Greater Charlotte

Function	CIP Code	Curriculum	2004-2008 Average Enrollment
QA/QC	A20100	Biotechnology	64
	A20160	Industrial Laboratory Tech*	24
Subtotal			**88**
Plant Ops & Mfg Support	A35100	A/C Heating & Refrigeration Tech	119
	A40240	Industrial Engineering Tech	89
	A50100	Biomedical Equipment Tech	47
	A50190	Facility Maintenance Tech	0
	A50240	Industrial Maintenance Tech	112
	50805	Mechanical Engineering/ Mechanical Tech**	30
	470705	Industrial Electronics Tech**	35
Subtotal			**432**
Total			**520**

Sources: North Carolina Community College System, BioNetwork; SC Commission on Higher Education

* Clinical Medical Lab Technician in South Carolina)

** South Carolina only

Table 5: Selected Undergrad Degrees: Greater Charlotte

Function	CIP Code	Curriculum	Average Annual Degrees: 1999-2007	
			Grads From Charlotte*	Grads at Univ's In Charlotte
Process Development	140701	Chemical Engineering	10	0
	143501	Industrial Engineering	7	0
Subtotal			**17**	**0**
Plant Ops & Mfg Support	150612	Industrial Technology	21	5
	150613	Manufacturing Technology	3	0
	150699	Industrial Production Tech	3	0
Subtotal			**27**	**5**
QA/QC	260101	Biology/Biological Sciences	251	176
	260202	Biochemistry	14	3
	260204	Molecular Biology	1	0
	260502	Microbiology, General	7	0
	261102	Biostatistics	1	0
	400501	Chemistry, General	69	45
Subtotal			**343**	**224**
Total			**387**	**229**

Sources: University of North Carolina, Academic Planning Inventory, (*http://fred.northcarolina.edu/enrindex.html*), and The South Carolina Commission on Higher Education (*http://www.che.sc.gov/New_Web/Rep&Pubs/Enrollment*)

*Note: Grads from the Charlotte area are based on share (%) of students at each univ reporting Charlotte counties as residence

Based on conversations with the chairs of several university departments BLS & Co assumes that 25% of these graduates will pursue additional education while the remainder will enter the labor force, resulting in:

- Approximately 425 graduates in Greater Charlotte who've majored in Chemistry, Biology, Biochemistry, Molecular Biology, etc. to satisfy the small annual need for relatively inexperienced QA/QC staffers;
- 13 graduates from the area who've majored in Chemical Engineering or Industrial Engineering to satisfy the need for approximately six inexperienced process development staffers; and
- About 24 graduates who've majored in Industrial Technology, Manufacturing Technology, etc. and could step into professional or managerial positions in plant operations and manufacturing support.

4.6 Graduate & PhD. Enrollment and Degrees

Lastly, we considered the potential pool of students graduating with advanced degrees in the biopharmaceutical disciplines. Even more so than their undergraduate counterparts, these persons would likely assume either process development or quality control positions, either at a higher level, or at the same level but with less actual on-the-job experience. The average number of annual graduates available in Greater Charlotte (132 total) constitutes an important addition to the labor pool.

Table 6: Selected Graduate & Ph.D Degrees: Greater Charlotte

			Average Annual Degrees: 1999-2007	
Function	CIP Code	Curriculum	Grads From Charlotte*	Grads at Univ's in Charlotte
Process Development	140701	Chemical Engineering	7	0
	143501	Industrial Engineering	8	0
	143601	Manufacturing Engineering	2	0
Subtotal			**17**	**0**
Plant Ops & Mfg Support	150612	Industrial Technology	7	0
QA/QC	260101	Biology/Biological Sciences	20	18
	260202	Biochemistry	4	0
	260401	Cell/Cellular Biology	1	0
	260502	Microbiology, General	2	0
	260503	Medical Microbiology	1	0
	260801	Genetics, General	4	0
	261001	Pharmacology	1	0
	261004	Toxicology	3	0
	261101	Biometry/Biometrics	1	0
	261102	Biostatistics	6	0
	261201	Biotechnology	8	8
	400501	Chemistry, General	23	8
Subtotal			**74**	**34**
Total			**98**	**34**

Source: University of North Carolina, Academic Planning Inventory (*http://fred.northcarolina.edu/enrindex.html*) and The South Carolina Commission on Higher Education (*http://www.che.sc.gov/New_Web/Rep&Pubs/Enrollment*)

*Note: Grads from the Charlotte area are based on share (%) of students at each univ reporting Charlotte counties as residence

5. CONCLUSIONS

Table 7 below provides a synopsis of our project's talent requirements and sources of qualified workers or labor market entrants that have the potential to satisfy this demand. Greater Charlotte resembles the Triad region in that the area boasts little biologics or pharmaceuticals manufacturing activity at present. However, the composition of the workforce is such that we can conclude that the existing skills (if not the experience) are available in sufficient quantity to be able to sustain a large biomanufacturing operation, provided that the recruiting, training and development of staff could proceed at a pace adjusted to local market conditions. The emerging labor pool is presently affected by the shortage of BioWork completers and of students enrolled in industrial pharmaceutical, chemical process or bioprocessing technology in local community colleges. The staffing of new production and quality control positions is expected to benefit from the resumption of BioWork training and the ability to fully enroll the new AAS in Biotechnology (and bioprocess area of concentration) program at Rowan-Cabarrus Community College.

As we have noted earlier, the Governor's office and the North Carolina Biotechnology Center have made biomanufacturing a strategic priority in their efforts to diversify the state's economy via clean, high-paying jobs. North Carolina's extensive biomanufacturing training capability and infrastructure, which has evolved and grown as a result of these initiatives, places the state in a strong position to supply the relevant skills identified in this study. While this pool will feature varying degrees of expertise specific to biomanufacturing (some will have direct skills, others will possess transferable experience) the state and its partners have made substantial investments to help bolster the biomanufacturing labor pool in Greater Charlotte and in other targeted regions around the state.

Table 7 : Summary of all Sources of Labor: Greater Charlotte

Function	Total Hires	Annual Hires	Target Yield @ 15:1 Ratio	Projected Annual Supply	Source of Supply
Existing Biopharma Manufacturing Labor					
Manufacturing/Production	140	70	1,050	5,827	Labor Force
QA/QC	90	45	675	1,536	Labor Force
Process Development	28	14	210	1,321	Labor Force
Plant Ops/Manufacturing Support	40	20	300	414	Labor Force
Emerging Biopharma Manufacturing Labor					
Manufacturing/Production	60	30	—	8	BioWork and Community Colleges
QA/QC	10	5	—	621	Community Colleges & Universities
Process Development	12	6	—	30	Universities
Plant Ops/Manufacturing Support	0	0	—	478	Community Colleges & Universities

REFERENCES

Endnotes

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2 "Learning Curves Ahead." Site Selection Magazine, August 2007.

3 "Job Creation and the Knowledge Economy: Lessons from North Carolina's Life Science Manufacturing Initiative." Nichola Lowe, Economic Development Quarterly, November 2007, and Life Science Manufacturing in North Carolina: A Case Study for Workforce Development." Carolina Context, June 2007

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For more information, contact:

Biggins Lacy Shapiro & Company
Andrew Shapiro
47 Hulfish Street
Princeton, NJ 08542
Phone 609-613-4273
FAX 609-924-8817

North Carolina Biotechnology Center
William Bullock
Statewide Operations and Economic Development
15 T.W. Alexander Drive
Research Triangle Park, NC 27709-3547
Phone 919-541-9366
FAX 919-990-9544
www.ncbiotech.org

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