A. Nature and significance of the project

This project's goal is to assess change in the population and the economy of Imperial County and assess its environmental impact in terms of water supply, energy supply, and urban structure. There will be particular focus on those Imperial County economic sectors affected by the rapid growth of the city of Mexicali, which borders Imperial County on the Mexican side. We include Mexicali in the study because it is one of the fifteen largest cities in Mexico and lies just adjacent to the border with Imperial County. In fact, Mexicali's population in 2000 is 765,000 (INEGI, 2000), which is five times Imperial County's estimated 2000 population of 155,000 (State of California, 2000). Hence, it is influential to Imperial County's population i.e. through immigration; to its economy; and to its environment, since many systems including water and energy are inter-connected.

The research questions are the following:

1. What is the extent of population growth in Imperial County and its cities, and what will be the projected population growth and its spatial array in the county?
2. Why hasn't the Imperial County system of cities, adjacent to the border, developed in base size to the extent of other U.S. border cities, such as San Diego and El Paso?
3. Do indicators and trends present in the late 1990s and 2000 point to a substantially larger urban complex in Imperial County?
4. What county industry sectors have benefited by the influence of Mexicali and the border, and how have they benefited?
5. How are those border-influenced sectors arranged spatially in the county, and what factors are influencing their future spatial pattern?
6. What are the effects on the urban structure of Imperial County from the NAFTA-driven growth in cross-border trucking and transport?
7. What are the potential environmental impacts of the border-influenced economic sectors on the environment of Imperial County? In particular, of major analytical interest here are the effects of population and economic growth in Imperial County and Mexicali on availability of water supply to Imperial County? What are the spatial proximities of future population and economic growth and water supply locations?
8. What are the effects of population and economic growth on the availability of energy supply to Imperial County? What is the spatial distribution of energy supply for Imperial County and its population centers, based on the southern California-Mexico energy grid?

The project is a new one. The significance of the project as it relates to CUEREC's mission and research objective is that Imperial County needs to better understand the border-induced population and economic growth in order to better plan and develop its urban complex. The present project's geographic information system and demographic and economic sector analysis will help planners and decision makers in the county and its cities understand the latest emerging patterns of growth in the post-NAFTA era and into the 21st century. The project involves a partnering with the county government unit VIDA that today has the most county capability and interest in economic development.

The population of Imperial County grew rapidly in the 1990s due to increasing migration from other U.S. regions and from Mexico due to economic reasons. This population growth is forecast to continue to increase rapidly over the next 30 years. For instance the State of California forecasts that Imperial County's population will grow to 394,000 by 2030 (Department of Finance, 1998). The cities will grow larger as well. The county is already highly urbanized, for instance in 1990 seventy four percent of the county population was located in urban incorporated places, and is forecast to become more urban. The three largest cities of El Centro, Calexico, and Brawley are projected to be in the 50,000 to 70,000 range by 2020 (Imperial Valley Association of Governments, 1996). This population growth is a key factor underlying this research proposal. Population of nearly 400,000 and much larger cities implies a very different type of urban structure, a changed economy, changes in business sectors, altered transport, and greater urban environmental impacts on issues such as water supply and energy supply. The county, cities, and private enterprises will need enhanced information on which to base decisions that plan and control this expansion.

On the other side of the border from Imperial County and directly across from Calexico is the large Mexican city of Mexicali. Mexicali's population is three quarter million in 2000 and is projected to be nearly

one million in 2020 (est. from Peach and Williams, 1999). It is a prosperous city that has developed substantial manufacturing and service sectors. The maquiladora industry has grown to a level of 128 maquiladora plants and 32,863 maquiladora workers in 1996 (INEGI, 1997). A maquiladora is a co-production arrangement between enterprises that partner on both sides of the U.S.-Mexico border. The Mexican partner firm focuses on low cost assembly and production, while the U.S. enterprise often focuses generally on component production, product development, logistics, and support. While the economy of Imperial County has been fairly stable and half agricultural, that of Mexicali has grown into a large industrial base of increasing national and international importance. Although Mexicali is smaller than the Mexican cities of Tijuana and Ciudad Juarez in maquiladora production, its maquiladora sector has been growing exponentially and the city ranks fifth in Mexico maquila output (INEGI, 1997; Butler, Pick, and Hettrick, 1999). Mexicali has three major economic sectors (1) maquiladora industry and services, which is foreign controlled and oriented nearly entirely towards foreign export, (2) industry and services of local origin, and (3) agriculture (Estrella and Ranfla, 1996). It is the maquiladora sector that accounts for the greatest border exchange and the strongest connections with Imperial County.

VIDA (Valley of Imperial Development Alliance) is a unit of the Imperial County government that has the goal of maintaining cooperation between county and city governments and the private sector and establishing a business environment that is conducive to economic growth, as well as improving the quality of life in the county. VIDA has gathered and provided information and data, gained funding for small businesses, and applied for and achieved community development designations in the county. It is the primary county location for economic development and demographic data. Its director has indicated strong support for the proposed project and has stated that the information and findings will be valuable in complementing VIDA's current information and enlarging its ability to provide knowledge and advice about urban growth and development.

The project will provide VIDA with cutting edge technologies, technology training, results and findings from the latest federal government and private sector data, benefits of advanced data-bases and knowledge of Mexican government data-bases, and the potential to incorporate parts of the GIS into VIDA's long-term planning system. It will also provide benefits to other county and city planning units that will help them understand the early stages of an enlarged urban and city complex.

Project Personnel

The proposed project will be based in the Department of Management and Business at the University of Redlands. Department faculty participating in the research are Dr. James B. Pick, Professor of Management and Business, as Principal Investigator (PI), and Dr. Nanda Viswanathan, Assistant Professor of Management and Business, as Associate Investigator (AI). As seen in the attached resumes, the investigators have had experience in research on economic development, population growth, marketing, statistical methods, and spatial analysis. Both researchers were involved in 1998-99 in a large study of the U.S.-Mexico border twin cities, and Dr. Pick has studied Imperial County and other southern California counties.

Approaches and Methods

The methodology includes spatial analysis (GIS), statistical analysis, demographic methods, and economic sector analysis. The GIS will build on an existing GIS that the investigators constructed as part of a large project in 1998-99 sponsored by the Ford Foundation (Pick et al., 1999a, 1999b). That project had a purview of the entire U.S.-Mexico border, of which Mexicali-Imperial County is one part. That project focused on small area data from the 1990 Mexican and U.S. Censuses and from some mid-90s government data. Thus that GIS presently contains the block group information for Imperial County for numerous demographic and socio-economic parameters.

The present project will greatly enlarge the existing Imperial County GIS by adding extensive data from the 2000 U.S. Population Census, 1997 U.S. Economic Census, from the Dun and Bradstreet Business File, and from the Metromail national consumer data-base. The present GIS will be supplemented with additional geographic layers including a street file layer, which will be helpful in understanding the siting of businesses as well as transportation and trucking changes and impacts. ESRI's Business Analyst software (ESRI, 1999) will be utilized and is compatible with the present ArcView/ArcInfo software.

The project will utilize the data available at the city level (i.e. for places of 2,500 +) from the 1997 Economic Census (U.S. Bureau of the Census, 1999). This is an exceptionally rich data set that appears only at five-year intervals. The city-level attributes utilized in the proposed research include those on manufacturing, retail and wholesale trade, information, transportation, professional/scientific/technical services, administrative and support services, waste and remediation services, real estate, health care and social assistance, educational services, accommodation and food services, and other services (U.S. Bureau of the Census, 1999). The 2000 Population Census data will be available to the project in November of 2000 and will provide detailed demographic and economic information on persons, households, cities, and other urban units.

The small area data of the Mexican Population Census of 2000 will become available to the project in April of 2001 and will be utilized to analyze Mexicali. In addition, the Mexican economic census of 1999 provides information on businesses and industry in Mexicali (INEGI, 1999).

The spatial analysis will be greatly assisted by access to data in the Center for Environmental Management and Policy Laboratory in Duke Hall at the University of Redlands. The researchers have benefited by interactions with Center researchers and other campus investigators and projects, including the multi-year Salton Sea Research Project (SSRP). The SSRP's publicly availably data will be particularly useful in assessing environmental impacts since it complements the economic and demographic data of the present researchers.

Univariate and multivariate statistical analysis will be applied to studying the patterns of changes in border-influenced economic sectors. The techniques include analysis of variance, regression analysis, and cluster analysis. The researchers have done many studies of urban areas utilizing these and other statistical techniques (Butler and Pick, 1982; Pick and Butler, 1997; Pick et al., 1999a; Pick et al., 1999b). Demographic methods include population projections, age structure graphical analysis, and labor force projections, which the investigators have applied extensively. The researchers have studied through GIS and spatial analysis the urban structure and binationality in all of the U.S.-Mexico border cities in a project sponsored by the Ford Foundation in 1998-99 (Pick et al., 1999a). In the proposed research, the economic sectors will be studied through statistical comparisons. One researcher did this previously for Imperial County (Butler and Pick, 1982).

Environmental analysis.

The potential environmental impacts of population and economic growth in Imperial County include effects on water supply, water quality, air pollution, noise, land use, congestion, and public health. Furthermore, future population growth in Imperial County may be constrained by the availability of certain resources, like water and energy. Future population growth will have certain impacts on the local environment that may have both local and regional consequences, thus this growth is both impacted by, and impacting on, the environmental base. The research will correlate existing and past development patterns with the location and characteristics of existing environmental resources, the evolution of technologies that have been implemented to overcome local constraints, and the environmental problems that are likely to occur. This research will emphasize the problems of water supply and energy supply. These attributes are of overriding importance in Imperial County because of the importance of agriculture and agri-business, which demand substantial water supply and depend also on energy supply.

The water system of Imperial County stems from the Colorado River. Water is diverted through the All American Canal and flows then through a large system of canals to irrigate the large agricultural area of Imperial County. Waste waters flow eventually through the New and Alamo Rivers draining ultimately into the Salton Sea. This system is further complicated by the water flows in the Mexicali Valley. Water again is diverted from the Colorado River and flows through irrigation canals in the Mexicali Valley, also draining into the two rivers prior to entry into Imperial County. As a consequence of the water consumption in Mexicali, the population and economic growth of the Mexicali municipio also need to be taken into account in assessing the water supply in Imperial County.

The data for the water supply in Imperial County are available from the Bureau of Reclamation, the EPA, and Imperial Irrigation District (IID). Much of the boundary and attribute data is already in GIS compatible form through the Salton Sea Project at University of Redlands, a project which provides data-sets to the public.

The energy data are available in the U.S. from a variety of sources including Imperial Irrigation District, Sempra Energy, U.S. Dept. of Energy, SANDAG, and California Energy Commission. In Mexico the energy data are available from INEGI, Pemex, and SEMERNAP. The energy production sites and the distribution grid will be digitized (Sweedler, 1995). The attributes available emphasize energy production. The

overlay of the energy grid with present and projected population and economic sectoral output will indicate proximity for development of energy consumptive industry. Also, the analysis will highlight in much more detail the interplay between Mexicali population and economic growth and that of Imperial County with respect to energy.

The GIS data analysis needs of this project require the following data categories: river, stream, and canal network coverages; EPA Storet water quality sample locations with data; USGS flow sample locations with data; geothermal energy plant facilities; major energy utility distribution liens. These will be juxtaposed as overlays with the U.S. and Mexican demographic layers.

The Salton Sea Database Program (SSDP) at University of Redlands has compiled most of the data for water resources and energy for Imperial County. The U.S.-Mexico Database Project has done the same for much of the demographic information for the U.S.-Mexico border (of which James Pick is co-director). Using the SSDP Request for Information (RFI) process, data will be requested based on the GIS data analysis needs. The SSDP will also provide metadata for the GIS data.

The analysis consists of establishing a study area, boundary coverages for Imperial County and the Mexicali municipio. The GIS data will be normalized to conform to 1:20,000 scale USGS DLG data. This enables proximity and buffer overlay analysis of population, economic development, and water supply. In the Mexicali Valley, it will highlight flow patterns that consume substantial water flow that may impact Imperial County. The analysis will also point out impacted corridors near the New and Alamo Rivers that may be adverse to economic development due to environmental pollution.

Based on this spatial analysis, the researchers will assess the potential influence of economic and demographic growth on these and other environmental impacts. The PI has experience in doing environmental impact analysis including for Imperial County geothermal energy (Butler and Pick, 1982) and environmental impacts on Mexico City (Pick and Butler, 1997), as well as in other projects and studies. The Center for Environmental Management and Policy at University of Redlands provides additional expertise.

Timetable

The project will run from January of 2001 through July of 2002. The extended length of this project is requested because the U.S. Census 2000 data for small areas become available in December of 2001, so this gives sufficient time to thoroughly incorporate those data. The detailed work plan is given below. This includes work and consultation with VIDA throughout the project. One of the project tasks is to assist VIDA staff in installing the project's GIS data on VIDA computer systems. The research work timetable showing the tasks of the project and due dates is given in Appendix A.

Outcomes

The outcomes of the project include articles, conference papers, reports, and a book. They will be completed during the second half of the project and in the several months afterwards. In addition, the researchers will provide parts of the data-base to VIDA and help to install it on its systems, and will provide training on its use and GIS. VIDA has already installed a new computer system for GIS technology at the time of this proposal. When the project's data-base is complete, the project team will help VIDA install the data-base on system(s) at VIDA and ensure that there is a workable GIS and that the staff is oriented to its use.

The researchers plan to follow up this project with three additional grant proposals for external funding. One is a study of the demographic and economic growth of San Diego relative to the growth of Tijuana. It is based on similar methodology and data relative to the present study, but is much larger and more complex due to the greater size of San Diego and Tijuana. A second external grant would fund an attitudinal survey in the twin urban areas of Imperial County and Mexicali regarding urban growth and its environmental impacts. A third follow-up grant proposal is planned to set up an econometric and demographic forecasting system for Imperial County and Mexicali.

The significance of the project for the urban environment is that problems can be ascertained before they occur or in early stages of development, so the planning agencies and public can become aware of them ahead of time. Secondly, the data and spatial systems will be made available to the county, cities, local universities and colleges, non-profit agencies, and the public for their future analytical uses. This will give them greater knowledge of recent economic and population trends, the effect of these trends on the availability

of water and energy, greater capability to make informed decisions about urban policies, and enhanced ability to assess the impact of Mexicali on the cities and urban growth of Imperial County.

APPENDIX A. Project Work Timetable

Research Work Plan

Jan - May 2001	Gather latest demographic and economic data from U.S. population and economic censuses. Incorporate industry and marketing data available from ESRI. Gather water and energy data from Bureau Reclamation, IID, EPA, DOE, Salton Sea Database Project, and other sources. Start to construct GIS and link in data. Gather literature. Conduct initial meetings with VIDA.
May - June 2001	Complete GIS and linking of the data. Conduct field visits to Imperial County to gather local business and sectoral industry data and discuss the GIS model with VIDA and city and county agencies.
July 2001	Submit materials to Cuerec for 6 month project review.
July 2001-Oct. 2001	Perform statistical analysis. Perform industry analysis/projections and initial demographic analysis/projections.
July 2001-Feb. 2002	Perform environmental impact analysis. Analyze impacts of population and economic growth on water supply, energy supply, and urban structure. Present and discuss the findings with subject matter experts and community experts in Imperial County. Update the GIS with the latest data, including U.S. Census 2000 data available in November.
March-April 2002	Prepare final report. Complete GIS for distribution to VIDA. Work with VIDA on initial installation of the GIS at VIDA. Provide a series of GIS training sessions to VIDA.
May 2002	Present Final Project Report to Cuerec Grants Management Board of Governors. Help VIDA develop an action plan on maintenance of GIS data-base.
May, June 2002	Evaluate research project. Prepare articles, papers, additional grant proposals, and work on book. Conduct capstone workshop with VIDA and others in Imperial County.

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