Eco-Industrial Parks in the Mexico-US Border Region:

A feasibility study

by

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ABSTRACT

This project focuses on finding the feasibility for Eco-Industrial Parks (EIPs) in the Mexico-U.S. Border Region. EIPs are communities of businesses, from different sectors of industry, that cooperate with each other to efficiently share resources (information, materials, water, energy, infrastructure and, specially, residual materials that would otherwise enter as waste streams or be released as pollution), leading to economic gains, improved environmental quality, and enhancement of human resources for business and local community (PCSD, 1997). The project analyzes potential opportunities of material exchange with a variety of wasted resources generated by industrial plants on the Mexico-US border (maquiladoras), using a by-product exchange representation of an EIP. It concentrates on the region of Ciudad Juarez, Mexico, the sister-border town of El Paso, Texas, one of the most industrialized border cities with high maquiladora activity. The methods used to gather data for the study consisted of interviews that identified the most prominent material flows from different sectors of maquiladoras of Ciudad Juarez, and a literature search on existing EIPs around the world to gather data on the most common by-products utilized through their exchanges. The project then considered the economic and environmental benefits, and regulatory and industrial issues surrounding a potential EIP By-Product Station. The study shows that there is not a good match between current waste-streams and by-product utilization potential of existing plants.

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"By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual performance only. The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impact" (Indigo Development, 2006).

1. INTRODUCTION

The fast pace of industrialization and population growth in the Mexico-US border region is most clearly illustrated by the growth of the maquiladora industry. Maquiladoras or foreign-owned or operated assembly plants in Mexico, like all other manufacturing businesses, have some impact on the environment; they emit pollution, produce waste and use resources for power. The aggregate environmental impact from the maquiladora industry takes the form of augmented demand for space, water and energy, increased traffic and congestion, hazardous waste generation and subsequent demand for waste management and disposal, atmospheric pollution, and risks for environmental accidents. Hazardous waste is especially perceived as one of the most alarming industry-environmental themes within Maquiladoras (EPA, 2000).

One possible remedy to relieve some of the pollution problems produced by maquiladoras is the development of Eco-Industrial Parks (EIPs). EIPs are characterized by a network of synergistic resource linkages among facilities, within a defined geographical area, that work together to improve their environmental and economic performance (Cohen-Rosenthal [1996], Lowe [1996] and Lowe et. al. [1997]). An EIP's design is based, in part, on mimicking a natural ecosystem i.e. self-contained and self-sustaining, producing zero waste through complex interactions of food chains, it usually includes features such as conversion of wastes into valuable inputs, cogeneration of energy, shared environmental infrastructure and the minimization of material throughput (Morgan R., 1996).

The objective of this Master Project is to examine the extent to which such a regional trading network of EIPs can be developed in the Mexican-U.S. border region within the maquiladora industry, focusing particularly on the management of materials (by-product reutilization) aspect within the EIP concept. To accomplish the objective mentioned above, the study focused on a group of 39 maquiladoras located in Ciudad Juarez, Mexico which is the sister border city of El Paso, Texas. Data was obtained on their generation of solid and liquid hazardous and non-hazardous waste materials. Using the EIP approach to convert some of their wastes into useful inputs, the study then explored opportunities for material exchange within the group of maquiladora participants and industries in the Ciudad Juarez / El Paso Border region.

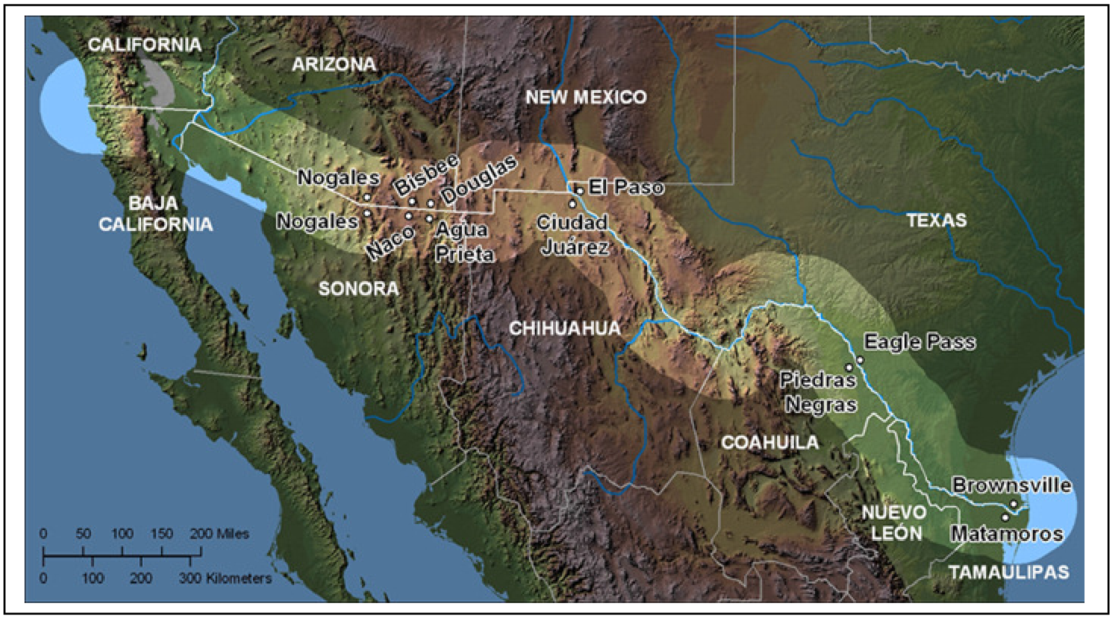
The results of the project are presented in tabular summaries of data on the following: Generation of solid and liquid hazardous wastes, current activity in recycling waste within the maquiladora industry; what might be done with resources present in common waste streams not currently fed back into manufacturing processes, and the potential to develop EIPs and new businesses based in the approach of industrial ecology, supported with an overview of the possible economic feasibility.

2. BACKGROUND

2.1. Mexico-U.S. Border Region

The Mexico-United States (Mexico-US) Border Region comprises one the most dynamic and complex industrial areas in the world. The region is characterized by high population growth and increasing urbanization and industrialization, all of which is taking place in a context of rapid political and economic change. The Mexico-US Border region is comprised of the four US States of California, Arizona, New Mexico, and Texas bordering with the six Mexican States of Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas. Figure 1 highlights principal ports of entry (sister cities) at the four US and six Mexican bordering states.

Figure 1. Mexico-U.S. Border



http://tx.usgs.gov/geography/US_MexBorder_colonias.jpg

2.2. Maquiladoras

Throughout Mexico and particularly in the Mexico-U.S. Border Region there are hundreds of foreign-owned or operated assembly plants called **Maquiladoras** that import raw materials into Mexico and assemble finished products, primarily for export (EPA, 2000). By temporarily importing most component parts from the US or other countries, maquiladoras utilize a competitively priced Mexican labor to assemble, process, or manufacture an extensive variety of products in their operations.

The initiation of maquiladoras in the US-Mexico border region took place in the 1960s. However, with the implementation of the North American Free Trade Agreement (NAFTA)[1] in 1994, the number of maquiladora plants expanded even more rapidly in the US-Mexico region (Wikipedia, 2007). In 2006, the number of maquiladoras in Mexico stood at 2,820 with an employment of 1,218,047 workers (INEGI, 2006). Table 1 depicts the distribution of the total number of maquiladoras and employees in the six Mexican Northern Border States.

[1] NAFTA reduces tariffs on goods that originate in Canada, Mexico, and the US, when the goods are traded between those countries. NAFTA, enacted January 1, 1995, will be implemented over a 15-year period, with more goods becoming duty-free each year, in anticipation of NAFTA, Mexico made deep unilateral cuts in import tariffs.

Table 1. Number of Maquiladoras in Mexico: 2,820

Maquiladoras in Border States: 1,958 Employees: 1,218,047

State	Maquiladoras	Employees
Baja California	914	252,922
Sonora	209	88,730
Chihuahua	409	311,187
Coahuila	221	99,039
Nuevo Leon	205	72,587
Tamaulipas	340	189,634

Information is supplied by INEGI. Current as of May 2006
http://www.twinplantnews.com/Maquila%20Scoreboard.htm

Maquiladoras produce a wide array of products that include electronic components, chemicals, clothes, machinery, automobiles and airplane parts. The value of the factories' production totaled $112.7 billion in 2005 (Twin Plant News, 2006). Table 2 offers some examples of maquiladoras in Mexico, while Appendix A provides a list of the top 100 maquiladoras in Mexico.

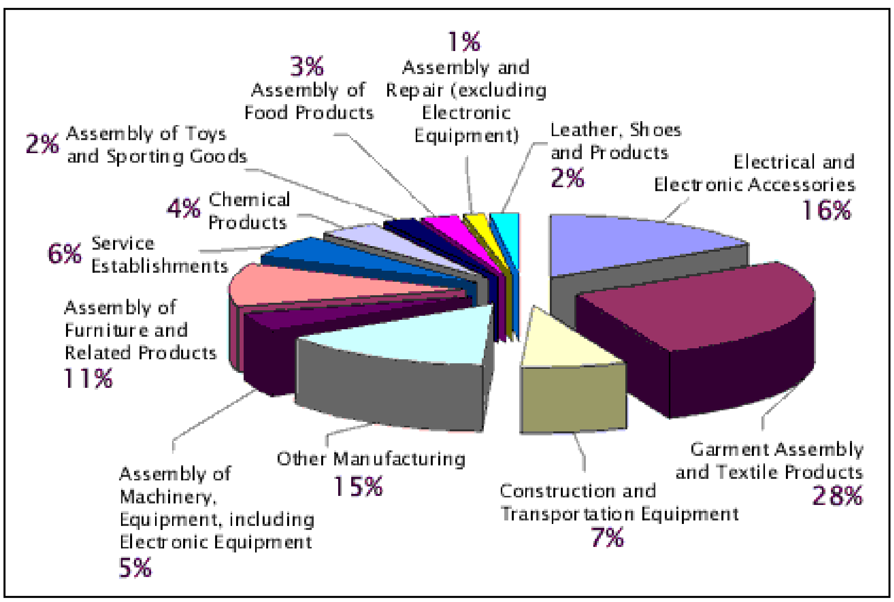
Table 2. Examples of Maquiladoras in Mexico

- 3 Day Blinds
- 20th Century Plastics
- Acer Peripherals
- Bali Company, Inc.
- Bayer Corp./Medsep
- BMW
- Canon Business Machines
- Casio Manufacturing
- Chrysler
- Daewoo
- Eastman Kodak/Verbatim
- Eberhard-Faber
- Eli Lilly Corporation
- Ericsson
- Fisher Price
- Ford
- Foster Grant Corporation
- General Electric Company
- JVC
- GM
- Hasbro
- Hewlett Packard
- Hitachi Home Electronics
- Honda
- Honeywell, Inc.
- Hughes Aircraft
- Hyundai Precision America
- IBM
- Matsushita
- Mattel
- Maxell Corporation
- Mercedes Benz
- Mitsubishi Electronics Corp.
- Motorola
- Nissan
- Philips
- Pioneer Speakers
- Samsonite Corporation
- Samsung
- Sanyo North America
- Sony Electronics
- Tiffany
- Toshiba
- VW
- Xerox
- Zenith

http://www.corpwatch.org/article.php?id=1528

Maquiladoras may be entirely foreign managed. As long as the imported components brought into Mexico are destined for export, no Mexican import duty is levied on the temporarily imported maquiladora inputs. Maquiladora operators must post a bond with the Mexican Customs Service to guarantee that components, raw materials and generated waste are re-exported from Mexico within a 6-moth period. Mexican law also allows maquiladoras to bring in most capital equipment and machinery from abroad. A bond on capital equipment and machinery ensures that they will be fully returned to the maquiladora operator's country or origin once it ceases operations in Mexico. As mentioned before, maquiladoras can manufacture a broad array of products under Mexican Law. There are exceptions to this allowance that include such industries as petroleum, petrochemicals, other chemicals, arms, and items containing radioactive elements. A breakdown of the percentage of maquiladoras distributed by industrial sector is shown in Figure 2.

Figure 2. Maquiladora Distribution by Industry



(Data is current as of September 1998, INEGI - National Institute of Statistics - Source: *The Maquiladora Reader*)

Although some of the maquiladoras are freestanding, many are located within industrial parks. In each of the major border cities like Tijuana, Ciudad Juarez, and Matamoros several industrial parks exist with dozens of plants located within a 20-mile radius of one another.

2.3. El Paso – Ciudad Juarez Border region

Of the six busiest cities along the Mexico-U.S. Border Region, one the most significant maquiladora activity occurs in the El Paso, Texas – Ciudad Juarez, Chihuahua border region. Figure 3 indicates the El Paso - Ciudad Juarez Border region.

Figure 3. El Paso- Ciudad Juarez Border Region

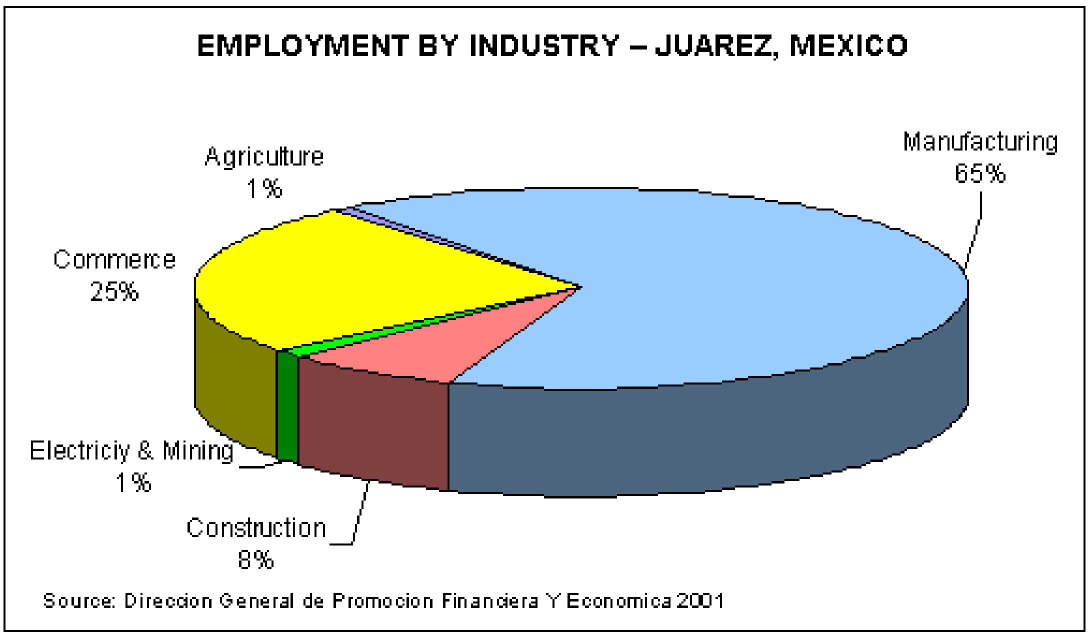
The city of Ciudad Juarez or simply Juarez (population of approx. 1.5 million) stands on the Rio Grande across the border from El Paso, Texas (population of approx. 721,598) (Wikipedia, 2006). Juarez contains the second highest concentration of maquiladora plants in Mexico (approx. 352 maquiladora plants) and the largest maquiladora plant labor force on the border employing over 249,562 workers (Maquila Portal, 2004). Technological firms have been attracted to Juarez like the largest Delphi Corporation Technical Center in the Western Hemisphere, which employs more than 2,000 engineers working on the automobile parts sector (Wikipedia, 2006). Table 3 indicates the total number of maquiladoras and employees from 1980 to 2004 in Juarez, Mexico.

Table 3. Maquiladora Scoreboard for Cd. Juarez, Mexico

Year	No. of Maquilas	No. of Employees
1980	111	39,402
1981	124	43,994
1982	129	42,695
1983	136	54,073
1984	155	72,495
1985	168	77,592
1986	180	86,526
1987	199	97,805
1988	248	110,999
1989	252	124,386
1990	238	122,231
1991	255	123,971
1992	267	129,146
1993	254	132,046
1994	232	140,405
1995	237	153,322
1996	264	169,133
1997	283	190,674
1998	258	206,897
1999	271	218,413
2000	208	249,509
2001	315	219,907
2004	352	249,562

In 2001, it was estimated that manufacturing in Juarez employed about 65% of the workers. More than 70,000 people are involved in the automobile-related manufacturing and assembly activities alone. Figure 4 shows the distribution of employment by industry in Juarez.

Figure 4. Employment by Industry- Juarez, Mexico

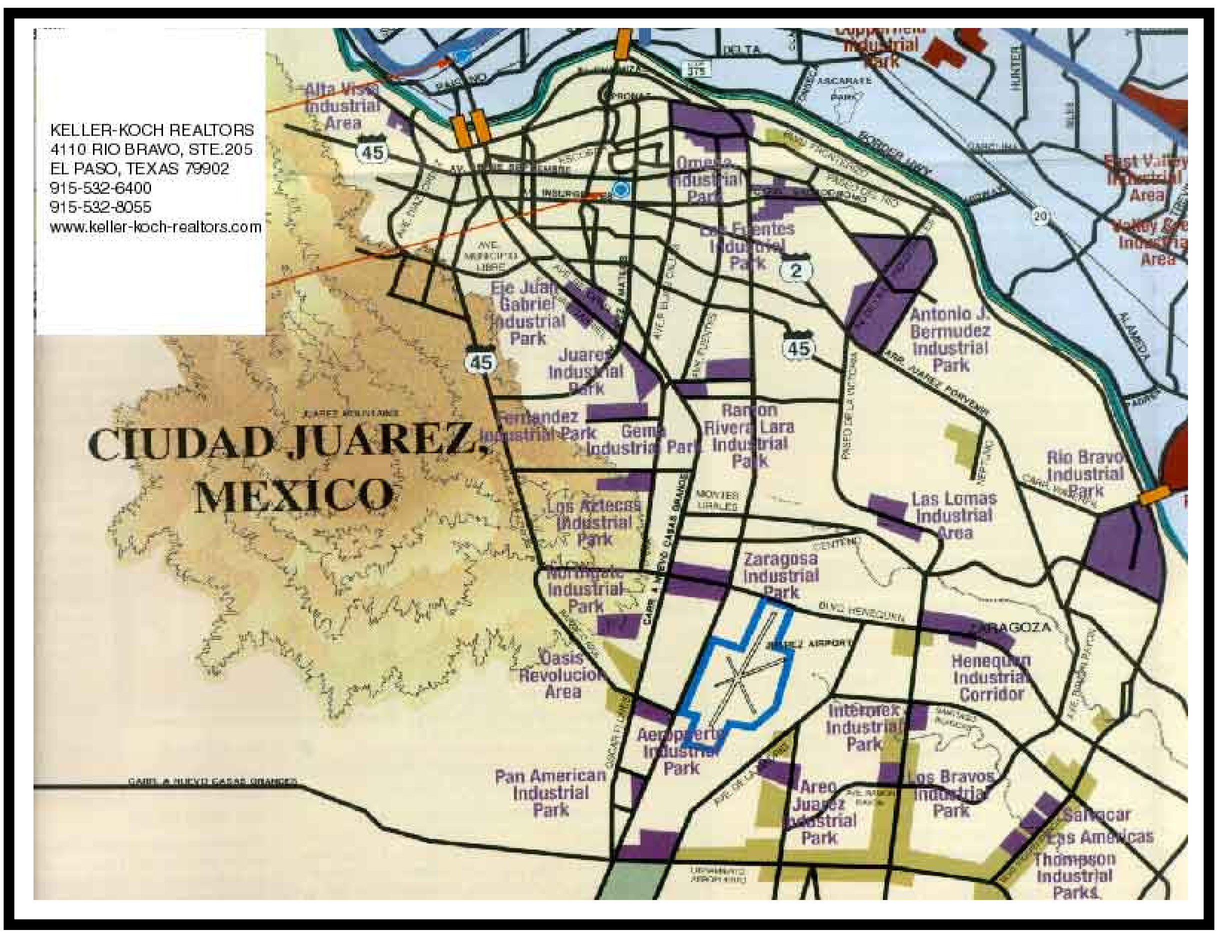


The dominant plant types in Juarez are automotive manufacturing and assembly (25%), manufacturing of electrical lighting supplies and lighting technologies (23%), and manufacturing and assembly of electronics including televisions, VCRs, and computers (21%) (Border Energy, 2004).

2.4. Industrial Parks in Juarez

Juarez counts a total of 18 Industrial Parks distributed throughout the city. There are usually ten to thirty maquiladoras operating in each industrial park. However, many maquiladoras in Juarez can also be found located outside industrial parks. Figure 5 depicts a map of the region of Juarez and its industrial parks.

Figure 5. Industrial Parks in Juarez

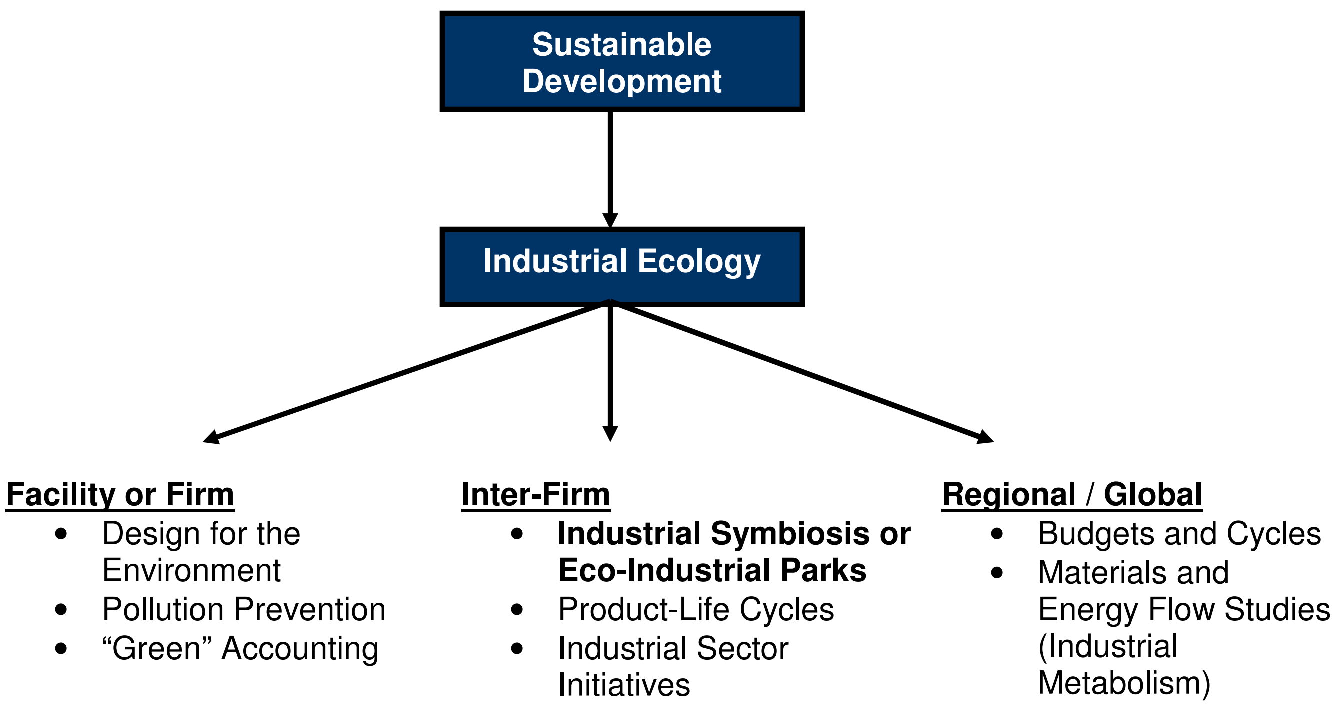


http://www.keller-koch-realtors.com/JUAREZ%20HTML%20DOCUMENT/WELCOME%20TO%20JUAREZ/Juarez.htm

2.5. Industrial ecology

Industrial ecology is a sustainable development concept that seeks to minimize waste generation and promotes by-product utilization in industrial areas to reduce the impact of human activity on ecosystems (Cohen-Rosenthal [1996], Lowe [1996] and Lowe et. al. [1997]). One of the important concepts in industrial ecology is that of Eco-Industrial Parks. Figure 6 shows the three levels of operation of industrial ecology.

Figure 6. The 3 Levels of Operation of Industrial Ecology

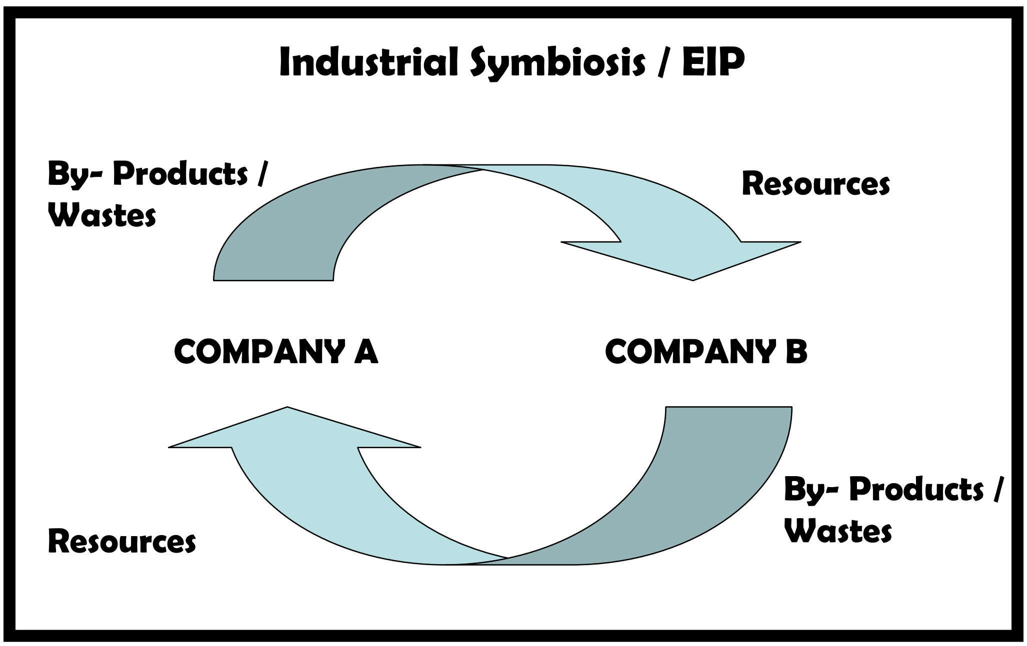


Marian Chertow "Industrial Symbiosis: Literature and Taxonomy." Annual Review of Energy and Environment 2000.

2.6. Eco-Industrial Park (EIP)

The concept of Eco-Industrial parks (EIP) is a new paradigm for achieving excellence in business and environmental performance (See Figure 7).

Figure 7. The EIP Concept



Marian Chertow "Industrial Symbiosis: Literature and Taxonomy." Annual Review of Energy and Environment 2000.

> *"An Eco-Industrial Park (EIP) is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, waste, and materials. By working together, the community of business seeks*

a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its individual performance only." (Lowe and Warren, 1996)

Through specialized professional management and information technology companies are recruited into an EIP based on the type and volume of their production inputs and outputs; a waste exchange system is carefully planned so each plant receives some by-product from another plant as production input and in turn creates a production input for the next company via their production by-products. By engaging in this system, participating companies can improve their economic performance while minimizing their environmental impact.

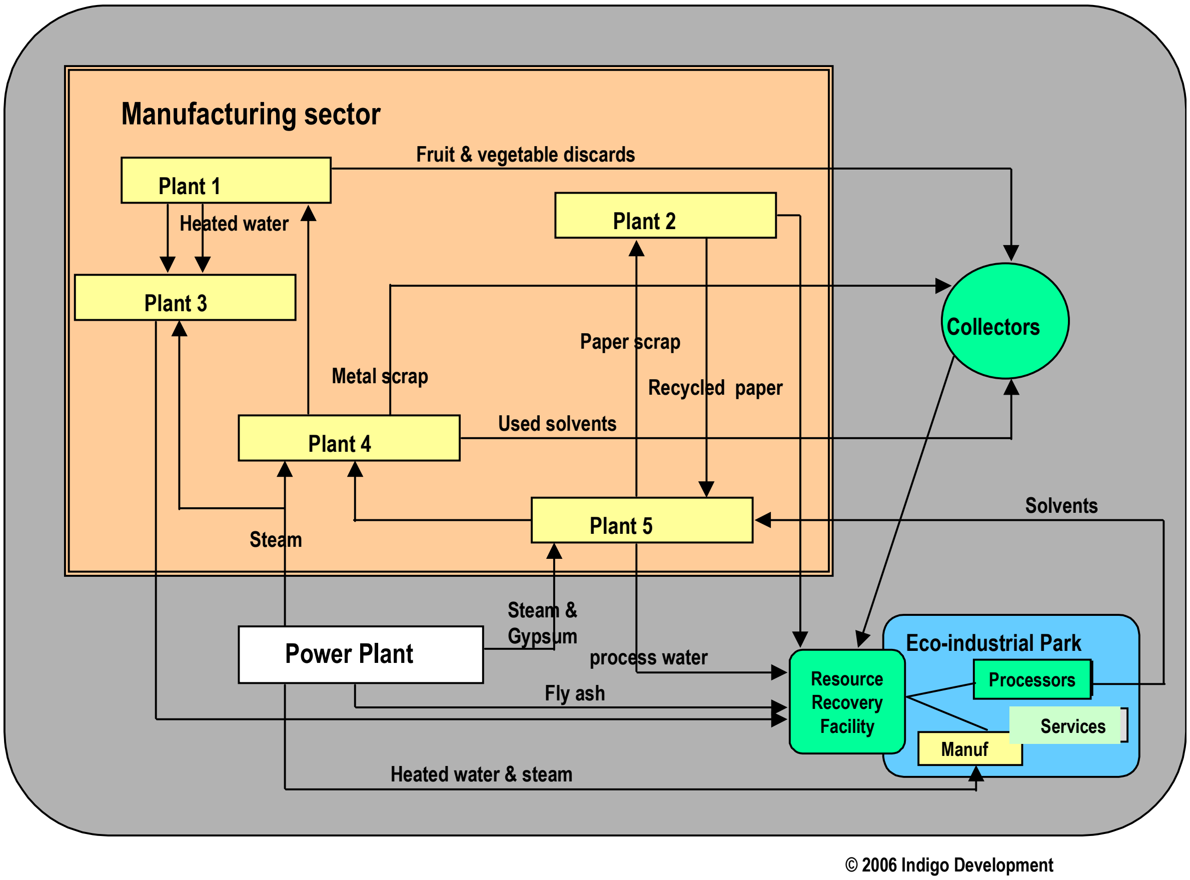
One of the first projects that attracted international attention and has been awarded a number of environmental prizes is the industrial symbiosis project at Kalundborg (100 km west of Copenhagen) in Denmark (Grann Henning and Statoil, 1994). The project is the result of a gradual development of co-operation between the Kalundburg municipality and four neighboring industries: Denmark's largest power plant, Denmark's largest petroleum refinery, a plaster board manufacturing plant, and a biotechnological industry. The power station supplies steam both to the refinery and the biotechnical industry for heating of their processes. By functioning in a co-generation mode, the power station is able to increase its efficiency. Excess methane gas from the operations at the refinery is treated to remove sulfur, which is sold as a raw material for the manufacture of sulfuric acid, and the clean gas is then supplied to the power station and to the plasterboard manufacturing plant as an energy source. The power station removes sulfur from its flue gases, which allows it to produce calcium sulfate (gypsum). This is the main raw material in the manufacture of plasterboard. By purchasing "waste" gypsum from the power station, the plasterboard manufacturing plant has been able to replace the natural gypsum that it used to buy at a much higher price. The biotechnical industry creates a large quantity of used bio-mass coming from its synthetic processes. Local farming communities use this bio-mass as a fertilizer since it contains nitrogen, phosphorus and potassium. Finally, residual heat is also provided by the power station to the district heating system of the town. The system functions via heat exchangers so that the industrial water and the district heating water are kept separate (UNEP, 2007).

The co-operation within the Kalundborg project has now developed into a high level of environmental consciousness, where the participants are constantly exploring new avenues of environmental co-operation. The Kalundborg project has achieved annual reduction of resource consumption (oil, coal, water), reduction in emissions (CO_2 and SO_2), and promoted re-use of waste products (fly-ash, sulfur, gypsum, nitrogen from biosludge, phosphorus from biosludge) (Grann Henning and Statoil, 1994).

An EIP allows industrial companies to break away from the old pattern of business that has lead to environmental impairment for many years. Instead it instills environmental protection while producing economic benefits through collaboration with new economic partnerships. Some of the outcomes of EIPs are economic profits, job creation, and environmental responsibility. In addition, benefits go beyond financial gain for the participants and reach into the community and the public sector. For example, EIPs can create linkages among local businesses, non-profit groups, governments, unions, and educational institutions to help create interactions within communities to capture waste-streams and turning them into value-added goods that can be sold in the market (Mitchell & Bahl , 1996).

Since the beginning of industrialization, companies have always depended on a larger ecosystem of suppliers, customers, geography, and market to be successful. However, companies have perceived themselves as a stand-alone unit of production; this notion has led to a taboo about transparency on what each company’s inputs and outputs are in their manufacturing processes. An EIP tries to change this notion by allowing participants of EIPs to maximize the reduction of wasted materials and recover by-products for sale. In EIPs, landfill disposal becomes the method of last resort. Figure 8 captures the Resource Recovery of an Eco-Industrial Park.

Figure 8. A Resource Recovery EIP Serves Regional Manufacturing



While the ultimate long term goal of the implementation of Industrial ecology is to fully integrate natural and human made systems, EIP developments activities represent only a small, but important, first step in that direction. Currently, there are EIP projects operating in North and South America, Europe, and Asia (Lowe Ernest, 2001). However, many of the EIP projects remain in the planning and early implementation. Appendix B offers a list and description of the EIP projects that exist around the world. Could this EIP concept be applied to the industries currently operating in Juarez?

3. METHODOLOGY

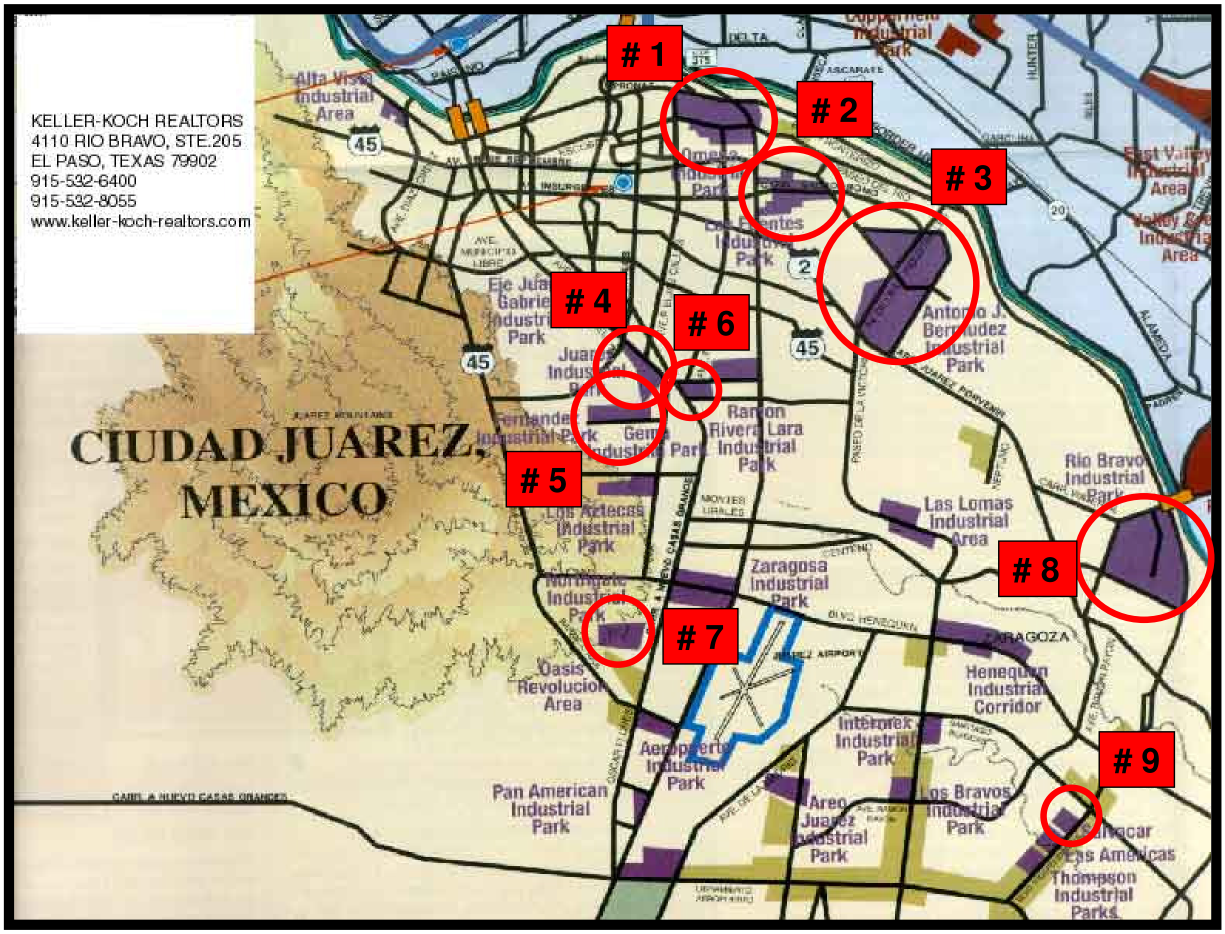
The methodology for the MP involved three phases. Phase I was data collection supported by ex-colleagues from the hazardous waste management industry, maquiladora plants, and the Maquiladora Industry Association of Ciudad Juarez (AMAC). A trip to Juarez was made in late 2006 to meet with the AMAC, maquiladora plant representatives, and local officials from both sides of the border. The data collected consisted of annual volumes and type of hazardous and non-hazardous waste generated by 39 maquiladoras and the waste disposal processes applied to the waste. To maintain the confidentiality of these maquiladoras, codes of letters from A to MM were assigned to refer to each maquiladora in the MP. Please refer to Appendix C to get an overview of the 39 maquiladora participants' industrial classification or Standard Industrial Classification (SIC) code.

Out of the 39 maquiladora participants, 17 are free standing outside of Industrial parks while 22 of them are located within 9 industrial parks. However, all of the maquiladoras are located within a 20-mile circle. Table 4 shows the 39 maquiladoras and their industrial parks and Figure 9 depicts a regional map of the industrial sector of Juarez pointing at the location of these industrial parks.

Table 4. The 39 Maquiladoras and their Industrial Parks

MAQUILADORA	INDUSTRIAL PARK
R, S, II	# 1
X, MM	# 2
H, J, AA, DD, HH, LL	# 3
M, EE	# 4
D	# 5
GG	# 6
CC	# 7
F, V	# 8
I, K, P, Z	# 9
A, B, C, E, G, L, N, O, Q, T, U, W, Y, BB, FF, JJ, KK	Outside Industrial Parks

Figure 9. Industrial Parks of Participants



Phase II of the MP was a literature search and review on existing EIPs around the world to gather data of the most common by-products utilized through their exchanges. This phase also looked at the types of industries that are receiving the most common by-product materials and the types of usage given to these. A couple of emails were exchanged with Ernest Lowe, the founder of the EIP concept, to obtain his guidance for obtaining such lists (See Appendix D).

In Phase III, the research of Phase I and II was combined to produce a series of tables providing an overview of the feasibility of materials exchanges within the 39 maquiladoras in the Juarez region and industries from its sister border city of El Paso. The information in these tables (Appendices E-I) was derived by (1) obtaining data from firms on waste-streams and (2) identifying waste-streams in Juarez that had been identified in the literature that are likely candidates for waste exchange. Finally, the regulatory, industrial, and economic, implications were assessed.

4. RESULTS

4.1. Most Common Waste Streams Generated by Maquiladoras

Appendix E identifies the most common waste-streams (hazardous and non-hazardous waste) generated by the 39 maquiladoras as well as the aggregate quantities and type of disposal practices applied to these waste streams. The data identified a total of 62 different waste-streams that are generated within the 39 maquiladoras. The waste-stream that is most commonly generated in greater quantities within the 39 maquiladoras is “Non-Hazardous Industrial Solids.” The data shows that a total of 34 maquiladoras out of the 39 generate Non-Haz Industrial Solids (e.g. Solidified resins, Debris, Scrap tape, Glue, Rags, Air filters, Solid wax, Aluminum bags, Scrap capacitors, Desiccant, Tyvek suits, Plastic gloves, Mouth & Shoe covers, Blue tape, Teflon tape, Film, Plastic bags) and accumulate an aggregate quantity of 6,667 Yd3 annually. The bulk of this waste-stream is disposed in landfills with a smaller portion sent to incineration, or fuel blend. The type of disposal or treatment given to this waste-stream depends on the cost of the disposal options or an existent waste disposal policy established by the parent company of each maquiladora.

“Empty 55 gallon metal drums” is another waste-stream that is shown to be generated in a large scale within the 39 maquiladoras. A total of 13 maquiladoras generate an aggregate of 2,350 metal drums annually. However, most of these maquiladoras have already a reuse program established onsite for these drums or they send these to metal recycling.

Another waste-stream that is generated in greater volumes is “Hazardous Industrial Solids contaminated w/Oil, Paint & Solvents.” Most of these industrial solids are rags, cardboard, and paper. A total of 17 maquiladoras out of the 39 generate an aggregate quantity of 1,890 Yd3 of this waste-stream annually. These hazardous industrial solids contain a high BTU value (heat or energy content); therefore, once a waste management company collects this waste-stream from maquiladoras it usually sends it to cement kilns as a source of alternative fuel.

A variety of hazardous waste liquids such as used solvents, paints, inks, and thinners, and non-hazardous ones like used oil and water w/oil are generated in diverse quantities by all the 39 maquiladoras. These waste-streams have a high BTU value and are sent to cement kilns as fuels blend. Also, depending of the recover value of each waste-stream some of these are sent to recycle for latter resale as virgin materials. A more detailed report on all the waste and quantities generated by each maquiladora is offered in Appendix F.

4.1.1. Limitation in Phase I

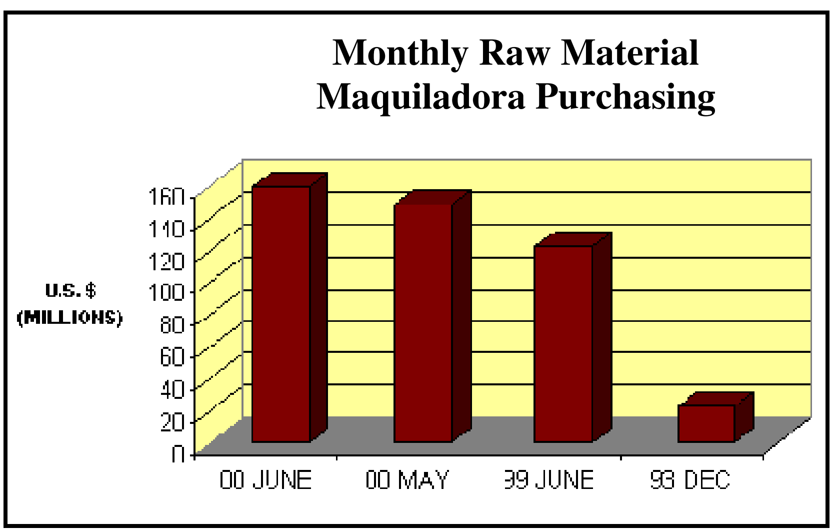
One of the limitations presented in Phase I was that the annual raw material utilization of each maquiladora was not made available because of confidentiality reasons. However, Table 5 offers a list of the top ten materials purchased by maquiladoras and Figure 10 depicts the incremented dollar investment on monthly purchasing of raw material by maquiladoras.

Table 5. Top Ten Materials Purchased by Maquiladoras

1. Molded Plastics
2. Repair Supplies for Machines
3. Packing Materials
4. Electronic Components
5. Wire
6. Metal Stamping
7. Steel
8. Chemicals
9. Apparel Supplies
10. Wood Products

http://www.keller-koch-realtors.com/MAQUILADORAS%20HTML%20DOCUMENT/maquiladoras_files/graphs.htm

Figure 10. Monthly Raw Materials Maquiladora Purchasing



http://www.keller-koch-realtors.com/MAQUILADORAS%20HTML%20DOCUMENT/maquiladoras

4.2. Most Common By-Products Exchanged in EIPs

Since the early 1990's 25 Business Councils for Sustainable Development (BCSC), representing more than 600 companies worldwide have established alliances to jointly conduct projects through global offices pursuing the sustainability concept (Reed, 2002). These industries have recognized that many valuable connections exist between themselves and others and action plans for synergies have been taken place ever since. These alliances have contributed to exploring and engaging in an array of by-product exchanges. For example, fly ash generated by an electrical utility is used by a graphite manufacturer to make roofing shingles and residual PVC generated by an industry is used by a shoe manufacturer to make robber shoe soles. Appendix G captures the most common by-products exchanged in EIPs and synergetic projects around the world.

4.2.1. Limitation in Phase II

Even though a great number of EIPs have been planned in the past years, many of these are in the early stages of development. Therefore, there is not a comprehensive baseline of information on the existing material flows of EIP projects. It is likely that these projects will help assess the economic and technical feasibility of greater materials that could be reutilized as well as determine what types of industries may be compatible for receiving these near in the future.

4.3. Opportunities for By-Product Exchange

The following materials, presented in Table 7 were found to be likely candidates for an EIP exchange in Juarez by assessing both research data from Phase I and II.

Table 6. By-products found in EIPs that are also found in Maquiladoras

By-products exchanged in EIPs	Waste Materials generated by Maquiladoras	Quantity	Units	Users in EIPs	Usage	Users in Juarez or El Paso Region
Alkaline wastewater streams	Alkaline Solution	141	*DM	Metallurgical industry	Acidic wastewater neutralizer	0
Spent Caustic Solution				Paper Mill	Feedstock	0
Chemical Drums and barrels	Empty Metal Drums	2,350	*DM	Industry	Reused	N/A
	Empty Plastic Drums	45	*DM			
Glass	Empty Glass Containers	35	Yd3	Glass Tile Factory	Tiles	0
	Empty Crushed Glass Containers	10	*DM			
Metal Scrap	Aluminum Shavings	57	Yd3	Metal industry	Feedstock	0
Oily, resin, and plastic residues	Non-Haz Industrial Solids	6,667	Yd3	N/A	Rehabilitation of polymers with nitrogen	N/A
Paper Scrap				Compost Producer	Feedstock	N/A
Polyethylene/polypropylene waste				Plastic Products Manufacturer	Plastic Cargo Pellets	0
Polymer residuals				N/A	Protective roof coatings	0
Scrap Plastic				Plastic Products Manufacturer	Feedstock	0
Sulfuric Acid	Sulfuric Acid	40	*DM	Specialty Chemical Plant	Feedstock	0
Spent Alcohol	Isopropyl Alcohol	215	*DM	Fertilizer Plant	Feedstock	0
Treated Sludge	Waste Water Treatment Sludge	74	Yd3	Brick Manufacturer, Fertilizer Plant, Aluminum Metals Plant	Feedstock, Spreading for control of tailings beds	400

* DM: 55 gallon drum

Out of 62 waste-streams generated by the 39 maquiladoras, only 8 waste-streams (alkaline solution, empty chemical drums and barrels, glass, metal scrap, non-hazardous industrial solids, sulfuric acid, spent alcohol, and treated sludge) were found in the literature of common by-products exchanged in EIPs. However, out of the likely users found in the EIP literature that can take these waste-streams (metallurgical industry, paper mill, glass tile factory, metal industry, compost producer, plastic products manufacturer, specialty chemical plant, fertilizer plant, brick kilns, fertilizer plant, aluminum metals plant), only industry and brick manufacturers were found within the 39 maquiladoras and the El Paso/ Juarez region. Therefore, only 2 waste-streams (empty chemical drums and barrels, and treated sludge) are likely candidates for a by-product exchange.

The literature shows that empty chemical drums and barrels are used by industry. This means that maquiladoras could potentially exchange this waste-stream as a by-product. However, many maquiladoras already reuse their own empty chemical drums and barrels onsite. The literature also shows that treated sludge could be used by brick manufacturers. There are approximately 400 brick manufacturers or kilns in Juarez. However, brick kilns are a major source of pollution in Juarez and are considered a serious social, health, and environmental threat to the El Paso-Juarez border region (SCERP, 2004). Increasing their output is seemingly not desirable.

The results of this study shows that the opportunities for an EIP by-product exchange within the maquiladoras are limited. This could be due to the current setting and operation design of the maquiladora industry. Potential opportunities for by-product exchange may exist but may not necessarily be apparent. Moreover, opportunities for by-product exchange could have been more easily revealed during the early stages of the design of maquiladora industrial parks in the Mexican-U.S. border region by having the EIP concept in mind. This could have allowed identifying the appropriate members for each park, not only from maquiladoras, but from local industries or even creating new enterprises that could benefit from by-product exchanges.

In summary, the results of the study uncovered the following:

1) The participating maquiladoras only generated a few of the mix of by-products that are currently exchanged by existing EIPs.

2) The participant maquiladoras generate very similar wastes, which limits possibilities to use each other's products. Therefore, there were no opportunities found for by-product exchange within the 39 maquiladoras.

3) The types of industries that are able to receive and utilize the mix of by-products do not exist within the El Paso/Juarez border region. The exceptions are brick manufactures. However, brick manufacturers found in the Juarez region are considered a serious social, health, and environmental threat to the El Paso-Juarez border region (SCERP, 2004).

4) EIPs in the Mexican-U.S. border region would need to be designed from the start in order to find and select industries that would be able to utilize each others resources. Trying to retrofit an existing industrial park to an EIP could become impractical and undesirable.

5. EIP BY-PRODUCT STATION

Even though the MP did not find opportunities for establishing EIPs within the existing maquiladoras, the MP does propose an EIP By-product station(s) in the industrial parks region to help identify and increase by-product usage. An EIP By-product station serves as a materials recovery facility for sorting of materials and used products and routing these to the appropriate user. The study revealed that great quantities of waste generated by maquiladoras are either sent to landfills or incinerated. These treatments are not the most beneficial methods for the environment and also represent a high financial cost to maquiladoras. See Appendix H to review a list of the average disposal cost that maquiladoras pay for each of their waste materials. Maquiladoras even pay a disposal fee for materials that are sent for recycling such as solvents and used oil. In addition, for the most part maquiladora waste has to travel hundreds of miles to meet its final destination e.g. landfill, incineration, or recycle. An example of a waste-stream that could potentially be reduced in quantity with the help of an EIP By-product station is the “Non-hazardous industrial solids” depicted in Table 7. The Non-hazardous industrial solids include a variety of materials (e.g. Solidified resins, Debris, Scrap tape, Glue, Rags, Air filters, Solid wax, Aluminum bags, Scrap capacitors, Desiccant, Tyvek suits, Plastic gloves, Mouth & Shoe covers, Blue tape, Teflon tape, Film, Plastic bags) that are being discarded as waste and are sent to landfill or incineration. The EIP By-product station could help maquiladoras determine how many of these non-hazardous materials are truly unusable by anyone and therefore reduce the amount of waste sent to landfills or incinerators.

Spent solvents are another example and category of waste-streams that an EIP By-product station could potentially handle. Maquiladoras currently pay waste management companies large fees to collect and dispose of a variety of spent solvents. However, some waste management companies eventually end up recycling these solvents (e.g. alcohols) themselves through distillation processes, or selling these as alternative fuel blend to cement kilns, and benefiting from both the collection fee and the sale of the recycled material. Maquiladoras could avoid unnecessarily disposal costs and potentially reverse these for profit. The EIP By-product station could receive these solvents and find them a closer location to preferably recycle them back into virgin materials for resale or sell these directly to cement kilns in bulk. Appendix I presents a table with other potential waste-streams generated by maquiladoras that could go to the EIP By-product station.

The EIP By-product station could operate as a business within the management structure of the industrial parks, or as a stand-alone business that creates a system of profit-sharing for the maquiladoras. The station could be responsible for managing all the maquiladoras' by-products, including the technical, regulatory, economics, marketing, and selling of recovered materials.

The following are potential benefits that could result from establishing a by-product station:

1) Assist maquiladoras in capturing greater productivity and resource utilization.
2) Help identify efficient uses of waste materials for maquiladora reuse.
3) Market opportunities for sorted by-products in local or close proximity markets to help reverse cost for profit.
4) Help negotiate high prices for recyclable materials in bulk (e.g. solvents) or fuels blend material products.
5) Assist in reducing materials going to landfill or incineration
6) Help avoid by-products travel long distances for reuse.
7) Get strong allies (e.g. government) to implement newer policies that could lead to more practical and appropriate resource utilization.
8) Foment maquiladora collaboration for waste reduction and by-product utilization.

In short, a by-product station could help maquiladoras reduce disposal costs, identify and increase by-product usages, and even find opportunities for profit sharing by reselling the maquiladora's by-products. Appendix J captures the way an EIP By-product station operates.

6. EIP BY-PRODUCT EXCHANGE IMPLICATIONS

6.1. Regulatory Implications of Hazardous Waste Exchange

Mexico's main environmental law, the LGEEPA, requires that maquiladora waste be exported back to the US for disposal (CONANP, 1988); however, it permits the import of hazardous wastes for recycling (Article 153) (RMALC, 2000). For example, The Integrated Hazardous Waste Management Program for Industrial and Hazardous Wastes in Mexico (1996 - 2000) includes waste blending and incineration of hazardous wastes in cement kilns as acceptable energy recycling practices and seeks to promote this practice in CIMARIs (Integrated Centers of Management and Treatment of Hazardous Wastes), which they propose locating throughout Mexico. However, it is very difficult to monitor the hazardous waste used as fuel, the emissions from burning them and the wastes generated. In the case of dioxins and furans, Mexico lacks the experience and equipment to accurately monitor and measure emission levels. Thus, even though there may be regulatory flexibility to allow the re-use or recycling of hazardous waste, appropriate technology needs to follow and support by-product exchange efforts.

Otherwise, the economic, social and environmental benefit of a by-product exchange would become futile since other environmental and health problems could be created.

6.2. Industrial Implications

One industrial limitation for an EIP By-product station is that there are maquiladoras that have already policies in place that enable them to reuse or recycle their waste. Instead, these companies incinerate all their waste regardless of the recycling content. These policies are placed to avoid clandestine waste dumping incidents that have occurred with companies that manage waste.

Another limitation is that even though some maquiladoras actively collaborate with one another on environmental issues through groups and associations, there is still a sense of individualism. As mention before, this results in lost opportunities for resource recovery and monies for disposing these resources.
Maquiladoras would need to reorganize themselves to fit a cyclical process for resource use in production and waste materials utilization. Maquiladoras in general use resources in a linear fashion rather than in a cyclical process. The results are increasing accumulations of waste and a corresponding decrease in natural resources. A system of sustainability production, as envisioned by industrial ecology, and applied by EIPs requires a fundamental change in industries mode of production. In the past two decades, along with the increase

of maquiladora development, a great number of small to medium businesses that offer waste management services have also increased. These companies have seen a business opportunity from a social problem that exists from the traditionally straight-line production system used by maquiladoras, which results in high amount of wasted resources. Maquiladoras would require a lot of awareness and assurance on the benefits of an EIP By-product station.

Finally, some maquiladoras may be reluctant to store their waste in an EIP By-product station with waste from other maquiladoras. Maquiladoras would want to avoid sharing liability with each other. Usually waste management companies offer maquiladoras full-scale liability coverage for the transportation, storage, and disposal of the waste collected. In the case of an EIP By-product station, maquiladoras would not have that liability protection. Therefore, many legal measures would need to be taken between the participant maquiladoras and the EIP By-product station in order to establish liability protection in case of a contingency. Also, the participants would require a substantial prearranged widespread safety assurance on the waste management handling practices intended at the EIP By-product station.

6.3. Economic Implications

Material waste disposed in landfills or sent to incineration are resources in which their utilization value is lost forever. If material waste is sorted out appropriately at the EIP By-product station there may be opportunities to resell or reuse products. Furthermore, disposal costs could be reduced and maquiladoras could even receive some monies back from the by-product exchange process. However, it would be important to note the issue of transaction costs, such as how much time and energy does it take to make a deal, relatively to the value of what is exchanged. Transaction costs for potential by-product exchanges would need to be determined before the planning process of an EIP By-product station since these costs could offset savings or revenues from the use of by-product materials.

7. CONCLUSION

This project focused on finding the feasibility for potential opportunities of material exchange with a variety of wasted resources generated by maquiladoras on the region of Ciudad Juarez, Mexico using a by-product exchange representation of an EIP. The project found that a great majority of waste generated by maquiladoras in the Juarez region is disposed in hazardous and non-hazardous landfills. Other waste is incinerated, treated, or used as alternative energy (fuels blend) in cement kilns. All of these disposal alternatives have an impact on the environment. In the last decade, recycling practices to maquiladora waste have been fomented to minimize the environmental harm caused by using traditional waste disposal methods. However, recycling of maquiladora waste still represents a small percentage compared to the traditional methods used for waste disposal.

In addition, waste disposal practices reflect a high financial cost to maquiladoras. Moreover, maquiladoras are aware that without altering their manufacturing processes, recycling or applying reusing methods to their waste are their best options to lessen their waste disposal costs. However, this study revealed that opportunities could be limited for material reuse or by-product exchange using a representation of an EIP with just maquiladoras. Other industries located within the border region would need to be included as participants or even new enterprises would have to be created in order to make by-product exchanges feasible. Thus, retrofitting the EIP framework into the current maquiladora setting would be impractical and undesirable. Instead, EIPs would need to be designed from the start in order to be able to identify the ideal network of participants and utilize each others resources.

An EIP maquiladora network supported by a By-product station or an EIP By-product station alone could create more economic and environmental sustainable value than a single firm. Industrial park developers should appraise EIPs for future industrial parks development in the Mexico-US Border Region. An EIP could help member maquiladoras with the creation of a positive image as a clean industrial operation. Most importantly, member maquiladoras in EIPs could explore new ideas plus efforts of environmental co-operation from a variety of industries and synergetic projects that could lead to instituting programs of reduction of hazardous wastes throughout their entire production-cycle.

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APENDIX A

TOP 100 MAQUILADORAS

Park	Parent Company	No. of Employees	No. of Plants	Home	Product Type
1	Delphi Automotive Systems	68,000	54	USA	Automotive
2	Lear Corporation	34,000	8	USA	Automotive
3	General Electric Company	30,900	34	USA	Industrial
4	Yazaki North America	27,506	22	Japan	Automotive
5	Alcoa Fujikura LTD	25,700	19	Japan	Automotive
6	Takata	15,000	10	Japan	Automotive
7	Volkswagen	13,500	1	Germany	Automotive
8	The Offshore Group	13,270	3	USA	Shelter Services
9	General Motors	12,200	3	USA	Automotive
10	Philips Electronics	11,500	16	Netherlands	Electronics
11	Vesteon Corporation	11,200	15	USA	Automotive
12	Thomson Consumer Electronics (RCA)	10,874	6	USA	Electronics
13	Siemens AG	10,000	14	Germany	Automotive
14	Sony Corporation of America	9,679	4	Japan	Electronics
15	Form Motor Company	9,150	3	USA	Automotive
16	Nissan motor co., LTD	8,500	3	Japan	Automotive
17	Daimler Chrysler	8,200	6	Germany	Automotive
18	Jabil Circuit	8,000	3	USA	Electronics
19	Sumitomo Wiring Electronic Systems	7,500	14	Japan	Electrical
20	Whirlpool	7,500	5	USA	Electronics
21	Kemet Corporation	7,005	5	USA	Electronics
22	Tyco International LTD	6,785	4	USA	Electronics, Medical
23	A. O. Smith Corporation	6,598	8	USA	Electrical
24	Cardinal Health	6,500	5	USA	Medical
25	Flextronics Corporation	6,200	2	Singapore	Electronics
26	Sanmina-Sci	6,150	6	USA	Electronics
27	Motorola, Inc.	5,961	2	USA	Electronics
28	Sanyo North America Group	5,879	2	Japan	Electronics
29	Samsung	5,789	2	Korea	Electronics
30	Emerson Electric Co.	5,678	7	USA	Electrical
31	Sanluis Rassini	5,030	4	Mexico	Automotive
32	Matsushita Electric Corp. of America	4,986	4	Japan	Electronics
33	Honeywell, Inc.	4,900	3	USA	Electronics
34	Daewoo Industrial Co., LTD	4,856	3	Korea	Electronics
35	TRW Incorporation	4,554	11	USA	Automotive

36	Key Safety Systems, Inc.	4,390	4	USA	Automotive
37	Bosch Group	4,320	7	USA	Automotive
38	Celestica, Inc.	4,150	5	Canada	Electronics
39	American Industries	4,138	22	Mexico	Shelter Services
40	ITT Industries	3,845	4	USA	Automotive
41	LG Electronics	3,700	3	Korea	Electronics
42	Leviton Manufacturing Company	3,600	6	USA	Electrical
43	Johnson Controls, Inc.	3,589	7	USA	Automotive
44	Nova Link	3,549	8	Mexico	Shelter Services
45	Am-Mex products, Co.	3,500	8	USA	Shelter Services
46	Autoliv, Inc.	3,333	3	USA	Automotive
47	Molex	3,200	2	USA	Electronics
48	Trico Technologies, Inc.	3,000	1	USA	Automotive
49	Scientific Atlanta Incorporation	2,996	1	USA	Electronics
50	Plantronics, Inc.	2,855	1	USA	Electronics
51	Avery Dennison	2,830	2	USA	Office Products
52	Key Tronic Corporation	2,760	2	USA	Electronics
53	International Business Machine (IBM)	2,689	1	USA	Electronics
54	TI Group Automotive Systems	2,639	9	USA	Electronics
55	Hyundai Motor Company	2,615	1	Korea	Automotive
56	Intermex Manufactura	2,600	9	Mexico	Shelter Services
57	Allied Signal Co.	2,589	4	USA	Automotive
58	AVX Corporation	2,587	2	USA	Electronics
59	Mattel Inc.	2,578	1	USA	Toys
60	Skywork Solutions	2,400	1	USA	Semiconductors
61	Advance Transformer Co.	2,387	3	USA/Holland	Electronics
62	Hamilton Proctor-Silex, Inc.	2,331	3	USA	Appliances
63	Schlage de Mexico S. A. de C. V.	2,227	3	USA	Security
64	Tatung	2,200	1	Taiwan	Electronics
65	Yale de Mexico, S. A. de C. V.	2,169	1	USA	Apparel
66	Avent	2,150	2	USA	Medical
67	Phelps Dodge Megnet Wire Company	2,136	1	USA	Electrical
68	Eaton Corporation	2,113	2	USA	Automotive
69	EDS Manufacturing Inc.	2,100	1	USA	Electronics
70	VF Imagewear	2,100	2	USA	Apparel
71	Saturn Electronics & Engineering, inc.	2,078	3	USA	Electronics

72	ACCO Brands inc.	2,063	2	USA	Stationary
73	plamex S. A. de C. V.	2,060	1	USA	Technology
74	Bose Corporation	2,050	2	USA	Electronics
75	Acustar Incorporation	2,003	1	Mexico	Automotive
76	National Processing Company	1,961	2	USA	Services
77	EDM International	1,948	2	USA	Services
78	Datamark, Inc.	1,865	2	USA	Electronics
79	Toshiba	1,780	1	Japan	Electronics
80	Irvin Industries, inc.	1,633	2	USA	Automotive
81	The Chamberlain MFG	1,589	1	USA	Electrical
82	NCH Promotional Services	1,569	3	USA	Services
83	Coilcraft, Inc.	1,547	2	USA	Electronics
84	Cooper-Standard Automotive	1,520	3	USA	Automotive
85	Alpine Electronics of America, Inc.	1,502	1	Japan	Automotive
86	Benchmark Electronics, Inc.	1,500	1	USA	Electronics
87	Superior Industries International, Inc.	1,500	2	USA	Automotive
88	Sara Lee Corporation	1,489	2	USA	Apparel
89	Honda	1,450	1	Japan	Automotive
90	Invensys	1,420	6	USA	Electronics
91	Accuride International	1,355	2	USA	Steel Products
92	Strattec Security Corporation	1,300	1	USA	Automotive
93	Arvin Meritor	1,300	1	USA	Automotive
94	Automotive Safety Components Int'l	1,250	2	USA	Automotive
95	Nokia	1,250	1	Finland	Electronics
96	Noma Appliance Electronics	1,235	2	Canada	Automotive
97	Plexus	1,211	1	USA	Electronics
98	Elcoteq Network Corporation	952	1	Finland	Electronics
99	SMTC	710	2	USA	Electronics
100	Mack Technologies	520	1	USA	Electronics

Source: Maquila Portal (November 2004) [*Note:* Ranking is based on number of maquila employees by Parent Corporation]

APPENDIX B: Eco-Industrial Development Tables

North American Inventory of Eco-Industrial Park Developments

	Brownsville	Burnside	Bruce Energy Centre	Volunteer Centre
Location	Brownsville, Texas	Dartmouth, NS	Tiverton, ON	Chattanooga, Tennessee
Year Established	One year feasibility study commenced late 1995, Implementation in 1997	Initial survey 1992, Cleaner Production Centre 1995	1985	Study initiated in 1994. Still in development stage.
Brown field vs. Green field	Brown field	Brown field	Brown field	Brown field - converting former military land
Number of Firms/Size of Firms	To incorporate 50 specific and 100 generic local industries	1300 single and mall unit firms (mostly small-medium) representing a variety of industries	7 firms and Ontario Hydro	Unknown
Cogeneration	Potential	Potential	Yes	Unknown
Development Participants	President's Council on Sustainable Development (PCSD), City of Brownsville, Research Triangle Institute, Indigo Development, Industry Advisory Board, other local, regional, state, and federal partners	Dalhousie University, Halifax Regional Municipality, Environment Canada	Integrated Energy Development Corporation	PCSD, City of Chattanooga, River Valley Partners, LDR International, National Environmental Test Center
Financing Source(s)	U.S. Department of Commerce, Texas Natural Resource Conservation Commission, City of Brownsville, Port of Brownsville	Federal-Provincial Sustainable Development Fund, The Donner Foundation, Halifax Regional Municipality, Federal and Provincial government, Dalhousie University and 2 other academic institutions	Integrated Energy Development Corporation	Partial funding from local agencies
Current Management	Brownsville Economic Development Council	Business Parks Office, Halifax Regional Municipality	Integrated Energy Development Corporation	River Valley Partners (private company)
Quantified Economic Benefits	Unknown	Waste management costs of some firms reduced through cleaner production techniques	Unknown	Unknown
Identified Environmental Benefits	Unknown	Reduced discharges to air and sewers. Reduced disposal of solid wastes through exchanges.	Reduced emissions of 43,000 tonnes CO_2, 487 tonnes SO_2, 93 tonnes NOx,1.7 tonnes VOC, other	Unknown
Distinguishing Characteristics	Regional eco-industrial network (park is just one component). Includes small business and agriculture. Features industrial database for matching material and energy by- products.	The first endeavour of its kind in Canada but very much a work in progress. Strong links to university research community.	Utilizes excess steam from Bruce Nuclear Power Station as the start of an energy cascade which is utilized to produce a variety of products.	Part of larger revitalization plan for Chattanooga. Not much data pertaining to industrial area part of project.

APPENDIX B: (Continued)

	Civano	Duwamish Corridor	Fairfield	East Shore
Location	Tucson, Arizona	Seattle, Washington	Baltimore, Maryland	Oakland, CA
Year Established	Still in planning stages. Grand opening for development project (residential and business) took place in July 1997	Duwamish Coalition first met in 1994 to address project, still need to specifically discuss EIP project	Currently studying potential through inventory and directory of potential industrial partners. No specific linkages to date.	Seeking funding for Feasibility Study
Brown field vs. Green field	Green field	Brown field	Brown field	Green field
Number of Firms/Size of Firms	Currently one large manufacturing firm located in the Civano Industrial Park	Unknown	Over 60 firms on 1300 acres	Unknown
Cogeneration	No	Unknown	Unknown	Unknown
Development Participants	Case Management, and others	Numerous local, regional, state, and federal partners	PCSD, Cornell University's Work and Environment Initiative, other local, regional, state economic development agencies	Indigo Development, Urban Ore, Economic Development Advisory Board
Financing Source(s)	Still seeking funding	U.S. EPA	Federal Empowerment Zone fund ($100 M), City of Baltimore, U.S. Department of Commerce, various economic development agencies	Unknown
Current Management	Case Management	Unknown	Baltimore Development Corporation	Indigo Development and Urban Ore
Quantified Economic Benefits	Unknown	Unknown	Creation of 2500 jobs in next 10 years. Estimated 30- 50% return on investment.	Unknown
Identified Environmental Benefits	Unknown	Unknown	Unknown	Unknown
Distinguishing Characteristics	Part of the Civano Master Plan to improve on seven specific environmental performance standards. Mandated to reduce energy consumption to 1991 levels.	Part of overall strategy to preserve and reclaim industrial land to create jobs and protect natural environment. Have yet to address planned EIP component of project.	Represents the only Empowerment Zone City grantee with a designed EIP. Looking to redefine area's regulatory framework. Focus on education, training, and network development to facilitate linkages.	Anchor for EIP will be a resource recovery facility encompassing reuse, recycling, re-manufacturing, and composting. Will also be "landscaped" to reflect native ecosystem characteristics.

APPENDIX B: (Continued)

	Green Institute	Plattsburgh	Port Cape Charles	Riverside
Location	Minneapolis, Minnesota	Plattsburgh, New York	Eastville, Virginia	Burlington, Vermont
Year Established	In feasibility study stage, implementation to begin in 1997	Currently in baseline study phase	Implementation planned for September 1997	Currently in planning stages
Brown field vs. Green field	Brown field	Brown field	Green field	Brown field
Number of Firms/Size of Firms	Unknown	Unknown	Unknown	Unknown
Cogeneration	Unknown	Unknown	Unknown	Planned
Development Participants	Green Institute, local organizations	Plattsburgh Airbase Redevelopment Corporation	Joint Industrial Development Authority of Northampton, numerous other local, regional, state, federal, and industry partners	Unknown
Financing Source(s)	Federal Enterprise Community program, local Neighbourhood Revitalization program, Minneapolis Foundation, Northwest Area Foundation	U.S. EPA Region I	17 different funding partners (local, regional, state, federal, and private industry)	Community Development Block Grant, Burlington Electric Department, Department of Public Works, other support
Current Management	Green Institute, University of Minnesota	Plattsburgh Airbase Redevelopment Corporation	Joint Industrial Development Authority of Northampton	Burlington Electric Department
Quantified Economic Benefits	The goal is to create 200 new jobs	Unknown	Unknown	Unknown
Identified Environmental Benefits	Unknown	Unknown	Unknown	Unknown
Distinguishing Characteristics	Project initiated by a grassroots, neighbourhood effort. Attempt to develop a small EIP on 3.5 acres by integrating existing businesses. Commitment to environmental education throughout project.	Conversion of Air Force Base to civilian uses	Part of a comprehensive community Sustainable Development Action Strategy. Has a Zero Emissions design goal. Selected as a PCSD EIP demonstration project in 1994.	It is an Agricultural-Industrial Park in an urban setting. Focus on generating energy from bio-mass fuels and using thermal energy for production of fish, vegetables, and water purificaion.

EIP Development and Canada: Final Report. Peck & Associates, www.acpco.com/panda

APPENDIX B: (Continued)

	Skagit County	Trenton	Raymond Green EIP	Shady Side Eco-Industrial EIP
Location	Skagit County, Washington	Trenton, New Jersey	Raymond, Washington	Shady Side, Maryland
Year Established	Feasibility study completed 1995, currently identifying funding sources.	Currently conducting feasibility study	Seeking funding for feasibility study	Currently in planning stage
Brown field vs. Green field	Brown field	Brown field	Green field	Brown field
Number of Firms/Size of Firms	Unknown	Unknown	Unknown	Unknown
Cogeneration	Unknown	Unknown	Unknown	Unknown
Development Participants	Numerous local, regional environmental, state, federal, and industry participants	Cornell University's Work and Environment Initiative (conducting baseline study)	City of Raymond, Port of Willapa Harbor, Weyerhaeuser Company, Ecotrust, Shoretrust Trading Group	Business Ecology Network (BEN)
Financing Source(s)	Northwest Area Foundation, EnviroCenter, Center for a Clean Washington, U.S. Department of Commerce	City of Trenton, New Jersey DEP, New Jersey Urban Zone Assistance Fund, U.S. Economic Development Administration, U.S. EPA (potential)	Unknown	Unknown
Current Management	Economic Development Association of Skagit County	City of Trenton, Division of Economic Development	City of Raymond	Unknown
Quantified Economic Benefits	Unknown	Unknown	Unknown	Unknown
Identified Environmental Benefits	Unknown	Unknown	Protection of coastal forest	Unknown
Distinguishing Characteristics	Features resource recovery centre, manufacturing centre, community centre, sales and marketing centre, and environmental business centre.	Park will be more of a virtual network of businesses with a management structure in place to assist with linkages, matchmaking, and other technical assistance. Have Advisory Round Table made up of government, business, non-profit and educational institutions.	Park will be developed within a second growth coastal forest that will continue to be selectively harvested. Firms will be targeted that make new uses of local natural resources with low impact manufacturing processes.	Renovation of an existing facility in an under-employed and under served community. Plan to integrate successful community-based tools and approaches from U.S. and abroad.

EIP Development and Canada: Final Report. Peck & Associates, www.acpco.com/panda

APPENDIX B: (Continued)

	Stonyfield Londonderry	Sarnia-Lambton	East Montreal	Becancour
Location	Londonderry, New Hampshire	Sarnia, Ontario	Montreal, Quebec	Montreal, Quebec
Year Established	Currently in planning stage, implementation in Summer 1997	Feasibility study conducted in 1996	Unknown	Unknown
Brown field vs. Green field	Brown field	Brown field	Brown field	Brown field
Number of Firms/Size of Firms	4 medium to large, currently undergoing expansion	6	14 major industries in petrochemical and minerals/metals sectors	12
Cogeneration	Unknown	Yes	Planned- on hold	Unknown
Development Participants	Advisory Board made up of local, regional, state, federal, non-profit, environmental, and academic organizations	Private sector driven, Ontario Hydro also participates	Environment Canada, local industry	Environment Canada, local industry
Financing Source(s)	Unknown	Unknown	Private funding	Private funding
Current Management	Town of Londonderry	Unknown	Unknown	Unknown
Quantified Economic Benefits	Plan to create 500-2000 jobs, increase tax base of community	Energy efficiency increases of 38 -85%. New cost effective source of gypsum.	Planned cogeneration: Potential $20 M in cost savings, 100- 210 jobs, $38 M into Quebec's economy	Unknown
Identified Environmental Benefits	Unknown	Estimated 926 tonnes of CO_2, 4.5 tonnes of SO_2 and 1.5 tonnes of NOx daily from a cogeneration project	Replacement of conventional fuels, reduction of air emissions, value added use for NH_3, energy reduction	Reduction of waste to landfill, replacement of H_2 from primary sources, recovery of aluminum
Distinguishing Characteristics	Eco-Auditing system to evaluate performance.	Significant potential given the clustering of chemical industry firms. Several projects under development, several completed.	Looking to promote industrial development in area which offers available industrial land, access by road and pipeline, and potential for cogeneration of electricity and steam.	Park offers: water transport all year, low cost electricity, natural gas, pool of skilled labour, competitive construction cost, access to North American markets by rail and road.

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APPENDIX B: (Continued)

	Varennes	Sorel- Tracy	Springhill, Nova Scotia	South Central EIP
Location	Montreal, Quebec	Montreal, Quebec	Springhill, Nova Scotia	Chattanooga, Tennessee
Year Established	Unknown	Uknown	Unknown	Unknown
Brown field vs. Green field	Brown field	Brown field	Brown field	Brown field
Number of Firms/Size of Firms	9 major industries	Uknown	4	Unknown
Cogeneration	No	No	Yes	Unknown
Development Participants	Environment Canada, local industry	Local industry and industry associations	Local industrial development commission	PCSD, River Valley Partners, United Nations University (ZERI), William McDonough Architects, Calthorpe Associates, Chattanooga/Hamilton County, Planning Commission Chattanooga Neighborhood Enterprise, plus others
Financing Source(s)	Priavate Funding	Private Funding	Environment Canada, municipality	Some local agency support
Current Management	Corporation de Developpment de Varennes	Societe d'aide au developpment de la collective du Bas-Richelieu (SADC)	Springhill Industrial Commission	River Valley Partners
Quantified Economic Benefits	Unknown	Unknown	Estimated energy savings of $50- 160 K per year	Unknown
Identified Environmental Benefits	Reduction in energy consumption, reduction in waste to landfill, decrease in pollution into environment	Recovery of products from scrap tires, manufacturing compost, and recovery of recyclables from waste	Unknown	Unknown
Distinguishing Characteristics	A number of existing linkages between firms in the area	Area looking to promote industrial, commercial, and tourist development	Employs energy cascading similar to that of Bruce Energy Centre and Kalundborg. One of the firms is an aquaculture facility for warm water fish species.	Ecological design and zero emissions is a goal

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APPENDIX B: (Continued)

Inventory of European Eco-Industrial Parks Developments

	Kalundborg	Styrian Region	Linkoping	Rotterdam- Europort
Location	Kalundborg, Denmark	Styrian Region, Austria	Sweden	Rotterdam, Holland
Year Established	Industrial ecology linkages instituted early 1980's	Recycling network initiated in the 1980's	Planning began in 1996	Cleaner production and waste exchange study began in 1995
Brown field vs. Green field	Brown field	Brown field	Brown field/Green field	Brown field
Number of Firms/Size of Firms	5 very large firms and several smaller organizations such as the local municipality	Large number of sectors and firms involved. Population of 1.2 M inhabitants.	Small number of firms and institutions in a research park around Linkoping University	85 medium to large
Cogeneration	Yes	Yes	Unknown	Unknown
Development Participants	Resident industry	State, industries, and university	University and industries	Erasmus University, Port of Rotterdam
Financing Source(s)	Resident industry	Industries and state	Unknown	Government and local industries
Current Management	Resident industry	Largely self-actuating	Planning stage	Unknown
Quantified Economic Benefits	$120 M (US) return on $60 M investment (5 years). Annual revenue estimated $12-15M.	Significant quantities of waste are being diverted from disposal or being substituted for virgin material	Unknown	Not quantified at this time but could be calculated
Identified Environmental Benefits	Reduced consumption of: 19,000 tonnes oil, 30,000 tonnes coal, 600,000 m3 water. Reduced emissions: 130,000 tonnes CO_2, 3,700 tonnes SO_2.	Examples of material recycled in 1994: 34,000 tonnes power plant gypsum, 200,000 tonnes of steel mill slag, 28,300 tonnes of sawmill dust, 100,000 tonnes of recyclable paper and board, 5,500 tonnes of used tires, etc.	Unknown	Unknown
Distinguishing Characteristics	The first EIP development involving multiple public and private organizations. Evolved without government or outside assistance. Undertaken purely for profit.	Regulations and cost of waste disposal played an important role. Strong regional approach.	Planned as a demonstration project	Unknown

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APPENDIX B: (Continued)

Inventory of Potential Asian/Pacific Rim and Middle Eastern Eco-Industrial Parks Developments

	Bandung	Manila	Fujisawa Factory	Eco-Cities Project
Location	Bandung, Indonesia	Manila, Phillipines	Japan	Japan
Year Established	1997	Planning began in 1997	Slated to open in 2000	No information available at this time
Brown field vs. Green field	Green field	Green field	Green field	Green field
Number of Firms/Size of Firms	Planned for 20 textile firms	Unknown	Fully integrated industrial development and community residences	Unknown
Cogeneration	Unknown	Unknown	Unknown	Unknown
Development Participants	SPM from Geneva, EBARA from Japan, Radiant from USA, META EPSI from Indonesia, Governor of East Java	Local development company, national and regional development institutions	EBARA Corporation	Unknown
Financing Source(s)	Local	Largely private	EBARA Corporation and others	Unknown
Current Management	META EPSI	Unknown	Unknown	Unknown
Quantified Economic Benefits	Unknown	Unknown	Unknown	Unknown
Identified Environmental Benefits	Zero emissions and total recovery of all dyes which are largest contaminants in the city	Unknown	Unknown	Unknown
Distinguishing Characteristics	Targeting zero emissions	Unknown	Targeting zero emissions. Appears to be the first comprehensive eco-industrial development. Includes residential, agricultural, recreational, and industrial facilities.	Unknown

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APPENDIX B: (Continued)

	Kashima Industrial Complex	Jubail Industrial Complex	Yanbu Industrial City	
Location	Japan	Eastern Saudi Arabia	Western Saudi Arabia	
Year Established	Limited information at this time	Limited information available at this time	Smaller sister project of the Jubail Industrial Complex. No further information available at this time.	
Brown field vs. Green field	Unknown	Unknown	Unknown	
Number of Firms/Size of Firms	Major industries include a petroleum refinery, a petrochemical plant, several chemical producers, a large steel plant, and a power generation station. Mix of small, medium and large industries.	Mix of approximately 100 primary, secondary, and support industries. Crude oil and methane are feedstocks for primary industries and they in turn provide feedstocks for other industries.	Unknown	
Cogeneration	Unknown	Unknown	Unknown	
Development Participants	Unknown	Unknown	Unknown	
Financing Source(s)	Unknown	Unknown	Unknown	
Current Management	Unknown	Unknown	Unknown	
Quantified Economic Benefits	Unknown	Unknown	Unknown	
Identified Environmental Benefits	Unknown	Unknown	Unknown	
Distinguishing Characteristics	Unknown	Unknown	Unknown	

APPENDIX C: Standard Industrial Classification (SIC) Codes of the Participants

MAQUILADORA	SIC CODE	INDUSTRIAL CLASSIFICATON
Q	SIC 2679	Converted Paper and Paperboard Products
L	SIC 3155	Copper Rolling Drawing & Extruding
B, C, X	SIC 3577	Computer Peripheral Equipment
D	SIC 3612	Power, Distribution, and Specialty Transformers
S, V, DD	SIC 3613	Switchgear and Switchboard Apparatus
C, MM	SIC 3643	Current-Carrying Wiring Devices
W	SIC 3646	Commercial, Industrial, and Institutional Electric Lighting Fixtures
T, Z, GG, HH	SIC 3651	Household Audio and Video Equipment
N, O	SIC 3670	Electronic components and accessories
H, J	SIC 3675	Electronic Capacitors
EE	SIC 3677	Electronic Coils, Transformers, and Other Inductors
S, FF, BB, CC, JJ, LL	SIC 3679	Electronic Components (various)
I, II	SIC 3694	Electrical Equipment for Internal Combustion Engines
MM	SIC 3699	Electrical Machinery, Equipment, and Supplies
R	SIC 3714	Motor Vehicle Parts and Accessories
E	SIC 3822	Automatic Controls for Regulating Residential and Commercial Environments and Appliances
KK	SIC 3829	Measuring and Controlling Devices (various)
AA	SIC 3841	Surgical and Medical Instruments and Apparatus
F, Y	SIC 3999	Manufacturing Industries, Miscellaneous
A, K, FF	SIC 5047	Wholesales-Medical, Dental, Hospital Equipment and Supplies
M, P	SIC 5063	Electrical Apparatus and Equipment Wiring Supplies
U	SIC 5084	Industrial Machinery and Equipment
G	SIC 5169	Chemicals and Allied Products

SOLUNET: Info-Mex http://www.solunet-infomex.com/

APPENDIX D: Email to Ernest Lowe (Founder of the EIP Concept) and Response

Dear Mr. Lowe,

I am a second-year graduate student, at Duke University, completing a Masters degree in Environmental Management at the Nicholas School of the Environment and Earth Sciences. During the past year, I have been carefully analyzing documents and studies done by you on Eco-Industrial Parks (EIP). I have been really impressed by your work and this has further evoked my interest in the EIP concept.

In order to fulfill my program requirements, I have to complete a masters project (MP) and the topic I have chosen is "Eco-Industrial Parks in the US/Mexico border- A feasibility study." My MP will be focusing particularly on the El Paso, TX/Ciudad Juarez, Mexico border region. Because of the amount of time and resources that a project of this magnitude could take, and the limited time that I have available to develop the project, I have decided to focus only on the management of materials within the EIP concept. In my project I intend to explore opportunities for material exchange programs for approximately 40 maquiladoras that are closely located in industrial parks in Cd. Juarez. Just last week I got back from a trip to Cd. Juarez where I met with the Association of Maquiladoras of Cd. Juarez (AMAC) and local officials from both sides of the border to present my project proposal. My visit to Juarez was immensely productive as both offered to support the project with the necessary data. The data will consist of the annual and monthly waste generation (hazardous and non-hazardous) and annual and monthly raw material utilization of each maquiladora.

In order to identify potential opportunities for material exchange within these parks and possibly the cities of El Paso and Cd. Juarez, I will also need to locate a list of the most common by-products or materials that are being utilized by industries and the type of industries that are receiving these materials in existing EIPs around the world. With this list I plan to compare and contrast materials and industries in EIPs with existing ones in the industrial parks found in Cd. Juarez; unfortunately, I have not been so fortunate in finding such a list and therefore I would greatly appreciate your assistance in guiding me to a source where I could obtain this information as it is vital to my project.

I would greatly appreciate your input and your expertise in this field. I thank you for your time and look forward to your response.

Sincerely,

Saul Perez
Master of Environmental Management
Environmental Economics and Policy
Duke University

(See next page for Response)

APPENDIX D:(continued)

Dear Saul,

Sorry for the delay in responding.

I don't know of anyone who has attempted to compile the sort of master list of materials exchanged that you describe below. It is not that easy to find data on company to company exchanges since it is often proprietary. I'm connecting a file that describes exchanges, some on the border, compiled by Applied Sustainability (I think its no longer active --) This lists quite a few products and uses but there is little data on volume and values/investments.

I suggest that it may be more valuable to focus on your particular maquiladoras and also ask them to describe exchanges that are already happening. Even more useful, also collect data on the formal and informal collectors and processors who are part of the resource use system. That way you'd have a view of a more complete system.

Note the issue of transaction costs -- how much time and energy does it take to make a deal, relatively to the value of what is exchanged? This is covered in the BPX chapter of my handbook.

I'll also attach a brief piece from work I did in Korea on the 3 levels of optimization needed for highest efficiency.

With warm regards,
Ernie

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Our Eco-Industrial Park Handbook is available as MS Word files at this page:
http://www.Indigodev.com/ADBHBdownloads.html
There is a link to information on ordering the Chinese language version.
A Korean language version has been produced by the Korean National Cleaner Production
Center and is available on its web site
www.kncpc.re.kr

APPENDIX E: Maquiladoras Waste-stream Generation

MAQUILADORA	WASTE-STREAM	ANNUAL AGGREGATE QUANTITY	UNIT	CURRENT TREATMENT
A, B, C, D, E, G, H, I, J, K, L, M, N, P, Q, R, S, T, V, W, X, Y, Z, BB, CC, DD, EE, FF, GG, HH, II, JJ, KK, MM	Non-Haz Industrial Solids (Solidified resins, Debris, Scrap tape, Glue, Rags, Air filters, Solid wax, Aluminum bags, Scrap capacitors, Desiccant, Tyvek suits, Plastic gloves, Mouth & Shoe covers. Blue tape, Teflon tape, Film, Plastic bags)	6,667	Yd3	Landfill, Incineration, Fuels Blend
A, G, J, M, P, U, W, X, AA, DD, LL	Hazardous Industrial Solids contaminated w/ metals	218	Yd3	Incineration, Haz-Landfill
A, B, F, H, I, K, O, P, T, U, W, Y, Z, BB, CC, KK, MM	Hazardous Industrial Solids contaminated w/ Oil, Paint & Solvents (Rags, Carboard, Paper)	1,890	Yd3	Incineration, Fuels Blend
A, D, F, I, J, K, M, O, R, T, U, V, W, AA, BB, DD, EE, FF, GG	Empty Metal Pails	492	Yd3	Landfill
D, E, F, I, J, K, M, O, R, T, U, V, W, X, AA, BB, CC, DD, EE, FF, GG, HH, JJ, KK, LL, MM	Empty Plastic Pails	846	Yd3	Landfill
A	Empty Propane Gas Containers	1	Yd3	Recycle
H, K, AA, HH	Empty Glass Containers	35	Yd3	Landfill, Recycle
U, V, X, Z, HH, MM	Spent Air or Halogen Filters Contam. w/ Ink or Paint	191	Yd3	Fuels, Haz-Landfill
V	Metal Hydroxides	75	Yd3	Haz-Landfill
G, CC	Aluminum Shavings	57	Yd3	Recycle
A	Metallic Dust	20	Yd3	Landfill
A, B, U	Scrap (Connector Parts, Circuit Boards)	47	Yd3	Recycle
GG	Cathode Ray Tubes	142	Yd3	Recycle
X, HH	Aluminum Bags	63	Yd3	Incineration
G, W, FF	Waste Water Teatment Sludge	74	Yd3	Landfill
A, D, F, G, H , I, S, X, CC, EE, FF, GG	Fluorescent Lamps	685	Yd3	Recycle
F, FF, GG, LL	Lead-Acid Batteries	25	Yd3	Recycle
LL	Nickel-Cadmium Batteries	1	Yd3	Recycle

APPENDIX E: (continued)

MAQUILADORA	WASTE-STREAM	ANNUAL AGGREGATE QUANTITY	UNIT	CURRENT TREATMENT
M, Y,	Empty Plastic Drums	45	DM	Recycle
I, J, L, M, S, U, V, X, Z, BB, FF, GG, HH	Empty Metal Drums	2,350	DM	Recycle
X	Empty Crushed Glass Containers	10	DM	Incineration
A, B, U, Z, BB, HH	Aerosol Cans	132	DM	Recycle
H, I, M, P, DD, EE, FF, GG, HH, LL	Epoxy Resin Liquid	381	DM	Fuels
G	Epoxy Resin w/ Methylene Chloride	9	DM	Fuels Blend
U	Methylene Chloride	12	DM	Fuels Blend
N	Waste Acetone	22	DM	Fuels Blend
F	Xylene	1	DM	Fuels Blend, Recycle
C, P, GG, HH	Isopropyl Alcohol	215	DM	Recycle
K, P	Thrichloro Ethelene	16	DM	Fuels Blend
K, X	N-Methyl-z-Pyrrolidone	58	DM	Recycle
A, D, G, I, J, K, M, N, O, S, X, EE, FF, GG, JJ, KK, LL	Mixed Spent Solvents	575	DM	Fuels Blend
I, N, T, U, AA, CC, EE, LL	Mixed Solvents w/ Paint	341	DM	Fuels Blend
F, J, N, O, R, II, LL	Waste Paint	154	DM	Fuels Blend
GG, HH	Waste Ink	7	DM	Fuels Blend
C, J, N, R	Solder Flux	88	DM	Fuels Blend
W	Thinner	40	DM	Fuels Blend
C, I, P, EE, FF	Degreaser	32	DM	Fuels Blend
C, D, F, H, I, K, M, N, O, P, Q, S, T, V, Y, AA, FF, GG, HH, II, KK, LL	Used Oil	634	DM	Recycle, Fuels Blend
C, G, H, L, W, Z, GG, HH, II, JJ	Water w/ Oil	3,853	DM	Evaporation, Recycle
L	Water w/ Acids	48	DM	Treatment
X	Water w/ Ink	1,080	DM	Evaporator, Incineration

* DM: 55 gallon Drum

APPENDIX E: (continued)

MAQUILADORA	WASTE-STREAM	ANNUAL AGGREGATE QUANTITY	UNIT*	CURRENT TREATMENT
S, GG	Water w/ Solvent	117	DM	Evaporator, Incineration
W, GG	Water w/ Resin	75	DM	Treatment
GG	Water w/ Lead Solder	42	DM	Evaporation, Recycle
I, P, W, Z, HH	Water Based Paint	1,084	DM	Treatment
D, Y, EE	Water Base Glue	66	DM	Solidification / Landfill
X	Peroxide Amonia & Hidroxide w/ Water	30	DM	Recycle
U	Mercury contaminated Waste	35	DM	Retort
F	Filing Dust	7	DM	Landfill, Recycle
H	Zinc Powder	200	DM	Landfill
FF, HH, II	Solder Dross	123	DM	Recycle
EE	Waste Copper Sulfate	3	DM	Recycle
W	Cyanide Salts	12	DM	Incineration
W	Filters contam. w/ cyanide	12	DM	Incineration
S	Mixed Acids	10	DM	Neutralization
X, GG	Sulfuric Acid	40	DM	Recycle
D, S, FF	Corrosive Liquid	141	DM	Neutralization
X	Butyl Cellosolve Acetate	15	DM	Recycle
A	Hot melt Adhesive	100	DM	Incineration
I	Black Silicon Solid	49	DM	Landfill
I	Black Silicon Semi-Solid	31	DM	Landfill
I	Black Silicon Liquid	14	DM	Fuels Blend

* DM: 55 gallon Drum

APPENDIX F: Individual Maquiladora Waste-Stream Generation

	Non-Haz Industrial Solids	Hazardous Industrial Solids w/ metals	Hazardous Solids: Rags, paper cont. with Oil, Paint and Solvents	Empty Metal Pails	Empty Plastic Pails	Empty Propane Gas Containers	Empty Glass Containers	Spent Air or Halogen Filters Contam. w/ Ink or Paint	Metal Hydroxides	Aluminum Shavings	Metallic Dust	Scrap (Connector Parts, Circuit Boards)	Cathode Ray Tubes	Aluminum Bags	Waste Water Teatment Sludge	Fluorescent Lamps	Lead-Acid Batteries	Nickel-Cadmium Batteries
	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3	Yd3
Mauiladora	Landfill, Incineration, solid fuels	Incineration, Haz Landfill	Incineration, Fuels	Landfill	Landfill	Recycle	Landfill, Recycle	Fuels, Haz-Landfill	Haz-Landfill	Recycle	Landfill	Recycle	Recycle	Incineration	Landfill	Recycle	Recycle	Recycle
A	250	5	130	25		1					20	40				2		
B	5		8									2						
C	100																	
D	2,400			16	20											2		
E	100				300													
F			80	68	38											7	20	
G	11	5								1					1	10		
H	48		58				8									1		
I	40		17	22	18											4		
J	3	5		5	6													
K	675		200	30	30		5											
L	120																	
M	195	25		40	40													
N	400																	
O			54	13	15													
P	3	4	1															
Q	80																	
R	50			20	20													
S	222															2		
T	12		18	13	15													
U		90	50	10	10			10				5						
V	15			40	30			1	75									
W	319	16	80	27	13										72			
X	140	10	280		20			41						40		20		
Y	5																	
Z	200		400					20										
AA		8		20	20		20											
BB	2		4	2	4													
CC	100		320		18					56						250		
DD	30	40		5	15													
EE	2		125	34	38											360		
FF	22			2	2										1	1	1	
GG	297			60	49								142			26	2	
HH	686				56		2	109						23				
II	75																	
JJ	7				6													
KK	43		45		18													
LL		10		20	30												2	1
MM	10		20	20	15			10										
Total	6,667	218	1,890	492	846	1	35	191	75	57	20	47	142	63	74	685	25	1

APPENDIX F: (continued)

Mauiladora	Empty Plastic Drums	Empty Metal Drums	Empty Crushed Glass Containers	Aerosol Cans	Epoxy Resin Liquid	Epoxy Resin w/ Methylene Chloride	Methylene Chloride	Waste Acetone	Xylene	Isopropyl Alcohol	Thrichloro Ethelene	N-Methyl-z-Pyrrolidone	Mixed Spent Solvents	Mixed Solvents w/ Paint	Waste Paint	Waste Ink	Solder Flux	Thinner	Degreaser	Used Oil
	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM
	Recycle	Recycle	Incineration	Recycle	Fuels	Fuels	Fuels	Fuels	Fuels, Recycle	Recycle	Fuels	Recycle	Fuels	Fuels	Fuels Blend	Fuels Blend	Fuels Blend	Fuels	Fuels	Recycle,Fuels
A				4									55	100						
B				10																
C										8							6		8	4
D													19							9
E																				
F									1						24					30
G						9							7							
H					9															4
I		30			6								45	20					12	5
J		40											7		13		23			
K											8	8	8							6
L		100																		
M	25	250			15								60							10
N								22					9	9	2		19			10
O													33		11					12
P					3					8	8								8	4
Q																				64
R															60		40			
S		276											34							125
T														22						13
U		40		10			12							30						
V		120																		50
W																		40		
X		100	10									50	50							
Y	20	20																		20
Z				80																
AA														20						20
BB		19		14																
CC														30						
DD					2															
EE					100								100	100					3	
FF		3			1								11						1	10
GG		1,000			215					179			83			2				118
HH		352		14	9					20						5				63
II															24					30
JJ													12							
KK													30							22
LL					21								12	10	20					5
MM																				
Total	45	2,350	10	132	381	9	12	22	1	215	16	58	575	341	154	7	88	40	32	634

DM: 55 Gallon Drum

APPENDIX F: (continued)

Mauiladora	Water w/ Oil	Water w/ Acids	Water w/ Ink	Water w/ Solvent	Water w/ Resin	Water w/ Lead Solder	Water Based Paint	Water Base Glue	Peroxide Amonia & Hidroxide w/ Water	Mercury contaminated Waste	Filing Dust	Zinc Powder	Solder Dross	Waste Copper Sulfate	Cyanide Salts	Filters contam. w/ cyanide	Mixed Acids	Sulfuric Acid
	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM
	Evaporation, Recycle	Treatment	Evaporator, Incineration	Evaporator, Incineration	Treatment	Evaporation, Recycle	Treatment	Solidification/Landfill	Recycle	Retort	Landfill, Recycle	Landfill	Recycle	Recycle	Incineration	Incineration	Neutraliza-tion	Recycle
A																		
B																		
C																		
D	398							28										
E																		
F											7							
G	10																	
H	5											200						
I							40											
J																		
K																		
L	60	48																
M																		
N																		
O																		
P							2											
Q																		
R																		
S				75													10	
T																		
U										35								
V																		
W	40				36		40								12	12		
X			1,080						30									20
Y								20										
Z	1,090						909											
AA																		
BB																		
CC																		
DD																		
EE								18						3				
FF													84					
GG	146			42	39	42												20
HH	2,037						93						5					
II	60												34					
JJ	7																	
KK																		
LL																		
MM																		
Total	3,853	48	1,080	117	75	42	1,084	66	30	35	7	200	123	3	12	12	10	40

DM: 55 Gallon Drum

APPENDIX F: (continued)

Mauiladora	Alkaline Solution DM Neutralization	Butyl Cellosolve Acetate DM Recycle	Hot melt Adhesive DM Incineration	Black Silicon Solid DM Landfill	Black Silicon Semi-Solid DM Landfill	Black Silicon Liquid DM Fuels
A			100			
B						
C						
D	30					
E						
F						
G						
H						
I				49	31	14
J						
K						
L						
M						
N						
O						
P						
Q						
R						
S	108					
T						
U						
V						
W						
X		15				
Y						
Z						
AA						
BB						
CC						
DD						
EE						
FF	3					
GG						
HH						
II						
JJ						
KK						
LL						
MM						
Total	**141**	**15**	**100**	**49**	**31**	**14**

DM: 55 Gallon Drum

APPENDIX G: List of By-products Commonly Exchanged at EIPs

By-products	Sources	Users	Usage
Acetic Acid	Pharmaceutical Manufacturer	Municipal Water Treatment Plant, Amino Acid Manufacturer	N/A
Air Dryer Solids	Polyester Fiber Manufacturer	Brick Manufacturer	N/A
Anyhdrous sodium sulphate stream	N/A	Pulp and paper industry	N/A
Alkaline wastewater streams	Pulp and paper industry	Metallurgical industry	Acidic wastewater neutralizer
Bagasse & Slag	Sugar Cane Field	Paper Mills	N/A
Carbon Dioxide	Alcohol Manufacturer Fermentation Plant	Produce Plant	Agricultural Process
Chemical Drums and barrels	Industry	Industry	Reused
Cotton Gin Trash	Cotton Ginner	Compost Producer	Feedstock
Electrostatic Precipitator dust w/ high concentration of boron	Fiberglass manufacturer	Fertilizer manufacturer	Dry fertilizer for land application
Dried Sugar Cane Leaves	Sugar Cane Field	Beef & Dairy Farm	N/A
Drywall Scrap	Mobile Home Manufacturer	Absorbent Manufacturer	Feedstock
Egg Shells	Dehydrated Food Manufacturer	Compost Producer	Feedstock
Ferric chloride	N/A	Waste water treatment plant	Waste water treatment
Ferrous sulphate	Metallurgical facility	Hazardous waste reatment facility	Hazardous waste tretment process
Fly Ash	Electric utility	Graphite manufacturer	Roofing shingles
Fly Ash	Power Plant	Soil Amendment Plant, Concrete Companies, Cement Roads	Feedstock
Foods Residue	Foods Facility	Farms, Alcohol Manufacturer	Animal Feed, Commercial Alcohols
Glass	Material Recovery Facility	Glass Tile Factory	Tiles
Granulated lime	N/A	Metallurgical facility	N/A
Green and Brown Waste	Material Recovery Facility	Ethanol Production Plant	Feedstock to produce Ethanol
Gypsum	Ethanol Production Plant	Composting Operations	Feedstock
Hydrogen gas	N/A	Hydrogen peroxide facility	Hydrogen stream
Hydrochloric acid	Industry	N/A	Reuse, Muratic Acid
Iron Oxide Sludge	Cathode corrosion	Metallurgical company	Oxides Recovery
Manganese	Battery Manufacturer	Brick Manufacturer	N/A
Manure	Dairy Farm	Mushroom Growing Company	Fertilizer
Metal Scrap	Industry	Metal manufacture	Feedstook

APPENDIX G (continued)

By-products	Sources	Users	Usage
Methanol	Industry	Formaldehyde Resin Plant	N/A
Methane	Gasifier, Municipal Landfill	Cogeneration Plant, Amino Acid Manufacturer	Fuel, Feedstock
Municipal Solid Wastestream	City/County Solid Waste Pick-up	Material Recovery Facility (MRF)	Plastics, Green and Brown Waste, Mixed Glass Cullet
Mushroom Base	Mushroom Field	Sugarcane Field	Fertilizer
Lignin	Ethanol Production Plant	Gasifier	N/A
Lime	N/A	Ethanol Production Plant	N/A
Limestone (CaCO3)	N/A	Metallurgical facility	N/A
Liquid Lime	Treatment of water in stream production	N/A	Neutralization
Oily, resin, and plastic residues	Industry	N/A	Rehabilitation of polymers with nitrogen
Organic Waste	Material Recovery Facility	Fish Farm, Green Houses, Composting Operations	Feedstock
Paper Bags	Industry	Paper / carboard manufacturer	Feedstock
Paper Scrap	Absorbent Manufacturer	Compost Producer	Feedstock
Polyethelyne/polypropylene waste	Industry	Plastic Products Manufacturer	Plastic Cargo Pellets
Polymer residuals	Industry	N/A	Protective roof coatings
Residual PVC	Industry	Shoe manufacturer	Rubber shoe soles
Sandblasting grif	Industry	Metallurgical company	Silica
Sawdust	Sawmill	Brick Manufacturer, Compost Producer	Fuel, Feedstock
Scrap Plastic	Material Recovery Facility	Plastic Products Manufacturer	Feedstock
Slag	Steel Mil	Cement industry	Feedstock
Sulfuric Acid	Wastewater treatment Plant	Specialty Chemical Plant	Feedstock
Spent Amino Acids	Amino Acid Manufacturer	Animal Feed Manufacturer	N/A
Spent Alcohol	Alcohol Plant	Fertilizer Plant	Feedstock
Spent Grains	Brewrery	Absorbent Manufacturer	Feedstock
Spent Butadiene	Industry	N/A	Natural gas fuel
Spent caustic soda (NaOH)	Industry	Pulp and paper facilities	Bleaching and neutralization
Spent Caustic Solution	Refinery	Paper Mill	Feedstock
Spent coating solution in sulfuric acid	Industry	Metallurgical company	Copper Sulfate recovery

APPENDIX G (continued)

By-products	Sources	Users	Usage
Spent potliner and steel slag	Industry	N/A	Flushing agent for lime content
Spent refractory high in aluminium	Industry	Construction industry	Cement , tile, and brick production
Spent & Sugar Juice	Sugar Cane Farm	Alcohol Plant	Feedstock
Spent Sulfuric Acid (Ferrous sulphate crystals)	Industry	Metals manufacturer	Feedstock
Treated Sludge	Wastewater treatment Plant	Brick Manufacturer, Fertilizer Plant, Aluminum Metals Plant	Feedstock, Spreading for control of tailings beds
Unhashed Eggs	Poultry Farm	Dehydrated Food Manufacturer	Feedastock
Waste Polyvinyl Alcohol	Industry	Paper, Adhesive, Textiles	High strenght glue
White Sludge	Paper Mill	Cement Kilns	Alternative fuel
Wood ash	N/A	N/A	Stabilization and neutralization agent for mineral tailing
Woodern Pallets	Industry	Compost Industries, Furniture Industries	Feedstock
Yeast	Brewery	Ethanol Production Plant	Feedstock

Appendix H: Average Disposal Cost for Waste Material

Waste Material	Average Cost	Unit	Treatment
Non-Haz Industrial Solids	$120	Yd3	Landfill, Incineration, solid fuels
Hazardous Industrial Solids w/ metals	$450	Yd3	Incineration, Haz-Landfill
Hazardous Solids: Rags, paper cont. with Oil, Paint and Solvents	$125	Yd3	Incineration, Fuels
Empty Metal Pails	$120	Yd3	Landfill
Empty Plastic Pails	$120	Yd3	Landfill
Empty Propane Gas Containers	$200	Yd3	Recycle
Empty Glass Containers	$120	Yd3	Landfill, Recycle
Spent Air or Halogen Filters Contam. w/ Ink or Paint	$450	Yd3	Fuels, Haz-Landfill
Metal Hydroxides	$120	Yd3	Landfill
Aluminum Shavings		Yd3	Recycle
Metallic Dust	$120	Yd3	Landfill
Scrap (Connector Parts, Circuit Boards)	$140	Yd3	Recycle
Cathode Ray Tubes	$200	Yd3	Recycle
Aluminum Bags	$400	Yd3	Incineration
Waste Water Teatment Sludge	$140	Yd3	Landfill
Fluorescent Lamps	$200	Yd3	Recycle
Lead-Acid Batteries	$225	Yd3	Recycle
Nickel-Cadmium Batteries	$225	Yd3	Recycle

Appendix H (continued)

Waste Material	Average Cost	Unit*	Treatment
Empty Plastic Drums	$35	DM	Recycle
Empty Metal Drums	$35	DM	Recycle
Empty Crushed Glass Containers	$125	DM	Incineration
Aerosol Cans	$230	DM	Recycle
Epoxy Resin Liquid	$125	DM	Fuels
Epoxy Resin w/ Methylene Chloride	$155	DM	Fuels
Methylene Chloride	$135	DM	Fuels
Waste Acetone	$100	DM	Fuels
Xylene	$100	DM	Fuels, Recycle
Isopropyl Alcohol	$100	DM	Recycle
Thrichloro Ethelene	$130	DM	Fuels
N-Methyl-z-Pyrrolidone	$130	DM	Recycle
Mixed Spent Solvents	$115	DM	Fuels
Mixed Solvents w/ Paint	$115	DM	Fuels
Waste Paint	$125	DM	Fuels Blend
Waste Ink	$125	DM	Fuels Blend
Solder Flux	$125	DM	Fuels Blend
Thinner	$125	DM	Fuels
Degreaser	$125	DM	Fuels
Used Oil	$80	DM	Recycle, Fuels
Water w/ Oil	$120	DM	Evaporation, Recycle

*55 gallon Drum

Appendix H (continued)

Waste Material	Average Cost	Unit*	Treatment
Water w/ Acids	$220	DM	Treatment
Water w/ Ink	$125	DM	Evaporator, Incineration
Water w/ Solvent	$125	DM	Evaporator, Incineration
Water w/ Resin	$125	DM	Treatment
Water w/ Lead Solder	$125	DM	Evaporation, Recycle
Water Based Paint	$125	DM	Treatment
Water Base Glue	$125	DM	Solidification/ Landfill
Peroxide Amonia & Hidroxide w/ Water	$130	DM	Recycle
Mercury contaminated Waste	$260	DM	Retort
Filing Dust	$120	DM	Landfill, Recycle
Zinc Powder	$120	DM	Landfill
Solder Dross	$120	DM	Recycle
Waste Copper Sulfate	$120	DM	Recycle
Cyanide Salts	$120	DM	Incineration
Filters contam. w/ cyanide	$330	DM	Incineration
Mixed Acids	$220	DM	Neutralization
Sulfuric Acid	$220	DM	Recycle
Corrosive Liquid	$220	DM	Neutralization
Butyl Cellosolve Acetate	$125	DM	Recycle
Hot melt Adhesive	$330	DM	Incineration
Black Silicon Solid	$125	DM	Landfill
Black Silicon Semi-Solid	$125	DM	Landfill
Black Silicon Liquid	$125	DM	Fuels

*55 gallon Drum

APPENDIX I: Waste-streams that could be transferred to the By-Product Center

MAQUILADORA	WASTE-STREAM	ANNUAL AGGREGATE QUANTITY	UNIT	AVERAGE COST	CURRENT TREATMENT
A, B, C, D, E, G, H, I, J, K, L, M, N, P, Q, R, S, T, V, W, X, Y, Z, BB, CC, DD, EE, FF, GG, HH, II, JJ, KK, MM	Non-Haz Industrial Solids (Solidified resins, Debris, Scrap tape, Glue, Rags, Air filters, Solid wax, Aluminum bags, Scrap capacitors, Desiccant, Tyvek suits, Plastic gloves, Mouth & Shoe covers, Blue tape, Teflon tape, Film, Plastic bags)	6,667	Yd3	$120	Landfill, Incineration, Fuels Blend
H, K, AA, HH	Empty Glass Containers	35	Yd3	$120	Landfill, Recycle
G, CC	Aluminum Shavings	57	Yd3		Recycle
A	Metallic Dust	20	Yd3	$120	Landfill
A, B, U	Scrap (Connector Parts, Circuit Boards)	47	Yd3	$140	Recycle
X, HH	Aluminum Bags	63	Yd3	$400	Incineration
G, W, FF	Waste Water Teatment Sludge	74	Yd3	$140	Landfill

MAQUILADORA	WASTE-STREAM	ANNUAL AGGREGATE QUANTITY	UNIT	AVERAGE COST	CURRENT TREATMENT
M, Y,	Empty Plastic Drums	45	DM	$35	Recycle
I, J, L, M, S, U, V, X, Z, BB, FF, GG, HH	Empty Metal Drums	2,350	DM	$35	Recycle
K, X	N-Methyl-z-Pyrrolidone	58	DM	$130	Recycle
C, P, GG, HH	Isopropyl Alcohol	215	DM	$100	Recycle
FF, HH, II	Solder Dross	123	DM	$120	Recycle
EE	Waste Copper Sulfate	3	DM	$120	Recycle
X, GG	Sulfuric Acid	40	DM	$220	Recycle
X	Butyl Cellosolve Acetate	15	DM	$125	Recycle

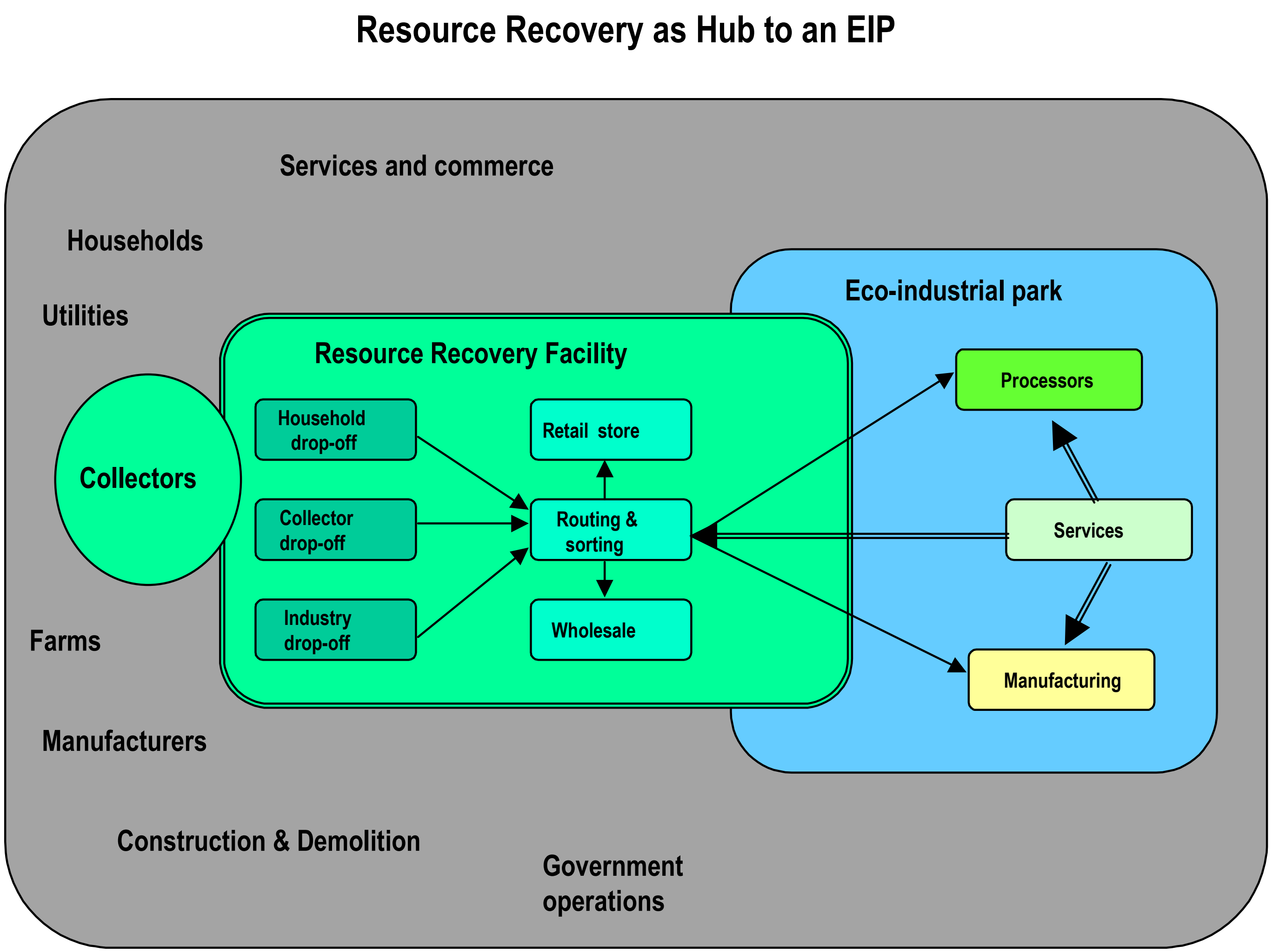
* DM: 55 gallon Drum

APPENDIX I : (continued)

MAQUILADORA	WASTE-STREAM	ANNUAL AGGREGATE QUANTITY	UNIT	AVERAGE COST	CURRENT TREATMENT
X	Peroxide Amonia & Hidroxide w/ Water	30	DM	$130	Recycle
H, I, M, P, DD, EE, FF, GG, HH, LL	Epoxy Resin Liquid	381	DM	$125	Fuels Blend
G	Epoxy Resin w/ Methylene Chloride	9	DM	$155	Fuels Blend
U	Methylene Chloride	12	DM	$135	Fuels Blend
N	Waste Acetone	22	DM	$100	Fuels Blend
K, P	Thrichloro Ethelene	16	DM	$130	Fuels Blend
A, D, G, I, J, K, M, N, O, S, X, EE, FF, GG, JJ, KK, LL	Mixed Spent Solvents	575	DM	$115	Fuels Blend
I, N, T, U, AA, CC, EE, LL	Mixed Solvents w/ Paint	341	DM	$115	Fuels Blend
F, J, N, O, R, II, LL	Waste Paint	154	DM	$125	Fuels Blend
GG, HH	Waste Ink	7	DM	$125	Fuels Blend
C, J, N, R	Solder Flux	88	DM	$125	Fuels Blend
W	Thinner	40	DM	$125	Fuels Blend
C, I, P, EE, FF	Degreaser	32	DM	$125	Fuels Blend
F	Xylene	1	DM	$100	Fuels Blend, Recycle
C, D, F, H, I, K, M, N, O, P, Q, S, T, V, Y, AA, FF, GG, HH, II, KK, LL	Used Oil	634	DM	$80	Recycle, Fuels Blend
C, G, H, L, W, Z, GG, HH, II, JJ	Water w/ Oil	3,853	DM	$120	Evaporation, Recycle
F	Filing Dust	7	DM	$120	Landfill, Recycle
H	Zinc Powder	200	DM	$120	Landfill
D, S, FF	Corrosive Liquid	141	DM	$220	Neutralization
X	Empty Crushed Glass Containers	10	DM	$125	Incineration

* DM: 55 gallon Drum

APPENDIX J: EIP By-Product Station Schematics



Collection companies may be part of the resource recovery facility and EIP or independent.