"Beyond the Generation of Data for Watershed Management: The experience of the Tijuana River Bi-national Watershed Advisory Council"

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Abstract. The major challenges faced by trans-boundary watershed management between two or more countries are not limited to the availability and compatibility of reliable data, but require the existence of a pool of actors able to work cooperatively under specific goals to improve and plan the conditions of the watershed. In this paper we present an overview of the evolution and accomplishments of the Bi-national Watershed Advisory Council (BWAC), a body organized as part of the project: *A Bi-national Vision for the Tijuana River Watershed* , during its existence to date. The paper covers the following aspects: 1. An introductory description of the Tijuana River Watershed (TRW) and the previous efforts in the region to approach its problems from a binational perspective; 2. The conceptual framework of operation of BWAC: a bi-national vision for the TRW; 3. The experience of BWAC to date; 4. Conclusions and reflections on what lies in the future.

Introduction.

The U.S.-Mexican Border is an area that faces important challenges in the future. Rapid industrialization and economic development have led to dramatic population increases, mainly in the Mexican urban counterparts, with the corresponding effects on the use of the available natural resources, and contamination patterns that further complicate the seeking of solutions. Since the early 1990s, an increasing interest has developed among the academia and other non-governmental sectors over the environmental problems faced by this region. Two of the most immediate avenues behind this trend may be identified as: 1. A growing presence of academic research activities at both sides of the border, and under a number of binational partnerships; 2. The emergence of binational initiatives to approach specific problems at the regional and local levels. In the first case a major challenge has been the availability of compatible data, while the formation of binational groups dealt with the coordination problems inherent to this type of organizations.

One of the characteristics of the growth experienced by the border region relates to its concentration in the so called twin cities. The relation between this trend and the relatively close geographical distribution of various binational watersheds along the border, led to the consideration of the later as a useful unit to approach and study the natural resource problems (Brown and Mumme, 2000). Currently, a number of binational

watersheds along the border are studied under different methodological tools, an effort that is providing an essential data base to approach the problems inherent to each watershed, from perspectives other that the environmental impacts. However, only in few occasions this effort has been paralleled by operative and action initiatives at the binational level, as is the case of the Tijuana River Watershed (TRW), undoubtedly the most important watershed along the U.S.-Mexico Border in terms of the population and urban dynamics it displays, and the problems faced as a result of these conditions. In this paper we depict the experience to date of one of the most recent initiatives developed in relation to the TRW, the Binational Watershed Advisory Council (BWAC), a body organized as part of the project: *A Bi-national Vision for the Tijuana River Watershed*, which is a baseline assessment of the current conditions in the TRW, and establishes a binational concensus of the desired state of the TRW, outlining ways to accomplish it. BWAC's role centered on the identification of those key actors at both sides of the border whose input and participation were essential to advance possible ways to mitigate or solve the problems in the watershed. The work is divided into four major sections. After this introductory part, the characteristics of the TRW are described, together with those binational experiences in the region that represent the background of the Binational Vision project. A third section describes the whole visioning process, from the principles and conceptual ideas that sustained it, to the major highlights behind the experience of the BWAC to date. The paper concludes with a section of conclusions and some reflections on future steps of the Vision project and the role of BWAC.

The Tijuana River Watershed

The Tijuana River Watershed (TRW) covers an area of 1,750 square miles (mi^2) or 4,430 square kilometers (km^2), with approximately one-third of the watershed in the United States, and two-thirds in Mexico (Wright, Ries and Winckell 1995). The watershed extends from the Laguna Mountains in the northeast, the Sierra Juárez Mountains in the south, to the Pacific Ocean in the west. In the San Diego portion of the TRW, 93% of the land falls under the jurisdiction of County of San Diego. In Mexico, almost all the TRW falls under the jurisdiction of the municipalities of Tijuana and Tecate, but a small part lies within the Municipality of Ensenada (Figure 1).

Communities in the U.S. portion of the Tijuana River Basin include the incorporated cities of Imperial Beach and San Diego (including the communities of San Ysidro and Otay Mesa), Campo, Barrett Junction, Portreo, Pine Valley, Morena Village, Buckman Springs, Boulder Oaks, Tierra del Sol, and Tecate (United States). Kumeyaay Indian reservations include Campo, Manzanita, and portions of the La Posta and Cuyapaipe lands. Mexican cities include Tijuana and Tecate, and the communities of Valle de Las Palmas, Nueva Colonia Hindú, Carmen Serdán, Vallecitos, Santa Verónica, Nejí, El Hongo, San Luis, and Terrazas del Valle. Mexican indigenous communities include San José de Tecate, Juntas de Nejí, Aguaje de la Tuna and Peña Blanca. These are not officially recognized as communities by the Mexican government, with the exception of Juntas de Nejí.

The eastern part of the watershed encompasses mountain ranges with altitudes reaching 1,900 m (6,233 ft), and an average precipitation of 250 mm (10 in.) (CNA 1995; Ojeda Revah 2000). The major tributaries in the TRW are the Cottonwood Creek-Río Alamar system and the Río Las Palmas system. The TRW is characterized by steep, hilly terrain and a Mediterranean climate. Vegetation cover is dominated by chaparral and coastal sage scrub, along with wetlands (vernal pools and riparian zones) and oaks and conifers in the mountains. Temperatures range between 8 to 18 degrees Celsius (46.4 and 64.4

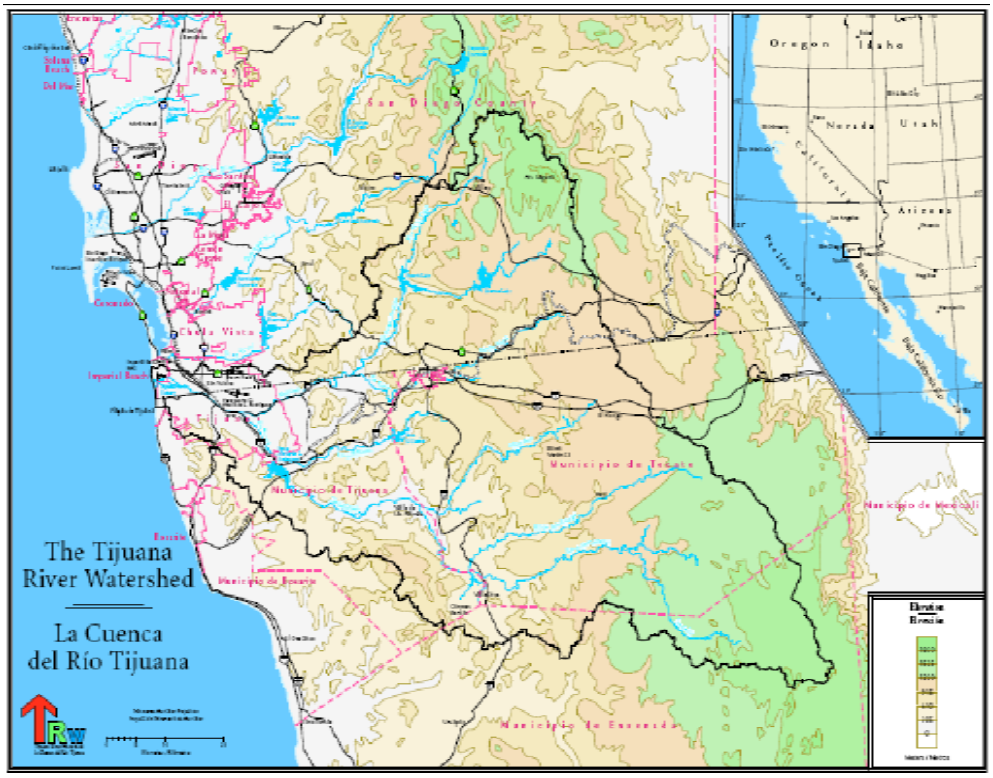


Figure 1. The Tijuana River Watershed.

degrees Fahrenheit) (Fig. 4) and precipitation amounts range from 150 to 650 mm (5.91 to 25.59 in.) per year (Aguado 2005).

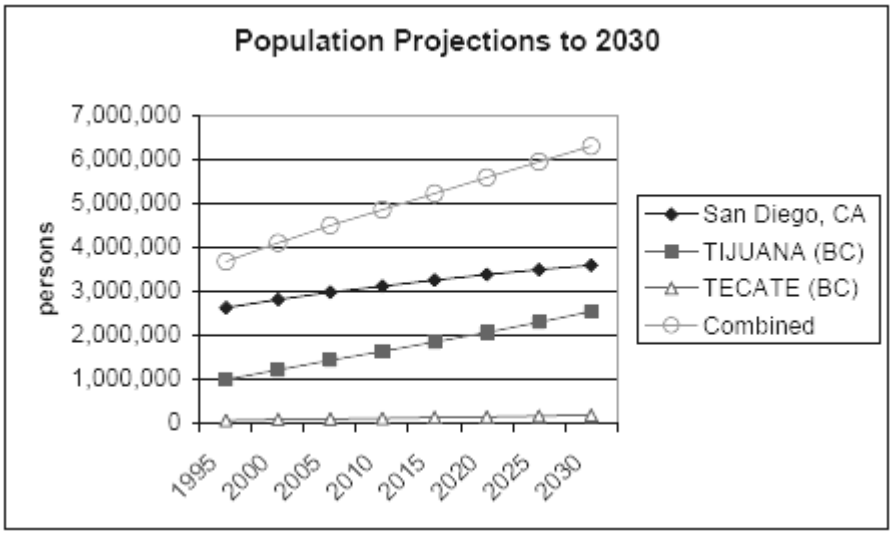
Main problems faced by the TRW

The TRW may be portrayed as a mix of high industrialization and urbanization rates, uncontrolled land use changes and infrastructure deficits taking place in an arid region. Many of the contrasts that characterize the relationship between Mexico and the United States meet at the TRW: the economic asymmetries, the differences in infrastructure and public services availability, and the intense flow of crossings at the ports of entry, as a partial product of this uneven relationship. These conditions are the cause of many environmental problems that continue to exacerbate in time. The most critical

environmental issues that have been identified include the rapid population growth on the Mexican part of the watershed, the unrestrained urbanization, the increasing demand for water and basic services such as sewage and waste water treatment, and the disappearance of important animal and plant species and habitats. On top of this, there are problems common to congested places such as a decreasing quality of life, traffic congestion, low air quality, loss of recreational areas, public safety, crime, and poverty. Finally, another issue of concern relates to the need to preserve the indigenous heritage existing in the watershed. The current state of deterioration of the TRW calls for the combined effort of authorities and the community as a whole to propose and implement actions to help improve its future.

Population trends. Currently, the TRW maintains a population of 1.4 million (INEGI, 2004; U.S. Census Bureau, 2004), with 97% residing on the Mexican portion of the watershed. The city of Tijuana is the major contributor for the population growth of the watershed, accounting for more than 82% of the total population.

The available projections for the TRW region foresee a doubling of its population by 2030 (Figure 2). San Diego County's population is expected to increase from 2.91 million on 2002 to 3.05 million in 2030. On the Mexican segment of the watershed, the same forecasts anticipate a population of 2.54 million for Tijuana, a 1.30 million increase from the 2000 figures. Tecate is expected to increase its population from 77,796 in 2000 to 117,273 by 2030. As rapid urbanization and industrial growth are most likely to persist, the urban expansion of the TRW will continue to spread south and eastward, making it quite possible for Tijuana and Tecate to physically merge over time. The corresponding burden on the infrastructure and services demand will be evident, as will the impacts on the quality of life, habitat fragmentation, and the animal and plant life linked to the natural corridor from Otay Mountain to the southeast of Tijuana (Institute for Regional Studies of the Californias [IRSC], 2005: 27-28).



Source: Peach and Williams (2003).

Figure 2. Population projections of the TRW Region

Land use patterns. The developed area of Tijuana covers approximately 25% of the Municipality of Tijuana, while about 90% of Tijuana's urban area lies within the TRW boundaries. The current urban expansion of the city continues to follow a southeast path, which will be fueled in the near future by infrastructure additions such as the Corredor Tijuana-Rosarito 2000, which intends to consolidate the infrastructure requirements for that area of the municipality, and connect it with the planned international border crossing at East Otay Mesa (Comisión Estatal de Servicios Públicos de Tijuana [CESPT], 2003).

Water quantity and quality. The past years have witnessed a growing dependence of the TRW on imported water from the Colorado River to meet the increasing demand. The TRW receives an average rainfall of only 250 mm per year, and ground water supply is scarce. The TRW is served by two surface systems: the Cotton Creek-Río Alamar system on the northern part of the watershed, and the Río Las Palmas system which runs entirely on the Mexican side. The first system benefits from those parts with the highest precipitation levels in the watershed. This water is captured by two reservoirs in the U.S. portion –the Morena Reservoir and Barrett Lake- and exported out of the TRW to support other users in San Diego County. The Río Las Palmas is a seasonal system with a variable runoff, which is captured by the Abelardo Rodríguez Dam. In 2005 this source provided about 16% of Tijuana's water needs[1]. The other reservoir in the area, El Carrizo captures both surface runoff and water from the Colorado River to serve the needs of the City of Tecate. On the average, the Colorado River provides about 80% of the water demands of the Mexican portion of the TRW every year. The underground sources contribute only 5% in the case of Tijuana, but they represent an important source for Tecate (nearly 30%). Other important aquifer zone is the Valle de Las Palmas. All of these zones are identified as being in balance, that is extraction and recharge rates are the same (Comisión Estatal del Agua [CEA], 2003: 47).

Contamination trends have accompanied the urban and rural activities in the TRW, and are currently exacerbating the problem of water availability. The U.S. portion of the lower TRW is classified as a category I (impaired) watershed by the California State Water Resources Control Board (CASWRCB) due to point and non-point pollution flowing into U.S. waters from the U.S. and Mexican sides. The most serious non-point pollution sources are nutrients and chemicals from agriculture/ranching and runoff from impermeable urban surfaces from sides of the TRW. These include agricultural sectors in the U.S. portion, and commercial and residential sectors in Mexico, as well as dumping of hazardous materials. Point-source pollution comes from industries, septic tanks, and sewage treatment plants. Currently, CESPT in carrying on a project to improve the wastewater treatment for Tijuana and Playas de Rosarito. This project is expected to complement the treatment performed by facilities such as the International Water Treatment Plant (IWTP) across the border to control the contamination problems caused by urban wastewater runoffs in the area.

[1] Information provided by the Planning Department at CESPT on 4/10/06.

Ecosystems and natural resources. The TRW region is the habitat of an important flora and fauna which are recognized internationally for their diversity and high levels of endemism. Endangered and threatened species such as the bighorn sheep, Stephen's kangaroo rat, the Arroyo toad, and several avian species may be found at both sides of the border. The region is also known for a number of valuable vegetation communities, such as coastal sage and chaparral (Delgadillo, 2000). The human activities in the TRW are increasingly impacting the loss of biodiversity through the continuous fragmentation of their habitats. The extent of these impacts have been documented by different studies on bird populations, plants, and wildlife (Bolger, Allison A.C. and Soule, 1991; CBI, Pronatura and TNC, 2004). The flora found in the TRW is also highly diverse and endemic. Portions of the Tecate River alone have been documented as holding the highest quality riparian habitat remaining in Southern California. These ecosystems have also suffered significant damage in recent years due to the expansion of the urban areas in the TRW.

Solid and hazardous waste. The accumulation of trash is a major problem in the TRW, since it harms wildlife and pollutes surface and groundwater. In the Mexican portion of the TRW there are important deficits in the trash collection system due in part to the sinuous topography of Tijuana, while the available landfills for proper disposal are limited, and some of them pose a health treat to the neighboring communities. The lack of a social conscience behind the problem makes people to dispose wrongly their trash, dumping it on unauthorized places or burning it. Unfortunately, recycling is not a consistent practice on either side of the border. Hazardous wastes, including industrial waste, commercial waste, and biological waste are illegally dumped due to a lack of enforcement, crossborder transportation costs and complexities, and lack of proper disposal and confinement facilities in the Mexican portion. This problem is aggravated by the lack of information on the quantities of this type of trash that are collected, and those that cross the border.

Air quality. The major concentrations of this type of contamination in the TRW originate from human sources, such as vehicular congestion in urban areas and border crossings, heavy commercial trucking, dust from unpaved roads, burning trash, and industrial contamination. Pollutants in the atmosphere affect the health of humans, flora, and fauna in the watershed though direct inhalation, or by deposition onto plants and soils, and absorption into water bodies. Additionally to the air quality patterns inherent to the TRW, some atmospheric pollutants have been found to be transported from outside the basin through prevailing wind currents (Sweedler, 1998).

The regulatory framework

The binational nature of the TRW has important implications in the ways public planning and decision making at different government levels takes place inside its boundaries. An essential factor behind this are the differences between the political systems that characterize both the U.S. and Mexico. The U.S. political structure rests on a federal arrangement stemming from the Constitution, by which the central national government

exercises power over some issues and the state governments exercise power over other issues. In contrast, and despite a number of modifications undergone by the Mexican Constitution like the Municipal Reform of the 1980's, the prevailing system in Mexico is basically centralized. These differences are clearly exemplified in the TRW. In the U.S. portion of the TRW, the EPA is the lead federal agency responsible for water quality management under the Clean Water Act. The regional office for this region (EPA Region 9) delegates authority at the state level to the California State Water Resources Control Board (CASWRCB) which is governed by the Porter-Cologne Water Quality Act. CASWRCB´s responsibilities are in turn delegated to nine Regional Water Quality Control Boards (CARWQCB). Region 9 is the particular CARWQCB for San Diego County and the U.S. portion of the TRW. Aside from water, many other federal, state, and local regulations restrict adverse effects on the environment within the U.S. portion of the TRW, including air, land, cultural resources, and socioeconomic impacts (IRSC, 2005: 190). Some of these regulations provide mechanisms to protect natural resources and open spaces. Examples at the federal level are the National Environmental Policy Act (NEPA), Habitat Conservation Plan (HCP), National Historic Preservation Act (NHPA), and Endangered Species Act (ESA). At the state level there is the California Environmental Quality Act (CEQA), California Endangered Species Act, and Natural Community Conservation Planning (NCCP) Act. At the county level we have the County of San Diego Biological Mitigation Ordinance and the County of San Diego Resource Protection Ordinance (RPO). Finally at the local level regulations include the City of San Diego Environmentally Sensitive Lands, the Resource Protection Ordinance, and Associate Guidelines.

In the Mexican case, the Law of National Waters of 2004 bestows on the National Water Commission (Comisión Nacional del Agua, CNA) the main authority for water management in Mexican territory, both at the national, and regional hydrological-administrative levels, the latter through the bodies known as Organismos de Cuenca. CNA's responsibilities go from the development, updating, and enforcement of the National Water Program, to the implementation of specific programs at the regional or watershed levels, including the development of water or environmental infrastructure in coordination with state and local governments. When it comes to water quanlity, the Commission proposes and enforces the operating standards, called normas, which are in turn issued by another Federal agency, the Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT). Another Federal law in Mexico that is relevant in relation to environmental issues in the Mexican segment of the TRW is the General Law of Ecological Balance and Environmental Protection (Ley General de Equilibrio Ecológico y Protección al Ambiente, LEGEEPA). At the state level there is the Plan de Ordenamiento Ecológico Territorial (State Ecological Master Plan), and the local level the Plan de Desarrollo Urbano del Municipo de Tijuana (Municipal Master Plan).

An important feature of water institutional changes in Mexico over the last 15 years has been the strengthening of the watershed as the formal management entity for the planning and management of the water resources in Mexican territory. Within this trend, the Consejos de Cuenca (Watershed Councils) are taking a more significant role in bringing the local and regional presence into the watershed decision making on important issues

affecting it. To date, there are 25 established watershed councils in Mexico, whose functioning is supported by Comisiones and Comités de Cuenca (Watershed Commissions and Committees) at the sub-basin and micro-basin levels respectively[2]. In the case of Baja California there is only one watershed commission –the Colorado River Commission- that supports the work of the Consejo de Cuenca de Baja California. The Mexican portion of the TRW is currently forming a Comisión de Cuenca .

A third regulatory component that affects planning and decision making activities in the TRW refers to the international arrangements that exist between the two countries over the distribution and management of their common resources. A major actor in this context is the Comisión Internacional de Límites y Aguas (CILA) in Mexico and its counterpart International Boundary and Water Commission (IBWC) in the United States, the twin agencies created under the 1944 Treaty to deal with binational resources and sanitation problems at both sides of the border. Since their operation began, IBWC-CILA have issued a number of minutes affecting the TRW. Currently there are no watershed management projects under IBWC-CILA so a minute would have to be created to expand the mandate of the IBWC-CILA in order to deal with binational watersheds.

Previous efforts to approach the problems of the region

The San Diego-Tijuana region has particular stories of binational collaboration between the two countries which represent an important background behind the creation of the BWAC project. Earlier efforts go back to the first part of the 1990's, with the Tijuana River Watershed Program, an undertaking by universities and public agencies from both sides of the border to help address environmental problems in the transborder TRW. The first step of TRW Program combined efforts from two academic institutions, San Diego State University and El Colegio de la Frontera Norte to develop a watershed GIS and its use for community outreach, education, and scientific research (Brown et al., 2003). The results of this project led to more than a dozen more undertakings with funding from the National Oceanic and Atmospheric Administration (NOAA) and the Southwest Center for Environmental Research and Policy (SCERP), focusing on water quality and quantity problems in the watershed. Another early effort included a binational and multidisciplinary study of the state of the environment of the basin that included socioeconomic analysis as well as physical science studies and was supported by the Ford Foundation, the Hewlett Foundation, and the Southwest Consortium for Environmental Research and Policy. This project included SDSU, COLEF, and UABC reachers who intereacted in a series of seminars and wrote short essays on basic features of the TRW. Topical articles provided an overview of the topic along with a discussion of existing literature, data sets and data gaps, key issues and problems, and key indicators. The project produced a draft report, *State of the Environment of the Tijuana River Basin* (IRSC 1998).

Main initiatives carried out as part of TRW included the Goat Canyon/Cañón de Los Laureles Vulnerability Assessment, a study targeting a 5 square-mile canyon located

[2] www.consejosdecuenca.org.mx

upstream from the Tijuana River Estuary, out of which 90% is located in Mexico, and represents a major source of the sediment that ends up on the estuary. Behind this project there was an effective binational data-sharing partnership from universities and federal and local agencies. Another important project under the TRW auspices was the Flood Forecasting and Warning System for the Tijuana River Watershed, a multi-institutional effort to approach the flooding threat in the watershed and which included stream and precipitation monitoring on the main rivers and creeks of the TRW. Finally, there was the Bight of the Californias, one of two pilot programs developed to help implement the Global Programme of Action (GPA), adopted by the U.S., Mexico, and Canada for the protection of the marine environment from land-based activities. The other program included the Gulf of Maine.

In 1996 the San Diego Association of Governments (SANDAG) promoted an initiative to address the region's problems from a binational perspective: the creation of the Committee on Binational Regional Opportunities (COBRO), an advisory body to exchange regional information based on a binational agenda of mutual interests. An important element of COBRO was the participation of the Consuls General of the U.S. and Mexico in the meetings, supporting the legitimacy of this body's activities. One of COBRO's recommendations that grew out of its annual summer conference in 1997 led to the development of the Border Water Council (BWC). This institution originated in 1997 from the need for transborder cooperation and regional water concerns (Brown et al., 2003) and utilized the instrument of the Border Liaison Mechanism (BLM) to enable the consuls general to convene government agencies and others from both sides of the border for face to face discussions on common concerns (Ganster and Sánchez, 1999: 48). The BWC functioned with the binational water authorities in the region—the San Diego County Water Authority and CESPT— as cochairs, and it was active in searching for new options to convey water from the Mexicali and Imperial Valleys to Tijuana and San Diego, in line to the principles of minute 301 by the International Boundary and Water Commission to make more information available on the water supply options for the region.

The Tijuana River watershed (TRW) has been a key component of binational cooperation in the San Diego-Tijuana Region. This 1,758 square mile watershed, two-thirds of which is in Mexico (fig. 2), embraces a wide range of topography, climates, biological resources, land uses, and social-political institutions. More than one million people live within the limits of the TRW, in political jurisdictions that include the County of San Diego, the City of San Diego, the City of Imperial Beach, several Native American reservations, and the municipalities of Tijuana, Tecate, and Ensenada in Mexico.

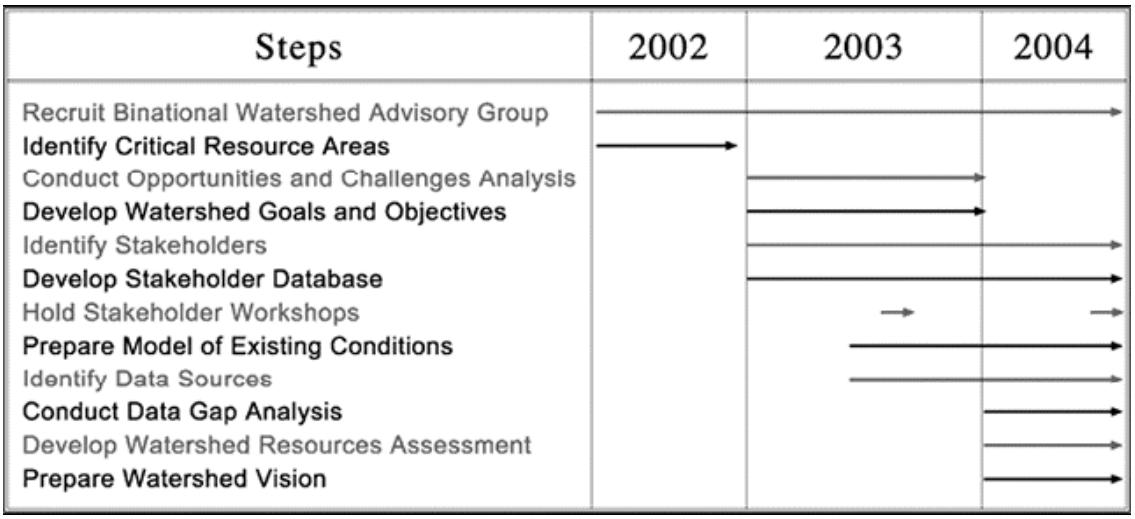
In recent years it has been the locus for a variety of binational efforts conducted by actors and organizations at both sides of the border. Since 1994, over a dozen projects have been carried out by different institutions, including El Colegio de la Frontera Norte (COLEF), which developed a GIS for the watershed and its use in community outreach, education, and scientific research (Brown et al. 2003). North of the border, San Diego State University (SDSU) sponsored the Binational Vision Project for TRW to address different environmental and social problems in the watershed. This project has promoted

the organization of a binational watershed advisory council (BWAC) to identify stakeholders from various sectors to provide views on the ideal state of the watershed in the near and distant future (http://trw.sdsu.edu).

The Tijuana River Watershed Binational Vision Project

In many ways, the previous efforts to approach binationally and collectively the San Diego-Tijuana region provided the fundamental base from which to promote the Binational Watershed Advisory Council for the TRW, and its final product, the Binational Vision for the Tijuana River Watershed. The project originated from The Institute for Regional Studies of the Californias and the Department of Geography at San Diego State University (SDSU), with the financial support from the California State Water Resources Control Board, the County of San Diego, the William and Flora Hewlett Foundation, and SDSU itself. State of California funding came from Proposition 13 bond funds that were made available to projects throughout the state to develop watershed management plans as a key step in the efforts to reduce nonpoint source pollution, particuly from stormwater runoff. The TRW project was the only funded project that included a binational watershed. The main objective of the project was to establish a desired state, or vision, of the TRW, and the ways to accomplish it. To do this, not only the participation of the academic sector was considered necessary, but the involvement of stakeholders from different areas and institutions, depicting a wide variety of interests on the TRW. The first step was directed to assemble an academic research team to support the substantive tasks of the project, such as the identification of data sources, and to provide continuous support, including stakeholder coordination. Aside from the presence of researchers at SDSU, the core team included colleagues from El Colegio de la Frontera Norte (COLEF) and the Universidad Autónoma de Baja California (UABC).

Figure 3 shows the general timeline followed for the development of the Binational Vision Project during its three years of work. The project was presented on a first meeting of the Advisory Council on November 2002, with the presence of a preliminary group of guests representing different organizations, businesses, and community groups in the TRW, who were initially invited to form part of the Advisory Council during the



Source: IRSC (2005:17)

Figure 3. General time line for the Binational Vision Project

sessions to follow. Following are the contributions from the BWAC members expected by the research team during the different stages of the project.

- Provide recommendations and advice from diverse perspectives
- Help identify stakeholders from both sides of the border in the watershed
- Provide interface between the project team and the larger binational community
- Help develop watershed vision
- Help develop strategies for implementation of the watershed vision
- Provide feedback on document projects, reports, studies, and the project web site.
- Attend BWAC meetings (2-4 times per year) and periodic public forums (1-2 times per year)

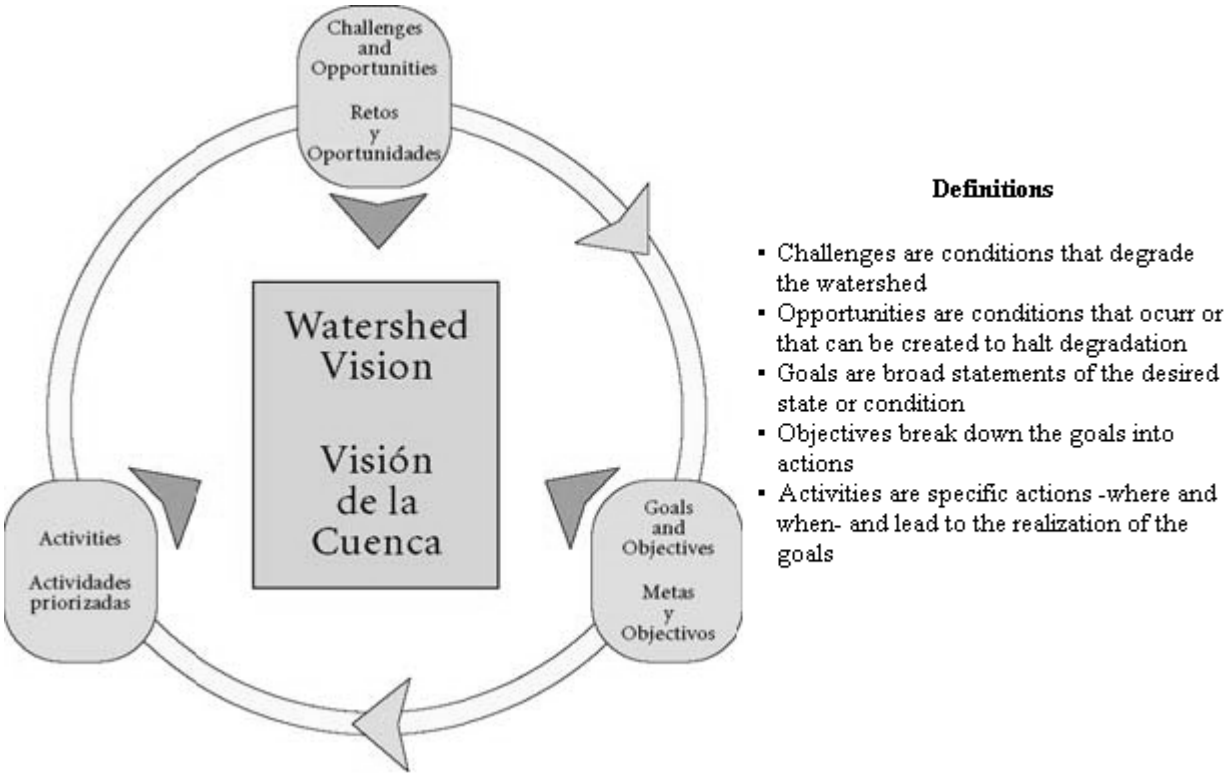
As seen here, not only the familiarity of the area and its problems was deemed essential among the Advisory Group members, but the knowledge of networks that would ensure the presence of the widest range of interests concerning the TRW. In the first case, the participation and feedback from the Advisory Group members was highly encouraged to propose and discuss goals and characteristics of the Binational Vision, and ways to accomplish it.

General visioning process

A central objective of the BWAC's role towards the building of the Binational Vision was the input from stakeholders and interested persons in the TRW in the identification of the problems faced by the watershed and the ways to approach them. This stage of the project was undertaken during the last months of 2003 (Figure 3). In preparation for that, the work of the Advisory Group during the previous months centered on two basic tasks: 1. Identification of major challenges and opportunities in the watershed; 2. Outlining of

goals and objectives for the watershed. During this exercise, definitions were discussed for each of the components in the holistic context of a watershed (Figure 4). The BWAC members and other participants in the meetings broke up into groups to exchange ideas in each of the tasks. For the work during these sessions, and based on different sources of information, the research team identified a preliminary set of seven major critical areas in the TRW: water quantity and quality, air quality, solid and hazardous waste, ecosystem functioning, quality of life, and multinationality. These initial areas were to be tested and refined throughout the sessions prior to the stakeholder meetings.

The exercise conducted with the approximately 60 BWAC members produced a final set of six critical areas of the TRW, each one with a specific number of related challenges and opportunities, as well as the goals and objectives sketched in each case. This cluster is presented in Appendix 1, and was put to test with 150 stakeholders during five meetings held between September 4th and October 7th, 2003, in different locations of the TRW. The mix of invited stakeholders included representatives from NGO's, government at different levels, academics, educators, business, industry, ranchers, indigenous groups, and private landowners from both sides of the border. During the stakeholder meetings, participants were asked to prioritize each of the critical areas identified for the TRW from lowest to highest, and to identify actions that could solve some of these issues in the watershed. The collective work on small groups for each of the major areas allowed a discussion and agreement on those actions more imperative in each case. These were all presented to the larger group and posted with the rest of the actions from other areas. Finally, at the end of each meeting all participants were asked to vote for the five most important actions from the total list. In all, 266 actions were identified by the stakeholder groups in the critical areas, with different degrees of priority as depicted by the assigned number of votes. Those actions for each resource area that received the highest priority across all meetings are reported in Appendix 2.



Source: IRSC (2005:16)

Figure 4. Conceptual framework of the visioning process

The months following the stakeholders meetings were centered on the presentation of the actions results to BWAC members and the participating stakeholders, the gathering and analysis of data to complement and provide more context to those results, and the development of recommendations by resource area, based on a number of sources and the opinion of specialists in each area (Figure 3). The Vision research team began also to develop the outline of the final Vision document that was to present all of these components in a comprehensive way by major area. Further analysis of the stakeholders actions data base, allowed the identification of the highest prioritized actions for the whole watershed, regardless of the resource area or meeting location. These actions were combined with others based on the feedback from specialists and the available literature to define a primary list of 14 actions. The views of the stakeholders themselves and a number of considerations in terms of logistics, political momentum, bureaucratic delays, and funding requirements among others, supported the definition of a most likely time line for each of the priority actions (Table 1). For each of these actions the Vision research team in turn provided implementation and timing recommendations, again based on the available literature and data sources, and the observations from different experts.

The first steps taken on the development of the final Vision document gave way to another important phase on BWAC's work. Simultaneously to the evolution of the document, and the work done by the research team to improve it, BWAC members addressed the ways to enrich and keep the final version up dated once finished. Another

concern were the strategies to have the proposed actions implemented. In the first case, some recommendations considered the inclusion of additional subjects such as tourism, transportation, enforcement, public health, urban development, emergency preparedness, and homeland security. Also, BWAC members were asked to provide information on data sources available for the work of the research team. Other members gave presentations on related activities in the TRW as well as information relevant to the Vision. Based on the information gathered from different data sources and the advice from stakeholders, BWAC members, and specialists, the research team identified a set of data gaps, as well as the research needs in each major category (see Appendix 3).

Action	Implementation should begin			
	2004	2005	2006	2007
1. Identify important conservation areas for restoration and rehabilitation based on ecosystem function and threats	x			
2. Increase knowledge of the cultural characteristics of indigenous and other peoples of the watershed	x			
3. Protect sensitive habitat as well as cultural and historical areas	x			
4. Market sustainable tourism opportunities	x			
5. Binational planning for floods	x			
6. Evaluate and protect groundwater supplies	x			
7. Develop and implement watershed education programs and products for children and adults	x			
8. Connect conservation areas across the border		x		
9. Expand water reuse			x	
10. Facilitate cross-border vehicular traffic flow and reduce impacts in adjacent communities			x	
11. Develop an integrated waste management system with recycling components			x	
12. Develop a binational water quality monitoring system			x	
13. Develop point and non-point source water pollution prevention programs				x
14. Develop mechanisms for transborder watershed management				x

Figure 1. Time line of priority 14 actions

The final version of the Vision document was presented on December 2004 after two more rounds of comments from BWAC members that provided feedback on alternative paths to assure the implementation of the actions. These included the identification of institutions active in the TRW, regulations and programs (i.e. Pronatura), as well as recommendations on what the general public can do to improve the quality of life in the TRW. Other changes considered the consequences of inaction. As part of the presentation

program, a panel and brake up session were organized to discuss and develop options for transboundary management mechanisms. The participants represented the Federal, State, and Local governments, the private sector, businesses and industry, Academia, and Non Governmental Organizations.

The possibilities of further funding beyond the completion of the project on march 2005, allowed the continuation of the work by BWAC on the central idea to promote ways to implement the Vision's actions. These activities included the formation of the Border 2012 Water Task Force, its Ecology Working Sub-Group, and the Water Technical Committee created under the Border Liaison Mechanism (BLM). More recently, an attempt was made to add other sub-groups under Border 2012: water, air, waste, and socioeconomic issues, but their work was left pending, given the concentration of BWAC´s members on the collaborative goals of the Vision. After the final version of the Vision document was ready at the Vision's site in August of 2005, the Vision research team began to work on a proposal for an annual conference with the idea to spotlight projects to implement activities recommended in the Vision document.

Conclusions

In this paper we tried to portray in a concise way the experience of the Binational Watershed Advisory Council throughout its more than two-year existence. As it may be concluded from this depiction, such experience was highlighted by different levels of progress in comparison to similar binational efforts. In this section we offer some reflections drew from this exercise as well as on the future perspectives.

One of the features that have characterized the San Diego-Tijuana Region during the last 15 years was no doubt the growing concern among different groups at both sides of the border for its problems, and ways to approach and solve them. The idea and objectives of the TRW Binational Vision Project were embedded in this philosophy, by recovering some of this scattered knowledge and interest in a formal and systematic framework. The TRW Binational Vision Project, and further more the operative body that supported it, the Watershed Binational Advisory Council, proved to be a success in terms of the interest that engendered among groups from different backgrounds and interests in the TRW, who shared a common concern for the quality of life in the watershed, and were willing to cooperate in the searching for solutions to the environmental problems that affected it. The experience throughout the meetings and activities of BWAC was an interesting and rewarding one. The combined exercise of convoking the BWAC during its years of functioning and the development of the Vision document allowed to bring closer the governmental actors and agencies at both sides of the border to share their views with stakeholders and other interested parties in the TRW. This exercise should be considered a step ahead in the search for a truly transboundary management framework in which this and other binational border regions will conduct their relationships in the future.

The development of the Vision document allowed the research team and the BWAC members to offer an integrated product as much documented as possible in terms of baseline data, historical and projected trends, challenges, data gaps, research needed, goals, objectives, and actions. The resulting product is a compendium of 100's of proposed actions by stakeholders and many other reliable sources related to the TRW, which comes to complement the already important base of publications and work done on binational areas along the U.S.-Mexico border, with the added value produced by the input of those sectors that live and experience the conditions in the TRW, and therefore can provide a first hand view of the problems.

One important reflection form the Vision project related to the next steps to be taken now that the document is ready and BWAC members adopted it as their working document. The Vision document in its present state is a comprehensive source of valuable information for decision makers in all areas related to the TRW. One important consideration that the Vision research group cannot oversight is the possibility of the document becoming out of date.

Though the BWAC experience may be considered a success in terms of cooperative work from all the participants, important challenges still lie ahead at the operative level. From the perspective of the Mexican institutions, and despite of significant advances accomplished such as the willingness of CNA's authorities to create a Comisión de Cuenca del Río Tijuana, a decision that would increase the involvement of CNA in the TRW's water problems, the centralized and rigid nature of Mexican institutions still represent a barrier in the context of a transboundary management scheme. However, the historical moment in which is Mexico now, in an election year, adds an element of uncertainty which might have a positive outcome if the new government adopts a truly binational approach to border issues. The nature of the Border 2012 group –with BWAC incorporated- is solidly enough to resist the perils of political transitions, and will naturally be the first choice to serve as a council or board for any future management structure.

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Appendix I
Set of Challenges, Opportunities, goals, and Objectives identified for the TRW

WATER QUANTITY			
Challenges	**Opportunities**	**Goals**	**Objectives**
• Growing population and industrial needs for water have outstripped local groundwater and surface water supplies • Due to over- extraction, water tables are much lower than historical levels and allow saltwater intrusion, which contaminates drinking supplies • Sand extraction reduces groundwater storage capacity of stream valley aquifers • Increased impermeability of surfaces contributes to flash flooding, which results in loss of life and property • A culture of water waste exists in the region • Increased impermeability of surfaces results in a more rapid flow of water to the ocean and decreased groundwater recharge	• Rechargeable aquifers • Groundwater storage capacity • Existing surface water flow • Existing restoration and reclamation efforts: Ecoparque, Campo Indian Reservation stream restoration, Oneata Slough, Model Marsh, TETRP at Estuary • Government interest in water reuse • Existing reservoirs • Riparian vegetation restoration	• Decrease dependence on imported water • Improve hydrology of watershed • Improve local water production • Decrease flood risk	• Map and characterize aquifers • Control erosion and manage sedimentation(e. g., bank regrading and revegetation, channel grade control structures, riprap) • Increase permeability of developed land by redirecting runoff into bioswales, and removing unneeded hardscape • Preserve open space to improve percolation into the aquifer and to decrease rapid runoff • Test the feasibility of recharging the groundwater basin with surface flows • Develop detailed water budget and hydrologic model • Manage groundwater to prevent future overdraft • Develop water source protection measures • Utilize neighborhood- based and subwatershed flood detention solutions(i. e., increase groundwater percolation and slowing of surface runoff) • Restore floodplain using management practices, such as reforestation, bioengineering,and/ or other nonstructural approaches • Implement stormwater retention and rainwater harvesting techniques • Create demonstration projects (i. e., septic tanks, constructed wetlands, industrial pretreatment systems) • Promote comprehensive conservation programs to reduce water consumption • Expand flood warning systems

WATER QUALITY			
Challenges	**Opportunities**	**Goals**	**Objectives**
• Toxic materials are entering streams and groundwater, causing human health problems and ecosystem impacts • Urbanization(paving) decreases filtering of contaminants by vegetation and soil • Channelization of Tijuana River and other streams decreases filtering of contaminants by vegetation and soil • Channelization of Tijuana River and other streams increases quantity and speed with which contaminants are transported downstream to the ocean • Industrial discharge in the watershed is partially uncontrolled, leading to degradation of water • Deforestation in riparian and recharge zones reduces filtration of pollutants by vegetation • Runoff from urban, industrial, and agricultural activities contributes to water contamination • Erosion of bare slopes and agricultural and construction activities are leading to increased sedimentation, which affects stream valleys and the Tijuana River Estuary functioning • Inadequate sewage treatment capacity and spatial coverage gives rise to renegade sewage flows that contaminate surface and groundwater • Urban and agricultural development increases water temperatures, which affects aquatic biota	• University water quality research projects • Existing water quality monitoring programs • Existing riparian areas • Binational agreement on industrial pretreatment • Potable Water and Wastewater Master Plan for Tijuana and Playas de Rosarito • IWTP Plans for Tecate wastewater infrastructure improvements • Rehabilitation studies on the Tecate River by Cal Poly Pamona • Alamar River study by SDSU and ASU • CalEPA- CEA Industrial Pretreatment Program • Ocean plume imagery by Ocean Imaging • Remote sensing work by UABC • Ocean water quality visualization techniques by SDSU • Water quality modeling by SDSU	• Enhance low- cost, local clean water supply • Decrease point- source contamination from industry • Decrease nonpoint runoff from urban and agricultural areas • Decrease health risks from contact with contaminated waters, fish, and shellfish • Improve water quality in the TRW Estuary and near shore marine environment	• Modify the concrete channels and other flood control structures • Plant native riparian species to filter and slow pollutants • Create river parks • Create meanders and braiding in floodplain • Restore floodplains using existing open spaces and green areas • Build weirs and berms to slow transport of pollutants downstream • Build erosion- control structures on steep slopes • Create holding ponds to filter pollutants and recharge groundwater • Enforce the mitigation of hazardous material disposal and industrial discharge • Design urban green areas for percolation and filtration purposes • Reforest the upper basin to slow runoff and reduce erosion • Provide adequate sewage systems for all communities • Restrict hillside development to reduce erosion • Continue university water quality research projects • Expand and coordinate water quality monitoring in streams and test for toxics in the tissues of benthic invertebrates • Remove hardscape where possible to allow filtration of storm water • Continue to monitor nutrients and biota in Estuary • Revegetate steep slopes • Implement binational watershed health indicators program • Develop integrated water quality water quantity model

ECOSYSTEMS AND NATURAL RESOURCES			
Challenges	**Opportunities**	**Goals**	**Objectives**
• Land development is increasing the number of endangered and threatened species through loss of habitats, direct kill, and by disconnecting breeding populations • Land development is increasing habitat fragmentation and the inability for animals to reach the resources they need in all life stages • Loss of riparian corridors is reducing important animal, fish, and plant habitats and the ability to move between habitats • The spread of exotic species (i. e., Arundo donax and Tamarix sp.) is contributing to the loss of native species • Loss of forests, wetlands, meadows, and other habitats is decreasing the overall functioning of carbon, nitrogen, and hydrologic cycles, and soil regeneration process • Wetland and habitat loss affects on migrating birds stopping over on the Pacific Flyway • Lack of protected areas that extend across border	• Existing riparian corridors • High percentage of undeveloped land • Existing public lands: Cleveland National Forest, Bureau of Land Management, Lake Morena County Park, TRNERR, MSCP, Biological easement in Tecate • Internationally recognized as a hot spot of biodiversity • Current and past initiatives to create binational reserves	• Balance economic needs and environmental preservation • Improve ecosystem functioning and increase associated natural capital • Fire management strategy that balances ecological functioning with public safety	• Create legal protection for biological core areas, such as patches of forests, sage scrub, chaparral, riparian, and other vegetation • Create a legally protected binational preserve network between existing open spaces, protected areas, and core areas with easements, agricultural preserves, land trusts, research reserves, river parks, and wildlife preserves • Continue existing university research on ecosystem functions • Begin a program to monitor animal movement and habitat use • Restore surface water flow in streams and rivers to improve aquatic habitat • Restore wetlands, such as vernal pools, salt marshes, and estuaries • Enforce endangered species laws and habitat protection laws • Create urban green areas for birds and other wildlife • Maintain water and sediment quality that will sustain populations of fish and other wildlife • Eradicate and control movement of nonnative species and introduce native species

SOLID AND HAZARDOUS WASTE			
Challenges	**Opportunities**	**Goals**	**Objectives**
• Control of hazardous materials transport and disposal within each country and across the border • Population growth is generating increased waste • Industry is producing unmitigated waste • Waste is being carried by streams and deposited downstream • Non- point source pollution from small and medium businesses	• Recycling center at the border • Existing crossborder education and outreach programs • Previous university research • Visibility of the challenge • Value of recycled materials • Cross- border synergies for recycling	• Decrease amount of solid waste generated • Decrease amount of solid waste entering waterways • Decrease production and transport of hazardous waste • Increase recycling	• Educate citizens and businesses on proper waste disposal • Enforce industrial waste laws Implement laws to mitigate flow of waste into waterways, including industrial pretreatment programs • Create more recycling centers and foster a recycling culture • Remove existing waste, and develop strategy for continual monitoring and cleanups • Create economic incentives to curb the illegal disposal of hazardous waste • Implementation of pollution prevention programs by industry

AIR QUALITY			
Challenges	**Opportunities**	**Goals**	**Objectives**
• Industrialization and urbanization have increased air pollution, which causes environmental and health effects • Motor vehicles are a major source of pollution • Open burning is a source of pollution • Nitrogen deposition from air pollution effects native and invasive plant species • Global warming and climate change exacerbate problems • Air quality effects of power plants • Regional climatic conditions • Unpaved roads are major contributors of solid particles in the air	• Existing South Bay, Tijuana, and Tecate air quality monitoring stations	• Improve quality of air	• Promote solar and renewable energy • Improve public transportation • Enforce emissions standards for industry and vehicles • Monitor air quality in Mexico and provide public access to data • Educate citizens about open burning • Research future effects of global warming on the region • Decrease health risks from air pollution • Decrease environmental impacts from air pollution • Conduct transborder air quality modeling and analysis • Reduce point- source pollution • Reduce mobile sources of air pollution • Develop transborder air basin (Binational Air Quality Alliance [BAQA]) • Develop emissions- trading mechanisms • Coordinate energy planning (Border Energy Forum) • Pave roads • Obtain formal recognition of the transborder air basin

SOCIOECONOMIC ISSUES			
Challenges	**Opportunities**	**Goals**	**Objectives**
• Different perspectives based on nationality and economic sector • Urban sprawl encroaches on green areas and decreases access to recreational opportunities • Loss of riparian zones decreases recreational opportunities • Beach closures decrease recreational opportunities • Deforestation decreases wildlife viewing and hiking areas • Inadequate transportation systems increase traffic congestion and smog • Lack of planning results in squatter settlements with a lack of infrastructure • Inadequate potable water delivery and sewage treatment systems contribute to residents' health problems • Historical and culturally important landscapes are threatened by commercial development • Air and water pollution causes illnesses • Residents and property in flood zones and steep, unstable slopes are at risk	• Development of baseline binational quality of life indicators for this area • Tijuana and Playas de Rosarito potable water and wastewater master plan • Binational flood warning system • National and binational NGOs concerned with environmental and human health	• Improve binational quality of life through cultural, economic, historical, educational, and recreational enhancement of the basin • Decrease environmental health risks • Maintain a strong economic base for sustainable development	• Monitor quality of life through indicators • Relocate residents from flood zones to safe areas • Create flood control structures that also provide recreational opportunities, such as river parks • Improve and expand sewage system services • Provide public transportation alternatives, bike paths, and improve traffic flow • Create trail systems for hiking and horseback riding • Create open spaces and green areas within cities and in the outskirts • Create green buffers for noise and air pollution, and to decrease urban heat islands • Create historical zones, restore historical buildings, and attract tourism • Create wilderness preserves for education and recreation • Clean beaches and monitor pollution violations upstream • Create urban tree- planting programs • Provide safe recreational opportunities, open space, wildlife viewing, green areas, tourism opportunities, and clean beaches and rivers • Reduce erosion and landslide hazards

Appendix II
Priority actions from stakeholder meetings by area

WATER QUANTITY		
% Votes	**Action**	**Location**
9%	Increase water re-use, new and appropriate technologies, investments	Valle de las Palmas, Arroyo Alamar, Tijuana River
7%	Analyze, monitor, and identify all water sources	Watershed-wide
6%	Identify critical points such as deforested, over exploited sand mining areas, and stream courses that are at risk	Watershed-wide
6%	Evaluate the aquifers for water quality and quantity conditions	Alamar River, Tijuana River, and watershed wide
6%	Subdivide the TRW in "sub-basins" for purposes of planning and local "task forces"	Watershed-wide
5%	Delimit streams (right of ways) to protect them	Watershed-wide
5%	Diversify water sources (alternatives)	Dams upstream of Rodriguez Dam
5%	Legally protect areas for aquifer recharge	Watershed-wide
4%	Create a natural park to protect surface and ground water and address social problems as well	Alamar River, Tecate Creek, Cottonwood Creek, Las Palmas (future Tijuana bedroom community), upper watershed creeks, small villages, ejidos
4%	Create a culture of water conservation	Mexico and United States
WATER QUALITY		
% Votes	**Action**	**Location**
7%	Collect groundwater quality data , including bacteria and nitrates	Watershed-wide
6%	Analyze and discuss the new sewage treatment plants project	Tijuana
6%	Educate people so they are aware of their actions (for water conservation and pollution prevention)	Watershed-wide
3%	Look for ways for the government to obtain funding for total sewage coverage	Tijuana and Tecate
3%	Apply pretreatment to 100% of the water	Critical points of discharge

3%	Implement activities, such as taking our channels and cleaning streambeds	Watershed-wide
2%	Educate children on ecosystems with the goal of educating the parents	Schools
2%	Restore vegetation (native species) to slow Erosion	Construction sites on slopes and canyons
2%	Increase the infrastructure in the treatment plants so they are more efficient	Urban zones in Baja California
2%	Put in pretreatment processing plants	New developing areas
ECOSYSTEMS AND NATURAL RESOURCES		
% Votes	**Action**	**Location**
4%	Educate children on ecosystems with the goal of education the parents	Schools
3%	Perform a survey of sediment sources and prioritize them	Watershed-wide
3%	Implement a neighborhood watch program (community environmental inspectors)	Watershed-wide
2%	Promote reforestation through adoption programs with native species	Watershed-wide
2%	Reforest urban areas not appropriate for development (áreas accidentadas)	Urban zones
2%	Develop public outreach campaigns and funding	Watershed-wide
2%	Protect pristine areas legally or with land acquisition techniques	Riparian zones, mountainous zones, Rio Alamar, Valle de las Palmas, Urban/Rural Transition zones
2%	Develop marine indicators to monitor watershed health and ecosystems	Around the Estuary
2%	Observe land use norms and management plans at all levels of government	Watershed-wide
2%	Remove exotic species	Riparian areas
2%	Establish more stringent policies for environmental impact assessment and monitoring	Watershed-wide
2%	Encourage cross border cooperation on power plants, land fills, land use	Entire border
SOLID AND HAZARDOUS WASTE		
% Votes	**Action**	**Location**
10%	Integrate the management of trash (education, incentives, bins, recycling, penalites, citizen participation)	TRW Region

7%	Provide waste education and training for teachers, students, parents, promotoras	Watershed wide
7%	Promote a culture of municipal solid waste generation and management	Schools, Universities, work centers
6%	Improve infrastructure for transport treatment, storage, disposal	Watershed wide
5%	Implement and give value to the environmental legislation in all branches of government	Watershed wide
5%	Convince Campo Band to Abandon proposed 400 acre landfill	Campo Reservation near Jardines de Rincon
4%	Perform an environmental risk assessment for dump sites	Tijuana Tecate, Campo Indian Reservation
4%	Education to encourage use of school-based environmental curriculum on recycling, proper waste disposal	Mt. Empire and San Diego Schools and Mexico
3%	Encourage more recycling opportunities: let them be predictable, have a tire amnesty day, large item pick ups, C & D, Appliances	rural U.S. and Mexico
2%	Pollution prevention programs	Watershed wide
2%	Create incentives to recycle in the community	Municipal and State Governments Watershed wide
2%	To improve waste collection (to separate cases of heavy waste) Special equipment for the town	Neighborhoods near the river and streams
2%	Restrict use of Hazmat in groundwater dependent areas by commercial and industrial facilities	Watershed wide
AIR QUALITY		
% Votes	**Action**	**Location**
7%	Create green areas: Areas Naturales Protegidas, Parks, and gardens	Watershed-wide
4%	Decrease waiting time for border crossing	Ports of entry
3%	Develop congruent and collateral public policies on air quality standards	Border-wide
3%	Revegetate to reduce dust	Watershed-wide
3%	Regulate power plant emissions at local, regional, and national levels	Northern Baja
3%	Monitor and inspect air emissions from fish farms, dairy farms, and cattle ranches	Mexico
3%	Create economic incentive for users to get “verificentros” smog checks	Mexico
2%	Enforce air quality laws fairly and systematically	Watershed-wide
2%	Develop better monitoring and inspection for industrial and commercial emissions by competent authorities	Mexico
2%	Study air quality by air basin	Watershed-wide
SOCIOECONOMIC ISSUES		
% Votes	**Action**	**Location**
11%	Recognize and respect the Kumiai people	Watershed-wide

9%	Reimplement the Bracero (temporary guest worker) program to help control undocumented immigration and drug trafficking	United States
8%	Market existing recreational opportunities and expand infrastructure for cross-border vacations, driving loops, ecotourism, camping. Lengthen the Pacific Crest Trail to the Sierra Juárez. Promote the cross-border field visits, training, planning for agencies	Laguna Mountain, Cleveland National Forest, Laguna Hanson, Sierra Juárez
8%	Build/ enhance GIS-based surveys of cultural and historic sites	Watershed-wide
6%	Increase local green space using low-tech infrastructure, local skills, and community groups. Build/restore wetlands, hiking trails, river flood plains, recreation areas, habitat linkages, and earthen flood control berms	Alamar River, Tecate Creek, Cottonwood Creek, Las Palmas (future Tijuana bedroom community), upper watershed creeks, small villages, ejidos
5%	Encourage greater use of Mexican roads to reduce truck traffic on California Highway 94	Mexico
5%	Create planning and regional coordination mechanisms for the watershed	Watershed-wide
4%	Use scientific studies for land use planning	Campo and backcountry
4%	Create incentives for conservation and development of natural areas and provide economic, training, assessment, and technical support	Watershed-wide
4%	Give legal and official recognition to the Kumiai people of Baja California	San José Tecate, Juntas de Neji, Tamamá
4%	Distribute information about the natural capital benefits of the watershed and cultural responsibility	Urban zones

Appendix 3
Data gaps on the TRW and recommended research

General resource area	Identified data gaps	Recommended research
Water quantity	• More surface water gauging stations at all the tributaries in the TRW • All stream gauge data in a centralized data base • Data on the extent of groundwater aquifers, quality, quantity, and flow (including transboundary aquifers) • Research on the potential for recharge of the aquifers through natural or artificial means • Data on runoff from precipitation and sediment loading in the rivers • Stream flow rates for the Alamar and Tijuana Rivers on the Mexican side • Measured evapotranspiration zones and rates	• Conduct regular periodic groundwater level monitoring along the Tijuana and Alamar Rivers • Install and observation well near a supply well in Tijuana and conduct pumping tests to determine hydraulic conductivity of the alluvial aquifer to better determine the flow, extraction potential, and recharge rates of water • Test hydraulic conductivity in the San Diego Formation alluvial aquifer
Water quality	• GIS data of residential areas with no piped potable water and/or sewage connection • More data on groundwater quality in the Mexican portion of the watershed • Temporal data on how pollutant loads vary in baseline and wet weather conditions	• A monitoring program to determine toxic accumulation in sediments and biota of the Estuary • A mathematical model of the rate of transport of surface water pollution over the TRW • Research on the impact of contaminated sites on surface and groundwater quality • A binational surface and groundwater quality testing program with common methods and quality control for Mexico and the United States • Automatic sampling of pollutant loading and sediment loading in the Tijuana River

Appendix 3
Data gaps on the TRW and recommended research (cont'd)

General resource area	Identified data gaps	Recommended research
Ecosystems and natural resources	• Pre- European data to evaluate the effect of livestock grazing on coastal sage scrub • A localized list of sensitive flora and fauna that is useful for authorities in San Diego, Tijuana, and Tecate • Maps of the distribution of fauna in general throughout the entire system, especially rare or endangered riparian species, such as the California red- legged frog, Arroyo toad, Southern steelhead, Western willow flycatcher, and Least bell's vireo • The identification of binational movement corridors for large mammals, especially mountain lions and mule deer • Current information on the Tijuana Estuary's bird populations • Improved methods for dune restoration to prevent sand deposition into the Estuary	• Mapping analysis of basin-wide rates of vegetation change, including succession (turn over) and recruitment (new members of populations) • Binational multi-species habitat modeling of critical areas to be conserved • Research on invertebrates, including insects and decomposing microorganisms • Research on the impacts of Border Patrol activities, such as the building of a border triple fence with lighting, and on the movement patterns of medium and large carnivores across the border • Research on the impacts of human traffic through fragile riparian corridors on both sides of the border • The impacts of water quality on in-stream native invertebrates and vertebrates (bioassessment) • Research on methods of sediment control, especially near Goat Canyon (Cañon de los Laureles) and Smuggler's Gulch (Cañon de Matadero) • More detailed information on wetland restoration methods34 34 • More research on contaminants in the Estuary • Update the state and federal endangered species lists on both sides of the border. • Investigate land tenure on the Mexican side of the border (CBI, Pronatura, and TNC 2004).

Appendix 3
Data gaps on the TRW and recommended research (cont'd)

General resource area	Identified data gaps	Recommended research
Solid and hazardous waste	• Quantified amount and type of waste crossing the border • Information on tons of recycled materials collected per year in the TRW	• Perform periodic characterizations of the source of the waste. • Perform scientific studies to support public policy making. • Study the role of landfill recyclers, or pepenadores. • Study the successful experiences with recycling in other cities in Mexico and abroad. • Research on classification of recyclables is needed.
Air quality	• More air quality monitoring data for Mexico and at border crossings	• A very important element in reducing air pollution in the region is the development of an adequate emissions inventory. Knowledge of the source and quantity of pollutants emitted into the atmosphere is a precursor for developing a program updated to reduce air pollution in the region. Suggested research topics include studies concerning the links between air pollutants and water quality in the TRW (Sweedler 1998).

Appendix 3
Data gaps on the TRW and recommended research (cont'd)

General resource area	Identified data gaps	Recommended research
Socioeconomic issues	**Economy** • Number ofcross- border commuters • Cross- border expenditures by consumers (in San Diego and Tijuana) • Tourism expenditures • Linkages of assembly plants across borders • Binational use of services (such as medical and recreational services) • Cross-border housing markets • Percentage of population with recreational facilities and natural settings within a 10-minute walk • Participation in organized youth programs at city centers • Annual municipal expenditures on parks, open spaces, and streetscapes **Health** • Data on specific disease rates for comparison to national rates • The impact of disease in terms of morbidity, mortality, or quality years lost • Prioritization for intervention strategies • Number of people going to clinics for respiratory problems • New cases of asthma **Tourism** • Tourism statistics from urban areas, Indian tribes, and land-managing agencies on both sides of the border	**Public health** • Microbial studies are needed to assess disease patterns and trends of water quality, emerging infections, enteric infections, and microbial-resistant organisms, such as tuberculosis and gonorrhea. • Studies to carry out systematic surveys and land- use patterning analysis to help predict where cultural heritage sites may be located and conserved. • Research existing or previous water treatment methods of border tribes may provide insights into current management techniques. • Research indigenous historical and current perspectives on animal habitat, vegetation communities, and medicinal plants and document them.